A/1. Abass, S.F.A., Amin, M. & Siddiqui, F.A., 1967. Talc deposits of Jamrud, Khyber Agency. Pakistan Journal of Scientific and Industrial Research 10, 300-303.

Geology and chemical composition of the talc deposits have been investigated. Two veins, about 3km apart, contained about 40,000 tons of talc. Talc is of fairly good quality, and suitable for use in the cosmetic, pottery, paper, textiles, tile preparation, and soap industry. Improved mining methods are recommended for winning the maximum %age of talc.
Key Words: Talc, Khyber Agency, Jamrud.

A/2. Abbas, A., 1843. Journey of a tour through parts of Punjab and Afghanistan, in the year 1837. Asiatic Society of Bengal Journal 12, 564 - 621.

This is a travelogue of the area stretching from the Salt Range to Waziristan, through Peshawar, Kohat and Kurram Agency. Written in Persian, it was translated into English by Major R. Leech. It contains brief mention of the occurrence of salt at Kalabagh and Karak, antimony in Kurram, and coal and iron in Kanigurum.
Key words: Afghanistan, FATA, Salt Range, Punjab.

A/3. Abbas, S.A., 1996. Mapping of the weathered and sub-weathered layers from seismic refraction rate in Ghaghriot area, Islamabad. M.Sc. Thesis, Quaid-i-Azam University, Islamabad.

The seismic refraction data of 'Ghagriot’ village, Islamabad has been reinterpreted with a view to map the weathered and sub weathered layer and establish a relationship between the velocity and lithology of the area. The data was of 25 spreads with reverse shooting scheme. After plotting the travel time curves the velocities and depths were determined and were put in the form of Isovelocity maps of V0, V1 and V2 and Isopach maps of Z0and Z1. An integrated study of these maps with the tubewell logs and VES columns reveal the following results.
The velocity of weather layer ranges from 333 m/sec to 620 m/sec and the thickness from 2.6m to 5.6 meters. It is composed of clay, silt and sand. The velocity of subweathered layer varies from 1358 m/sec to 1655 m/sec and its thickness varies from 18.9 to 35.1 m. It is composed of boulder and gravel with lesser amount of clay. This thick bed of boulder and gravel is saturated with water and water table varies from a depth of 4m -5m. The velocity of third layer varies from 1974 m/sec to 3096 m/sec showing the presence of interbedded clay within the gravel and boulder layer. It is also saturated with water.
Key words: Seismology, Seismic reflection, Islamabad.

A/4. Abbas, S.G., 1974. Brief report on geology of chromite deposits near Bucha Village, Mohmand Agency, Malakand Division. Geological Survey of Pakistan, Information Release 87, 7p.

Small Chromite bodies were found associated with ultramafic rocks, during a one day reconnaissance traverse near Bucha Village, Mohmand Agency, Malakand Division. The examined area appears to have some economic potential, as Chromite is believed to be of metallic grade and number of boulders indicate the presence of more Chromite bodies which could not be found out during the short time available for investigation. Boulders also show the presence of massive magnetite and haematite probably derived from the adjoining area.
Key words: Chromite, ultramafic rocks, Mohmand Agency.

A/5. Abbas, S.G., 1992. Prospects for metallic minerals in Pakistan. GSP, Information Release 520, 11p.

This report gives brief information on metallic minerals of Pakistan and includes those reported from the northern parts of the country. A generalised summary report describing present status and future prospects of Aluminium, Chromium, Copper, Lead-Zinc, Gold, Silver, Iron, Platinum, Tungsten and Lithium.
Key words: Metallic minerals, economic geology.

A/6. Abbas, S.G., & Rossman, D.L., 1969. Geology and economic potential for Chromite, Dargai Ultramafic Complex, Malakand Agency, Peshawar Division, West Pakistan. GSP and U. S. Geological Survey Project Report, PK Series, PK (IR)–51.

This report presents the geology of the area, along with information on ultramafic rocks including dunites and peridotites. There is some detail on the occurrence and economic potential of the chromite deposits. The report is accompanied by detailed maps (1:25000) and cross-sections.
Key words: Indus Suture, ultramafic rocks, chromite, Malakand Agency

A/7. Abbas, S.H. & Bhuiyan, K., 1967. Geology of Pezu-Sheikh Budin-Paniala (Khisore and Marwat Ranges): Dera Ismail Khan, North West Frontier Province. GSP, Information Release 109, 28p.

Key words: Stratigraphy, Siwalik Molasse, Khisore - Marwat Ranges, DI Khan.

A/8. Abbas, S.Q., Bhatti, M.A., Pasha, M.K. & Din, F., 1992. Structural analysis of Margala-southern Hazara fold belt. Abstracts, First South Asia Geological Congress, Islamabad, p.50.

The structural behavior inferred from the geological mapping of the Margala and southern Hazara Hills depicts that the area is fault propagated folded belt which is characterised by the sub- thrusting and isoclinal folding. On the northern margin of this belt lies the Nathiagali Thrust whereas the southern boundary is marked by the presence of the Main Boundary Thrust (MBT). It is also evident that the folding thus developed within the Jurassic-Miocene sedimentary rock sequence have been truncated as a result of subsequent thrusting and back thrusting. The ramping of the MBT has placed the Jurassic-Pliocene strata to come to abnormally in contact with the Eocene-Miocene rocks.
In the north, this belt has been overrun by the Pre-Cambrian flysch deposits of Hazara Formation while it is riding over the Eocene-Miocene rocks of the Potwar foredeep in the South. An attempt has been made to illustrate the tectonic model of the folded belt by balancing the selected cross-sections across this structural block.
Key words: Structural analyses, Margala, Hazara.

A/9. Abbasi, A.A., 1936. A study of Minapin Glacier. Indus 3(9), 29-34.

Key words: Glaciology, Minapin Glacier, Hunza, Karakoram.

A/10. Abbasi, A.A., 1965. Land sculpture by Karakoram glaciers. Indus 5(12), 28-32.

This is a report of the impact of the major Karakoram glaciers on the landform/ geomorphology of the central Karakoram region. There is an obvious relationship between the two, and glaciers have played a major role in the development of the geomorphic forms.
Key words: Glaciology, geomorphology, Karakoram.

A/11. Abbasi, I.A., 1989. Sedimentology and structure of the southern Kohat, Trans-Indus Ranges, Pakistan. Ph.D. thesis, University of Cambridge.

Key words: Sedimentology, structure, foreland basin, Siwalik molasses, Kohat.

A/12. Abbasi, I.A., 1990. Major patterns of fluvial facies of the Himalayan foreland-basin in the trans-Indus area, Pakistan. Abstract, 2nd Pakistan Geological Congress, University of Peshawar, p.20.

Consult Abbasi, 1992 below for further details.

Key words: Foreland Basin, fluvial facies.

A/13. Abbasi, I.A., 1991. Large scale vertical aggradation of sandstones in the Kamlial Formation of the Kohat basin, Pakistan. Geological Bulletin, University of Peshawar 24, 33-44.

The Kamlial Formation in the Kohat fold-thrust belt is composed dominantly of thick sandstone interbedded with siltstone and intraformational conglomerate. The sandstone bodies are over 100 meter thick in the upper part and, on the average, 30 meter thick in the lower and middle part of the formation. The sandstone bodies are multistoried and their large thicknesses are due to vertical and lateral amalgamation of sand bodies deposited in a slowly subsiding foreland basin. An average thickness of 4-6 meter has been estimated for the individual sand bodies deposited by 6-8 meter deep, intermediate to high sinuosity streams. Tabular sand bodies interbedded with overbank fines were deposited by high sinuosity streams. The drainage system during the deposition of the Kamlial Formation in the Kohat foreland basin was mainly flowing to the east, which is consistent with that of the Potwar Plateau.
Key words: Siwalik Molasse, Kamlial Formation, Kohat.

A/14. Abbasi, I.A., 1992. Major patterns of fluvial facies of the Himalayan foreland-basin in the trans-Indus area, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.1.

Molasse sediments (over 6 km thick) were accumulated in the western Himalayan foreland-basin (Kohat area) and reflect the subsidence of the basin, and approach of the Himalayan orogenic belt. The succession is composed largely of sand and silt in the lower part, and conglomerate in the upper part. The sand-bodies in the sand silt succession are mainly composed of plane bedding, low-angle plane bedding and trough cross bedding. The abundance of plane bedding and low-angle plane bedding suggest deposition from high energy flow conditions commonly associated with low-sinuosity river systems. The sand-bodies are usually 10 to 20 metres thick in the lower part, but up to 100 meters thick and many km in lateral extent in the upper part of the succession. The earliest recorded progradation of proximal conglomeratic facies over the finer grained sediments occurred in the Kohat area of the foreland-basin during Late Miocene. The coarser grained facies probably appeared in response to the northward drift of the depositional area closer to the source area, and the site became the proximal part of a large fluvial system. The thick polymict succession comprised of clast supported massive conglomerate, crudely stratified to horizontally bedded, and planar cross-bedded conglomerate assemblages suggest deposition by proximal braided streams. The early appearance of thick proximal plain facies suggests that the major palaoeriver system entered the foreland-basin through the Kohat area earlier than 10 Ma, approximately along the present day course of the Indus River.
Key words: Molasse sediments, foreland basin, Kohat.

A/15. Abbasi, I.A., 1994a. Subsurface geological and structural studies based on the gravity and magnetic measurement between Mandra-Jhelum and Dina Mirpur. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 51p.

Key words: Geophysics, subsurface geology, structure, Jhelum.

A/16. Abbasi, I.A., 1994b. Clay minerals in the Himalayan foreland basin sediments: Implications for the progress unroofing of an orogenic belt. In: Ahmed, R. & Sheikh, A.M. (Eds.), Geology in South Asia-I. Proceedings of the First South Asia Geological Congress, Islamabad, 1992. Hydrocarbon Development Institute of Pakistan, Islamabad, 280-284.

A sequence of over 6km thick detrital sedimentary rocks is exposed in the Kohat area, western Himalayan foreland basin. These rocks are grouped into two coarsening-upward sequences: the basal Rawalpindi Group and upper Siwalik Group. Clay-mineral studies from silt and clay beds through this succession reflect a fairly consistent mineralogy, but relative abundance of different minerals vares across the succession. Chlorite content decreases upsection with a corresponding increase in the smectite content. The proportion of muscovite/illilte remains constant. Muscovite/illite crystallinity increases progressively upsection, showing highest crystallinity values in the Shakardarra Formation, which makes up the upper part of the Siwalik Group. The variations in the mineral abundance and inverse trends in the muscovite/illite crystallinity are probably due to progressive unroofing of an orogenic belt in the source area exposing higher grade metamorphic and igneous rocks.
Key words: Clay Minerals, orogeny.

A/17. Abbasi, I.A., 1994c. Fluvial architecture and depositional system of the Miocene molasse sediments, Shakardarra Formation, southeastern Kohat, Pakistan. Geological Bulletin, University of Peshawar 27, 81-98.

The Neogene molasse sediments in southeastern Kohat area are divided into two groups, the Rawalpindi, and the Siwalik groups. The Siwalik Group in the study area, around Shakardarra town, is a coarsening upward sequence of silt dominated Chinji Formation, sand dominated Shakardarra Formation, and polymictic conglomerate dominated Indus conglomerate Formation. The Shakardarra Formation is comprised of sandstone-siltstone in the basal part, dominantly sandstone in the middle part and sandstone –conglomerate in the upper part. The major sandstone-bodies, on average, are up to 15m thick and many km in lateral extent in the lower part, whereas, upto 100m thick and tens of kilometers in lateral extent in the middle and upper parts. The sandstone-bodies are multistoried, and are characterised by inchannel lithofacies such as plane bedding, low angle plane –bedding and trough cross-bedding. A number of bar macroforms and channel features of different hierarchical order have been observed in the sandstone-bodies. A high-energy braided river system is suggested for the deposition of the sediments. The paleoriver system was flowing approximately parallel to the present day Indus River and entered the foreland basin through the study area at least since last 10 Ma.
Key Words: Siwalik Molasse, Shakardara Formation, Kohat.

A/18. Abbasi, I.A., 1997a. Sedimentology and tectonic setting of polymictic conglomerates in a rapidly subsiding Miocene-Pliocene Foreland Basin: Kohat Plateau, Northern Pakistan. Geological Bulletin, University of Peshawar 30, 297-309.

More than 6km of Neogene molasse sediments of the Rawalpindi and Siwalik Groups accumulated in the western Himalayan (Kohat) foreland basin, northern Pakistan, in response to active basin subsidence and orogenic uplift. In the Kohat Plateau, the Siwalik Group consists of a coarsening upward sequence of silt in the lower part (Chinji Formation), sand in the middle part (Shakardarra Formation) and conglomerate (Janak Conglomerate Formation) in the upper part. This formation was previously named as the Indus Conglomerate Formation by Abbasi and Friend (1989), but I now propose that it should be called the Janak Conglomerate Formation. This new name is proposed because of the danger that the previous name will be confused with stratigraphic terms used in the Indus Suture Zone of Ladakh, India, where the terms Indus Group, Indus Formation, Indus Molasse and Indus Flysch have all been used in recent years (e.g. Srivastava, et al., 1979; Searle et al., 1990; Searle, 1996). The name of Janak belongs to a village located on the northwestern edge of the outcrop area of the formation, at 71º38′30″E, and 33º14′30″ N (Fig. 2).The Janak Conglomerate Formation is exposed over an area of 400km^2, and is about 1500m thick. The conglomerate/sandstone ratio is 1:1 in the lower part and increases to 4:1 in the middle and upper parts. The formation is laterally variable but consists of three main lithofacies i.e., a) crudely stratified to horizontally bedded conglomerate (Gh), b) massive, clast supported conglomerate (Gm), and c) planar cross-stratified conglomerate (Gp). In lithofacies Gp, some of the cross-sets are up to 7m thick suggesting channels as deep as 14m or more. However, the average thicknesses of the cross-sets are 3-5m, suggesting channels 6-10 m deep. The progradation of the conglomerates over the finer grained formations is probably mainly a response at this depositional site on the Indian plate, to the progressive movement of the plate towards the uplifted Himalaya. But in the Kohat area, the late Miocene progradation of the conglomerates is distinctly earlier than elsewhere in the western Himalayan foreland basin. The conglomerates pass laterally into the finer grained facies of the Nagri and Dhok Pathan formations to the east and south of the Kohat basin, and also pass into finer

grained sediments to the west. This suggests that it was in this area that the largest river system entered the western foreland, about 10 ma, approximately along the course of the present-day Indus river.
Key Words: Sedimentology, tectonics, Siwalik Molasse, Kohat.

A/19. Abbasi, I.A., 1997b. Channel pattern and range front influence on the Indus River, Punjab Plain, Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p. 3.

The Indus River is one of the world's major river systems and is the largest in Pakistan which along with its tributaries drain most part of the Punjab plain. The river pattern is control by bed-rock structures and morphology in the higher mountains and foreland fold-thrust belt, and by its own alluvium in the Punjab plain. Data from Survey of Pakistan topo sheets, satellite images and some old maps were used to interpret the channel pattern and the influence of range fronts i.e., Suleiman Range on the lateral migration of the river system. Wada's reports (Attalla, 1970) and later, are used for water discharge and sediment load.
Average annual sediment load at Methanol (at the confluence of five Punjab Rivers called Punned) was calculated as about 600x1'09 kg (Attalla 1970). New estimates of Millikan and Meade (1983) have shown an annual sediment discharge of about 11Ox109 kg at the mouth of Indus River due to enormous silting in large reservoirs. The combined waters of Punned River have over 70% of their sediment load in the form of clay and silt in suspension which has a major influence on the channel pattern further downstream. The river system changes its morphology from a strongly braided in the north, to a meandering system in the south due to decrease in gradient (11cm/km) and high suspended load. The river system is multichannel, low sinuosity in the northern reaches with a 'Total Sinuosity' (Rintoul and Richards, 1993) of 3.5 and a strong braiding element. It is transitional between meandering and braided, rather more of an anastomosed type in its middle reaches with a 'Total Sinuosity' of 2.5. South of Mithankot, the river flows as a single, large sinuous system and the 'Total Sinuosity' decreases to 1.5. The Miocene and younger molasse sediments in the Kohat and Trans Indus Ranges and in Indus fan delta suggest that the Indus river occupied its present course at about 8 Ma (Abbasi and Friend, in press). Major thrust loading along the Sulaiman and other western ranges may have controlled the flow direction along their axis since then. The present day river system shows a tendency to migrate laterally towards the range front. A similar range front control is also evident for the Jhelum River due to thrust loading along the Salt Range Thrust.
Key words: Indus river, channel pattern, Punjab plain.

A/20. Abbasi, I.A., 1998. Major patterns of fluvial facies and evolution of the Himalayan foreland basin, southeastern Kohat Plateau, Pakistan. In: Ghaznavi, M.I., Raza, S.M. & Hasan, M.T. (Eds.), Siwaliks of South Asia, 59-96 Geological Survey of Pakistan, Islamabad.

Key words: Siwalik Molasse, sedimentology, Kohat.

A/21. Abbasi, I.A., 2000. Fault geometries in new hydrocarbon prospective zone of Shkardarra area, Kohat Plateau, North Pakistan. Late Abstracts, Third South Asia Geological Congress, Lahore, 2-3.

Key words: Structural geology, petroleum geology, Shakardara, Kohat.

A/22. Abbasi, I.A., 2001. Post Miocene gravel progradation in the western Himalayan foreland basins, Kohat Plateau, northern Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p. 21.

The sedimentary detritus shed by the Himalayan collision belts and accumulated in the foreland basin, allow correlation between the tectonic processes, lithologies involved in deformation and the resulting sediments. Thick coarsening upward molasse sediments deposited by major river systems characterize the Kohat foreland basin along the western fringes of the orogenic belt. Coarse-grained gravel sequences are deposited in the upper part of the

Siwalik Group as proximal alluvial plain facies. Two major polymictic conglomerate sequences are described from the southeastern and western part of the Kohat plateau.
In the southeastern part of the plateau, near Shakardarra town, the conglomerate sequence named as the "Janak Conglomerate", is considered to be Miocene in age. The conglomerate has a transitional contact with the underlying Shakardarra Formation (Nagri Formation), and is comprised of thick gravel beds interbedded with sandstone. The formation is exposed over an area of 400 kin, and is about 1500m thick. The conglomerate/sandstone ratio is 1:1 in the lower part and increases to 4:1 in the middle and upper parts. The clasts are comprised of gneisses, volcanics, schists, granites and quartzites, derived from the igneous and metamorphic belts of the higher and lower Himalayas, and deposited by a trunk river system analogous to the Indus River. In the southwestern part of the plateau, near Zarwam area, an approximately 2500m thick conglomerate sequence is named as the 'Ahmedzai Conglomerate". The Ahmedzai Conglomerate is considered as Pliocene-Pleistocene in age and has a transitional contact with the underlying Dhok Pathan Formation.
The conglomerate is comprised of clasts belonging to limestone, quartzite, chert, ultramafics and serpentinites - derived mainly from the western ranges of Waziristan and Parachinar. The conglomerates were deposited by the Kuram River, a major western tributary of the Indus River. The source area for these conglomerates is interpreted as the north Waziristan-Thal collision belt, dominated by the Cretaceous-Palaeocene igneous complex, and Mesozoic and younger carbonate rocks. The conglomerates of the Janak Formation represent deposition by a large trunk river system draining through the higher and lower Himalayan zones and are described as the high mountain fed conglomerates. These middle and lower Siwalik conglomerates provide information about the extent of older incision in the high mountains, and the portion in the basin of the major drainage path. The clasts of the Ahmedzai Conglomerate represent deposition by tributary streams draining the foothills, and are widespread along the mountain fronts. These upper Siwalik conglomerates provide information about relatively young frontal fault activity and growth of local river systems, such as Kuram River.
Key words: Siwalik molasse, sedimentology, Kohat.

A/23. Abbasi, I.A., Abid, I.A. & Khan, M.A., 1983. Statistical study of the Dhok Pathan Formation, Puki Gudikhel, Surghar Range, Karak. Geological Bulletin, University of Peshawar 16, 85-96.

Size analyses of a part of the Dhok Pathan Formation, Surghar Range, was carried out to study the behavior of different size fractions and to interpret the environments of deposition. The measures obtained on phi-scale reveal that the sandstone of the area is medium to fine-grained, moderately sorted, positively skewed and has platykurtic distribution. The C-M pattern for these sediments suggests suspension and tractive current deposits, and is comparable in appearance with the basic pattern IV and V of Passega (1957). There is no systematic horizontal or vertical variation in different statistical measures but present a rather zigzag pattern, which indicates that the material of variable size was brought to the basin between each cycle.
Key words: Siwalik Molasse, Dhok Pathan Formation, Surghar Range, Karak.

A/24. Abbasi, I.A. & Ali, F., 2000. Tectonic significance of Pliocene-Pleistocene polymictic conglomerates exposed along the western margin of Indian plate; Bannu-Waziristan area, North Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.36.

Thick molasse sediments of the Rawalpindi and Siwalik Groups are exposed over a large area around Bannu and North Waziristan, along the western margin of the Indian Plate. The base of the molasse sequence is defined by the Kamlial Formation, overlained by the Chinji, Nagri and Dhok Pathan formations. The uppermost part of the sequence is comprised of over 2 km thick conglomerate interbedded with sandstone, known as Ahmedzai Formation. The best exposures of the conglomerate are along the Ahmedzai Syncline, North of Bannu town. The conglomerates of the Ahmedzai Formation are comprised of clasts derived h m the Mesozoic and Tertiary carbonate sequences, quartzites, and from mélange zones. The clasts from mélange zones are represented by abundant chert, ultramafics such as serpentinites, and some volcanics. The material is contributed from within the Kunam Mélange Zone, located to the West of the study area. Isolated outcrops of ultramafic lithologies associated with the Paleocene abduction, due to collision along the western margin of the Indian Plate with Afghan block, are exposed in areas such as Kai and North Waziristan. The conglomerates were deposited by a river system analogous to present-day Kurrarn river draining through the western ranges, such as Koh-e-Sufaid and Kurram Mélange zone. Angular to

subangular clasts of ultramafics, particularly the serpentinites, indicate a close by source area and little transportation.
Key words: Siwalik Molasse, tectonics, Bannu, Waziristan, Indian Plate.

A/25. Abbasi, I.A. & Friend, P.F., 1989. Uplift and evolution of the Himalayan orogenic belts, as recorded in the foredeep sediments. In: Derbyshire, E. & Owen, L.A. (Eds.), The Neogene of the Karakoram and Himalayas. Zeitschrift fur Geomorphologies, Special Publication 76, 75-88.

Key words: Siwalik molasse, Sedimentology, Himalaya.

A/26. Abbasi, I.A. & Friend, P.F., 1993. Fluvial sole structures from the Siwalik Group north Pakistan. Geological Bulletin, University of Peshawar 26, 103-112.

The Siwalik Group consists of over 6 km of fluvial clastic sediments, fluvial cycles of thick sandstone (5-20 m) and siltstones (5-50 m) are common particularly in the Chinji Formation. Sole structures are well developed on the base of the sandstone bodies and represent an early phase of erosion of the overbank fines related to channel evulsion before deposition of major sandstone. Examples from the Chinji and Shakardarra formations include gutter casts, crescent marks, and flute marks all due to aqueous scour. Polygonal marks and pedestal structures, meters across, and locally metres in relief, may be subaqueous or sub-aerial in origin.
Key words: Sedimentology, Siwalik molasse, Chinji Formation, Shakardara Formation.

A/27. Abbasi, I.A. & Friend, P.F., 1997. The Neogene of Janak Conglomerate Formation of northern Pakistan: Stratigraphic effects of continental convergence and drainage. Abstracts, 3rd GEOSAS Workshop on Siwaliks of South Asia, Islamabad. Geological Survey of Pakistan, Records 109, 32-33.

Over 6 km thick Neogene molasse sediments were deposited in the western Himalayan foreland basin in Kohat area in response to active deformation along the orogenic belt and its gradual migration in the foreland basin. In south eastern Kohat area, west of Indus river the sediments are characterised by two coarsening upward sequences of Rawalpindi and Siwalik groups. The Siwalik Group is comprised of an overbank fines rich the Chinji Formation, an inchannel sand rich the Shakardarra Formation and an upper coarse grained polymictic conglomerate rich the Janak Conglomerate Formation. This formation was first named the Indus Conglomerate Formation by Abbasi & Friend (1989), but we now propose that it should be called the Janak Conglomerate Formation. We propose this new name because of the danger that our previous name will be confused with stratigraphic terms used in the Indus Suture Zone of Ladakh, India, where the terms Indus Group, Indus Formation, Indus Molasse and Indus Flysch have all been used in recent years (e.g. Srivastava, Pal and Mathur, 1979; Searle, Pickering and Cooper, 1990). The name of Janak belongs to a village located on the northwestern edge of the outcrop area of the Formation, at 71°38’30”E, and 33°l4’30”N.
The study of the Siwalik Group of the Potwar area by Gill (1952), was the first in which it was recognised that the mainly sandstone-dominated successions of the central Potwar are the lateral equivalents of major conglomerates further west, near the Indus River. Outcropping on both Kohat and Potwar sides of the Indus River, these form the Janak Conglomerate. The Janak Conglomerate Formation was deposited by a large (approximately 15 m deep) river draining southwards from the High-Himalayas of northernmost Pakistan. The deposition appears to have started about 8 Ma ago and lasted until Quaternary times. The formation has a thickness of about 1500 metres, and a lateral extent perpendicular to general river flow of about 25 km.
Comparison with other conglomerate occurrences along the Himalayan front shows that a distinction can be made between foothills-fed conglomerates**,** for which clasts came from local source areas, that were being uplifted along thrusts in the Sub-and Lower Himalayas during Upper Siwalik deposition.
High-mountain-fed conglomerates, for which clasts came from all the Himalayan lithotectonic zones. These conglomerates were formed by large rivers, involving drainage of the whole Himalayan belt, and conglomerates of this type are found in both Middle and Upper Siwalik deposits. The Janak Conglomerate Formation is of this type, and was formed by the paleo-Indus.
Key words: Janak Conglomerate Formation, Siwalik Molasse.

A/28. Abbasi, I.A. & Friend, P.F., 2000. Exotic conglomerates of the Neogene Siwalik succession and their implications for the tectonic topographic evolution of the western Himalaya. In: Khan, M.A., Treloar, P.J., Searle, M.P. & Jan, M.Q. (Eds.), Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya. Geological Society, London, Special Publication, 170, 455-466.

Published information on the Siwalik Group (Neogene) conglomerates in the Sub-Himalayan belt of Himachal Pradesh, India, and the Potwar Plateau, Pakistan, is used as the basis of a model that recognizes two types of conglomerates with different relationships to the linear Himalayan mountain front. The two type are: (1) foothills-fed conglomerates, widespread along the mountain front, that mark the appearance in the basinal succession of sediments derived from within the Sub-Himalayan fold-and-thrust belt or the neighboring Lower Himalaya; these Upper Siwalik conglomerates provide information about relatively young frontal activity and the growth of local river systems that transferred the sediments generated; and (2) high-mountain-fed conglomerate, with restricted lateral extent along the front, that mark the presence of large trunk rivers, draining the Lower and Higher zones of the Himalaya; these Middle and Upper Siwalik conglomerates provide information about the extent of older incision in the high mountains, and the position in the basin of the major drainage paths.
Our work on the Janak (formerly Indus) Conglomerate Formation, outcropping near the present Indus River, shows that it is a high-mountain-fed conglomerate, and was deposited by a large braided system (channels up to 15 m deep) that drained southwards from the High Himalaya of northmost Pakistan. The conglomerate was deposited between 9 and 1 Ma, and is preserved as a formation 1.5 km thick and 25 km wide, perpendicular to flow. This conglomerate marks the position of the Palaeo-Indus in this part of the foreland basin. The syntaxial position of the present Indus in the mountain front, and the remarkable route of the upper Indus, have resulted from drainage evolution during the alter stages of transpressive indentation of the western margin of the Indian block. Our interpretation of the Janak Conglomerate implies that this special role of the Indus must have already started by 9 Ma.
Key words: Siwalik Molasse, Janak Conglomerate Formation, tectonics, Potwar.

A/29. Abbasi, I.A. & Khan, M.A., 1990. Heavy mineral analysis of the molasse sediments, Trans Indus Ranges, Kohat, Pakistan. Geological Bulletin, University of Peshawar 23, 215-229.

The molasse sediments in the Kohat plateau comprise two coarsening upward sequences, the Rawalpindi and Siwalik Groups, which are further subdivided on the basis of their lithological characteristics into a number of formations. Correlation of these formations across different areas becomes very difficult due to their time transgressive nature. Heavy minerals area a useful tool for such correlations, as each formation is characterized by a particular heavy mineral suit. The Murree Formation of the Rawalpindi Group contains a simple association of heavy minerals, and epidote constitutes bulk of the heavy mineral suite. The epidote decreases upsection with a corresponding increase in the contents of other minerals and also by the appearance of new minerals. The Kamlial Formation is characteristically rich in tourmaline and garnet. The Siwalik Group, particularly the Shakardarra Formation of the Miocene age, is marked by the introduction of high-grade metamorphic and igneous minerals such as amphibole, staurolite and kyanite. Amphibole constitutes the bulk of heavy minerals in the Indus Conglomerate Formation (Miocene-Pliocene age) besides pyroxene, kyanite and staurolite.
The mineral chemistry of amphibole and garnet shows that the amphibole was derived mainly from the igneous and metamorphic belts of the Kohistan island arc. The major source of garnet in the molasse sediments is interpreted as the metamorphic belts of the Indian plate exposed along its northern margin. Some garnet in the Indus Conglomerate Formation may have been derived from the Kohistan island arc terrain.
Key words: Siwalik Molasse, Murree Group, heavy minerals, Trans Indus Salt Range, Kohat.

A/30. Abbasi, I.A., Khan, M.A. & Hadi, S., 2000a. Mass movement and landslides in the Murree area, N. Pakistan. Project Report, ICIMOD, Nepal, 55p.

Consult the following for further details.
Key words: Hazards, mass movement, landslides, Murree.

A/31. Abbasi, I.A., Khan, M.A., & Hadi, S., 2000b. Mass movement and landslide hazard, Murree area, North Pakistan. Earth Science Frontiers 7, Abstract Volume, 15th Himalaya-Karakoram-Tibet Workshop, Chengdu, China, P.43.

The summer resort of Murree and adjoining areas is characterized by high degree of erosivity and erodibility due to both natural and man induced factors. This area is part of a young orogenic belt that is experiencing one of the world's most rapid uplift rates, and is located in near vicinity of major thrust faults. Shear zones associated with still active faults, such as Murree Thrust and also the folding generated due to thrusting induce an inherited weakness and natural instability potential in the rocks of the Murree Hills. Ever increasing population pressure, deforestation, large-scale construction works including a new township and a road network have further aggravated the problem.
In order to study the landslides and other mass movement related problems in Murree, an area around the main town is selected for detailed analysis of the problem as it has been focus of major development and road construction work; this study is an attempt to prepare a preliminary hazard/landslide map along major road network, around Murree town to identify the unstable areas. Data collection during the fieldwork and analysis were carried out on Geographic Information System (GIS) based ILWIS format of the ITC, the Netherlands. Detailed study of few selected landslides has also been conducted to understand the mechanism of failure and extent of damage. The landslide distribution map shows that the western slopes of the Murree ridge are worst affected by the land sliding. Major landslides such as Shifang Hotel and MIT, located on the upslopes of the Jhika Gali-Lawrence College Bypass road are caused by an inadequate drainage system from the city center (Murree ridge). Beside the Bypass road section, the MIT Housing Scheme is also adversely affected by the mass movement. In most part of the area around the Murree ridge, creep is a common phenomenon in thick colluvium cover due to obvious loss of vegetation. Most of the landslides initiated at the colluvium-bedrock interface, but once initiated the tension cracks spread into the bedrock and therefore causing the failure in it. Major landslides in the area, such as Kashmir Bazar, Chitta Mor, MIT etc. exhibits a complex array of joint/fracture pattern both parallel and perpendicular to the bedding, and in various ways contribute to the mass movement.
Key words: Hazard, mass movement, landslide, Murree.

A/32. Abbasi, I.A., Khan, M.A., Hadi, S., Ishfaq, M. & Mool, P.K., 2001. Geological controls on slope failure and landslide hazards, Main Boundary Thrust Zone, Murree Hills, North Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.40.

The summer resort of Murree and adjoining areas are characterized by high degree of erosivity and erodibility due to both nature and man induced factors. This area is part of a young orogenic belt that is experiencing one of the world's most rapid uplift rates, and is located in near vicinity of major thrust faults. Shear zones associated with still active faults, such as Murree Thrust and also the folding generated due to thrusting induce an inherited weakness and natural instability potential in the rocks of the Murree Hills. Ever increasing population pressure, deforestation, large-scale construction work including a new township and a road network have further aggravated the problem.
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The landslide distribution map shows that the eastern slopes of the Murree ridge are worst effected by the land sliding. Major landslides such as Shifang Hotel, Midway and MIT, located on the upslopes of the Jhika Gali-Lawrence College Bypass road are caused by an inadequate drainage system from the city centre (Murree ridge). Beside the Bypass road section, the MIT Housing Scheme is also adversely effected by the mass movement. In most part of the area around Murree ridge, creep is a common phenomenon in thick colluvium cover due to obvious loss of vegetation. Most of the landslides initiated at the colluvium-bedrock interface, but once initiated the tension cracks spread into the bedrock and therefore causing the failure in it. Major landslides in the area, such as Kashmiri Bazar, Chitta Mor, MIT etc. exhibit a complex array of joint/fracture pattern both parallel and perpendicular to the bedding, and in various ways contribute to the mass movement.
Key words: Hazards, landslide, MBT, Murree.

A/33. Abbasi, I.A., Khan, M.A., Hadi, S., Ishfaq, M. & Mool, P.K., 2001. Geological controls on slope failure and landslide hazards, Main Boundary Thrust Zone, Murree Hills, North Pakistan. Journal of Asian Earth Sciences 19, p.1.

Consult the preceding account for further information.
Key words: Hazards, landslide, MBT, Murree.

A/34. Abbasi, I.A., Khan, M.A., Ishfaq, M. & Mool, P.K. 2002. Slope failure and landslide mechanism, Murree area, north Pakistan. Geological Bulletin University of Peshawar, 35, 125-137.

The area around Murree town is inherently vulnerable to mass movement processes, most commonly due to land sliding. It is characterized by high degree of erosivity and erodibility due to both natural and man induced factors. The area is part of a young orogenic belt that is experiencing one of the world's most rapid uplift rates, and is located in the near vicinity of major thrust faults. Shear zones associated with still active faults, such as Murree Thrust and also the folding generated due to thrusting induce an inherited weakness and natural instability in the rocks of the area. This compounded with ever increasing population pressure, deforestation, large-scale construction work in the form of residential and commercial buildings and road network have further aggravated the problem. Lithologically the area is comprised of shale, siltstone and sandstone belonging to the Oligocene-Miocene Murree and Kuldana formations. In order to study the landslides and other mass movement problems in Murree, an area around the main town and along the Murree-Kashmir Highway is selected for detailed analysis of the problem. The eastern slopes of the Murree ridge, and the road section between Jhika Gali and Aliot village are worst affected by the landsliding. Around Murree town, major landslides such as Shijang Hotel, Midway and MIT landslides, located on the upslopes of the Jhika Gali-Lawrence College Bypass road are caused by inadequate drainage system from the city centre (Murree ridge). In most part of the area around Murree ridge, creep is a common phenomenon in thick colluvium cover due to obvious loss of vegetation. The area between Jhika Gali and Aliot village is also affected by landsliding, and some of the largest landslides such as Aliot, Birgran and Kasseri landslides have inflicted great damage to farm and forest land. This area is located in the footwall of the MBT and is deformed by folding and termination splays associated with it. Mast of the landslides initiated at the colluvium-bedrock interface, but once initiated the tension cracks spread into the bedrock and therefore causing the failure in it. Major landslides in the area exhibits complex array of joint fracture pattern both parallel and perpendicular to the bedding, and in various ways contribute to the mass movement.
Key words: Slope failure, landslide, MBT, Murree.

A/35. Abbasi, I.A. & McElroy, R., 1991. Thrust kinematics of the Kohat Plateau, Trans Indus Salt Range, Pakistan. Journal of Structural Geology 13, 319-327.

The Kohat Plateau consists of a heavily deformed and structurally elevated thrust sheet. Pop-ups, broad synclines and narrow fault- and evaporite-cored anticlines record high-level translation of a large thrust mass along Eocene evaporites. A lower detachment level is also inferred, located at the base of the Mesozoic-Palaeozoic section. This lower detachment is common to both the Kohat and the adjacent Potwar Plateaus whereas the upper level is restricted to the Kohat. Beneath the Kohat, a blind imbricate stack of pre-Tertiary rocks is developed. Above their roof thrust, the foreland basin-fill of Kohat records greater internal deformation compared to that of the adjacent Potwar Plateau. In contrast, the Potwar thrust belt displays a greater amount of overthrusting on its basal surface, this displacement emerging in the Salt Range. Total shortening across the two plateau is comparable, but is accommodated in an areally smaller thrust belt with a higher structural relief in the Kohat as compared to the Potwar structural province. The resultant geographical offset of the thrust front is denoted by the Hukni-Kalabagh lateral ramp. The differences in the thrust kinematics are tentatively suggested to be caused by the mechanical response of the orogenic wedge to different imposed geometries of the wedge laterally within the basin. The Kohat Plateau appears to have a lower basal dip than does the western Potwar, and thus shows greater internal deformation.
Key words: Thrust kinematics, Trans Indus Salt Range, Kohat.

A/36. Abbasi, I.A., Tanoli, S.K., Riaz, M., Iqbal, H. & Rehman, O., 1994. Provenance of the early Eocene Chashmai Formation in south-western Kohat: Indications of an uplifted Island arc. Pakistan Journal of Hydrocarbon Research, 6, 53-59.

Key words: Chashmai Formation, sedimentology, uplift, Kohat.

A/37. Abbasi, K.M., 1982-84. Geotechnical Studies of landslides along Karakoram Highway from Shetan Pari to Aliabad. M.Sc. Thesis, Punjab University, Lahore, 122p.

This thesis is mainly composed of the study of about land sliding along Karakoram Highway from Shetan Pari to Aliabad. A brief description of other geological features is also included in the thesis. The geological map shows the different types of rocks present in the project area. Detailed study has been made in the project area to collect the data about discontinuities as joints, which plays the dominant role in case of sliding in hard rocks. This data has been plotted on equal-area stereonet to check the stability of the slopes. In case of sliding in soft material like alluvial fan, samples were collected and tested for detailed analysis. Finally on the basis of this analysis the road is classified into stable, potentially unstable and unstable regions.
Key words: Hazards, landslides, Hunza.

A/38. Abbasi, M.F., 1999. Interpretation of seismic reflection data from E-Salt Range and Potwar Plateau of Pakistan. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 20p.

Key words: Seismology, Salt Range, Potwar.

A/39. Abbasi, M.H., 1973. General geological mapping of Chalt area and report on feasibility of dam site near Chalt. M.Sc. Thesis, Punjab University, Lahore, 52p.

The Chalt area is located in the south central part of the Hunza valley. The area contains volcanic and low grade metasediments. The Hunza river has a rather narrow span at Chalt, making the locality appropriate for the construction of a hydroelectric dam. Rocks abutting on both banks of the river appear to be hard and compact.
Key words: Mapping, engineering geology, Chalt, Hunza, Karakoram.

A/40. Abbott, J., 1848. Inundation of the Indus, taken from the lips of an eye witness, A.D. 1842. Journal of the Asiatic Society of Bengal 17, 230-232.

This is an account of the great flood in the Indus River. It was caused by breaching of a dam generated by a huge landslide near Raikot on the western flank of the Nanga Parbat. The sudden release of water caused a great damage on the river banks all the way to Attock-Khairabad, where a whole regiment of the Sikhs' army was swept away.
Further information is not available to the authors.
Key words: Indus, flood, hazard.

A/41. Abdullah, S.K.M. & Offield, T.W., 1968a. Reconnaissance geology of the Balakot and Mahandri Quadrangles, Hazara district, West Pakistan. U.S. Geological Survey, PK (IR) 34, 41p.

Key words: Reconnaissance geology, Balakot, Hazara.

A/42. Abdullah, S.K.M. & Offield, T.W., 1968b. Reconnaissance geology of the Darband Quadrangle, Hazara district, West Pakistan. U.S. Geological Survey.

Key words: Reconnaissance geology, Darband, Hazara.

A/43. Abdelouahab, M., 1991. Petrologie-geochimie des roches mafiques et ultramafiques grenues de l'arc volcanique obducte du Kohistan (NW Pakistan). Contributions a la genese des arcs volcaniques intra-oceaniques. Ph.D. Thesis, University of Montpellier, France, 189p.

This is an account of mafic and ultramafic rocks of the Kohistan arc, with details of petrography and geochemistry. Petrological and structural conclusions have been drawn on the genesis and development of this intra-oceanic volcanic arc in the neo-Tethys. Many tables of analyses and figures accompany the text
Key words: Kohistan arc, geochemistry, petrology, mafic rocks.

A/44. Abdus-Sattar, 2000. Some geochemical attributes of Higher Himalayan granites from Upper Kaghan valley, NW Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.114.

Higher Himalayan crystalline unit in the Upper Kaghan Valley is comprised of granitoids, pelites, psammites migmatites, turbidites and associated minor marble horizons recognized as basement, covered with thin pelites-psammites and intercalated marbles having amphibolite at the base and a thick sequence of calc-pelites and marbles at the top, intruded by sheet granites. This sequence is bound by the MCT in the south and MMT in the north. The whole block is metamorphosed to upper amphibolite facies. Granitoids of H.H.C in Upper Kaghan valley are mainly concordat with the regional structure md are deformed along with enclosing metasediments and associated amphibolites with minor discordance and interfingering. The geochemical analysis for major and trace elements of twenty three samples of the H.H granites has been carried out with the aim of their geochemical characterization and determining their origin. Colour index ranges from leuco to mesocratic. Analyses are plotted on various diagrams and plots including variation diagram for major/trace elements, major/minor elements, triangular diagrams, discrimination diagrams, trace element spidergrams and indexes & ratios are determined for complete overview of the granites of the Upper Kaghan valley. The analyses confirm that these granites are peraluminous, S-type, and plot in within plate granite and calc-granite field. Fractionation ratios suggest fractional crystallization.
Key words: Geochemistry, granites, Upper Kaghan.

A/45. Abetti, G. & Alessio, A., 1929. Geofisica, Gravita e Magnetismo. In: Spedizione Italiana De Filippi Nell'Himalaya, Caracorum e Turkestan Cinese (1913-1914), ser. I, Vol. II, Geodesia e Geofisica-Zanichelli, Bologna, 1-222.

This is an account of the geophysical surveys (gravity and magnetism) carried out by the de Filippi Italian Expedition to the Himalaya, Karakoram, and Chinese Turkistan in 1913-1914. Further information is not available to the authors.
Key words: Geophysics, Gravity, Magnetism, Karakoram, Himalaya.
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A/46. Abetti, G., Alessio, A., Antilli, C., et al., 1929. Astronomia geodetica, geodesia e topografia. In: Spedizione Italiana De Filippi Nell'Himalaya, Caracorum e Turkestan Cinese (1913-1914), 1 (1), Geodesia e Geofisica-Zanichelli, Bologna, 1-418.

This is a report of the De Filippi Italian Expedition to the Himalaya, Karakoram, and Chinese Turkistan in 1913-1914. It concerns geodetic data and topography. Further information is not available to the authors.
Key words: Italian expedition, geodesy, Karakoram, Himalaya.

A/47. Abers, G., Bryan, C., Roecker, S., & McCaffrey, R., 1988. Thrusting of the Hindu Kush over the southeastern Tadjik basin, Afghanistan: Evidence from two large earthquakes. Tectonics, 7, 41–52.

We infer from the mechanisms and depths of two large earthquakes that the Hindu Kush is actively thrusting northwest over the Tadjik basin and that the basin is closing rather than being displaced to the west. Teleseismic body waves were used to determine focal mechanisms and depths for the two largest shallow earthquakes on the southern edge of the basin. The two earthquakes, on June 24, 1972 (mb=6.0), and December 16, 1982 (mb=6.2),

have seismic moments of 2 × 1018 N-m and 6 × 1018 N-m, respectively. Focal mechanisms of both events indicate almost pure thrust faulting with nodal planes striking northeast-southwest. The inferred fault planes dip southeast, at 20° for the first event and 50° for the second. The P axes for both events are oblique to the direction of relative motion between India and Asia, suggesting that the Pamir is overthrusting the basin to the west. Depths for both earthquakes are between 20 and 25 km and place them well below the Tadjik basin sediments. The depths and steep fault planes suggest that these earthquakes represent a down dip extension within the basement of shallow folding and thrusting seen in the sediments northwest of the events. Thus convergence in Afghanistan between India and Eurasia is taken up along southeast dipping thrust faults north of the Hindu Kush as well as by northward subduction under the southern part of the range.
Key words: Tectonics, earthquake, Hindukush, Afghanistan.

A/48. Abid, I.A. & Abbasi, I.A., 1983. Stratigraphy, petrography and statistical studies of Siwalik group, Surghar Range, Kohat, N.W.F.P. M.Sc. Thesis, University of Peshawar, 128p.

The late orogenic sediments i.e. Siwalik molasses of post Eocene age, exposed along the western limb of Makarwal Anticline (Surghar Range) are objective of this report. Brief petrographic and statistical studies are carried out to determine characteristics of sandstone to establish a possible provenance. Sandstone comprises of quartz, feldspar mica, calcite, hornblend, rock fragments, and minor amount of epidote, garnet, zircon, apatite chlorite, and ore. Kyanite, staurolite, sphene, orthopyroxene and rutile are the other rare minerals. According to the scheme of Folk (1958) the sandstones are lithic arkose to feldspathic litharenite. From bottom to top feldspar, rock fragments and medium to high grade metamorphic minerals increase while calcite decreases. It may indicate unroofing of granite, granodiorite, and medium to high grade metamorphic belts with the passage of time.
Sieve analyses of 40 samples indicate that dominant clastic fraction is medium to fine (0.25 to 0.125 mm), moderately sorted, positively skewed and steeply peaked. Average values of various statistical measures obtained are

Sorting	skewness	kurtosis	Mean
0.90	0.70	0.86	2.37

All the parameters plotted graphically show that there is a zig-zag pattern rather than a vertical one, which suggests a cyclic repetition of the size factor.
Stratigraphic sections measured at two localities are analysed in term of fluvial stratigraphy. The stratigraphy indicates a fluvial system of laterally migrating stream, leaving behind fining upward cycles of lateral and vertical accretion deposits. The origin of uranium mineralization is not clear. It may be either due to mechanical concentration in old paleochannels (O.W.Chase, 1976) or by perculation of mineralized solution through impervious beds (M.Masoor et. al., 1980)
Key words: Siwaliks, Stratigraphy, Petrography, Kohat.

A/49. Abid, I.A. & Abbasi, I.A., 1984. Preliminary petrography of the Hangu Sandstone, Hangu, Kohat. Geological Bulletin, University of Peshawar 17, 109-112.

The quartzitic sandstone of the Hangu formation is mature both texturally and mineralogically. The detritus is diagenetically cemented by secondary silica giving rise to interlocking texture. The petrography and stratigraphic position of the sandstone suggests shallow marine environments of deposition where feldspar, lithic fragments and other softer material were completely destroyed as a result of repeated winnowing by long shore currents, while quartz and a resistant suite of heavy minerals were retained.
Key words: Petrography, Sand Stone, Hangu, Kohat.

A/50. Abid, I.A., Abbasi, I.A., Khan, M.A. & Shah, M.T., 1983. Petrography and geochemistry of the Siwalik sandstone and its relationship to the Himalayan orogeny. Geological Bulletin, University of Peshawar 16, 65-83.

The Siwalik molasse of post Eocene age, exposed along the western limb of the Makarwal Anticline (Surghar Range), has direct relationship with uplifting episodes of the Himalayan Mountains present to their north. Detailed petrography of the sandstones together with chemical analyses of a few selected samples indicate varied mineral

assemblages and major oxide proportions for Lower, Middle and Upper Siwalik. Thus the Siwalik molasse, which is hitherto classified on the basis of sandstone and shale proportions and the variations in their color, may also be divided into different units on the basis of mineral assemblages and major oxide geochemistry, or at least these aspects can be used for subsurface correlation in limited domains of the Siwalik belt.
Regarding the source rocks, carbonates were major contributor along with other rocks during the deposition of the Lower Siwalik. The presence of igneous and metamorphic rock fragments along with medium to high-grade metamorphic minerals suggest crystalline rocks as the source of the Middle Siwalik. Such a mineral assemblage has also been reported from the Middle Siwalik of India, indicating unroofing of crystallines on a regional scale in the source area. Common occurrence of zircon in the Middle Siwalik seems to have some relationship with recently reported radioactive mineralization. The Upper Siwalik seems to have been derived from the foredeep sediments (Lower and Middle Siwalik), which were involved in the southward prograding orogenic activity by the Pleistocene period.
Key words: Petrography, Geochemistry, Sandstone, Siwalik Molasse.

A/51. Abid, M.S., 1975. Evaluation of geothermal resources in Pakistan. In: World energy crisis and its implications with particular reference to developing countries. World Energy Symposium, Nov. 1975, Karachi, 1-7.

This paper gives an evaluation of geothermal resources of the country, including hotsprings of northern Pakistan.
Key words: Energy (geothermal).

A/52. Abid, M.S., & Farid, A., 1995. Cambrian rocks in Pakistan: Distribution and petroleum possibilities. In: Abstract volume, Dissanayake, C. B., Almond, D. C., and Cooray, P.G. (Eds.). Second South Asia Geological Congress, (GEOSAS-II), Colombo, Sri Lanka, p.229.

This a general account of the occurrence of the Cambrian rocks of Pakistan, including those of the Salt Range and Himalayan fold-and-thrust belt.
Key words: Cambrian, Attock-Cherat, Hazara.

A/53. Abubakr, M., 1965. Geology of parts of Trans-Himalayan region in Gilgit and Baltistan, West Pakistan. Geological Survey of Pakistan records, 11 (3).

Reconnaissance geological mapping at a scale 1 inch to 4 miles was carried out in the Trans-Himalayan region of Gilgit and Baltistan. The region contains three major mountain ranges, namely, the Kailas Range, the Karakoram Range, and the Hinduraj Range. They are arcuate and parallel to each other with convexity northward. The region is underlain by a sequence of metasedimentary and sedimentary rocks, and several types and ages of igneous rocks. Metasedimentary and sedimentary sequence includes slate, quartzite, limestone, and gneiss of Permo-Carboniferous age. They are intruded or intercalated by a group of rocks called Greenstone complex. All these rocks have been intruded by granodiorite and hornblende which are probably of Tertiary age. The salient structural features are the swinging of the strikes of rocks sequence on that of ranges; and isoclinal folding of the Permo-carboniferous rocks, in places, tending to recumbent folds. This swinging g nature can be explained as due to the bending of all rock components around the syntaxis of the northwest Himalayas. Metamorphism of the Greenstone complex and carboniferous rocks is widespread.
Key words: Reconnaissance, Mapping, Transe-Himalaya, Gilgit, Baltistan.

A/54. Abubakr, 1986. On a collection of Siwalik Carnivora. Biological Society of Pakistan, Monograph 11, 1-64.

Key words: Paleontology, Siwalik Molasse.

A/55. Achache, J., Courtillot, V. & Besse, J., 1983. Paleomagnetic constraints on the late Cretaceous and Cenozoic tectonics of Southeast Asia. Earth and Planetary Science letters 63, 123-136.

Many features of the Cenozoic tectonic history of central and southeastern Asia can be understood as direct consequences of the thrust and penetration of India into Asia. Recent indentation experiments with plasticine (Tapponnier et al.) have extended this idea and have led to the prediction of a pattern of large rotations and displacements of continental blocks that can be tested by paleomagnetism. The available Cretaceous and Cenozoic paleomagnetic data from this part of the world have been reviewed and a new APWP for Eurasia has been constructed for reference. The negligible rotation of South China and large clockwise rotation of Indochina are consistent with the model, i.e., with a history of large-scale left-lateral strike-slip motion along the Altyn Tagh and Red River faults. Data from Malaya and Borneo can be reconciled with the model, although in a less straightforward fashion. The large counter clockwise rotation of South Tibet implies that it rotated in sympathy with India during the collision and suggests that future indentation experiments should include this feature. Finally a middle Cretaceous reconstruction of the south margin of Asia is proposed. One interesting result is the restored continuity of geological features in Tibet and Indochina, with active subduction of oceanic (Indian plate) crust taking place to the south at subtropical latitudes.
Key words: Paleomagnetism, Tectonics, Southeast Asia.

A/56. Afrasiabin, A., 1970. Geological report on Abbottabad and Dunga Gali, Hazara. M.Sc. Thesis, Punjab University, 45p.

This report, as part of the M.Sc. thesis, describes the geology of the Abbottabad-Dunga Gali section. The area is covered by various types of sedimentary rocks ranging from Paleozoic to Tertiary.
Key words: Stratigraphy, Abbottabad, Hazara.

A/57. Afridi, A.G., 1992. Lithogeochemical studies of the Chitral area, Hindukush Range, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, 1-2.

Lithogeochemical studies were carried out in the Chitral area, Pakistan to delineate the potential gold mineralization. The Chitral area lies in the central part of the Hindu Kush Mountains, which constitute the northwestern extension of the greater Himalayas. The area is underlain by a wide variety of metamorphic and sedimentary rocks, which are intruded by granites, pegmatites, quartz veins, and basic dikes.
One hundred and twenty samples of a variety of rocks were analyzed for Au, Ag, As. Sb, Cu, Mo, Pb, Zn, K, Rb, and TI. The concentration of the trace elements is generally low in most of the rocks with the exception of altered carbonates and some quartz veins associated with granites and slates. The altered carbonate rocks have a significantly high concentration of Au, Pg, As, Sb, Cu, Mo, Pb, Zn, Ti. Several samples contain up to 1 ppm Au and more than 1% As. Some of the quartz veins in granitic rocks and in slates contain high contents of Au, Ag, As, Sb, and TI, but the enrichment of these elements is not high enough to mine them profitabily. A high grade vein sample containing boulangerite, however, contains extremely high enough concentrations of Au (30 ppm) and (1350 ppm). Thallium is significantly higher in hydrothermally altered carbonate rocks compared to the unaltered rocks. The enrichment of Ti over K and Rb in hydrothermally altered rocks is demonstrated in Ti-K-Rb ternary diagram. The mineralized rocks fall close to the TI apex, and the unmineralized rock samples plot near the K apex.
The abundance of Ag. As, Sb, Cu, Mo, Pb, and Zn in altered carbonate rocks is more or less similar to the sediments hosted good deposits of western United States. The enrichment of Au and Ti, however, is not as high as in some of these deposits. The preliminary study suggests that Chitral area probably contains economically important gold deposits. Detailed lithogeochemical and pedogeochemical surveys of certain areas may prove to be useful in locating sediment hosted gold deposits.
Key words: Geochemistry, Hindukush, Chitral.

A/58. Afridi, A.G., Iqbal, S. & Khan, S., 1995. Shangla. US Geological Survey, Geological Map Series 1106, old sheet no. 59 (43 B/9, 1:50000).

Consult the following account for further details.
Key words: Indus Suture, Kohistan Arc, amphibolites, mélange, Shangla, Swat.

A/59. Afridi, A.G., Khan, R.N., Shah, H. & Walliullah, 1995. Charbagh. US Geological Survey, Geological Map Series 1072, old sheet no. 58(43 B/5, 1:50000).

This map and the following show the geology of the Indus Suture zone. The southern part of the area is occupied by the southern Amphibolite belt of the Kohistan Arc. The northern part, Shangla area, is occupied by a tectonic mélange containing ultramafic blocks and blue schists in a sedimentary mélange.
Key words: Indus Suture, Kohistan Arc, Amphibolites, Mélange, Charbagh, Swat.

A/60. Afridi, A.G.K., 1986. Barite deposits of North West Frontier Province, Pakistan. Geological Survey of Pakistan, Information Release 134, 35p.

Key words: Mineral Deposits, barite, NWFP.

A/61. Afridi, A.G.K., Shah, H. & Rahim, S., 1980. Magnetite occurrences in the Kohistan Area, Hazara Division, NWFP, Pakistan. GSP. Information Release 124, 20p.

Minor lenses of magnetite occurs in a complex metamorphic belt in the Kohistan region of the North West Frontier Province, Pakistan. Preliminary field studies carried out by the Geological Survey of Pakistan during 1977-79 have shown that all the known magnetite bodies are of limited extent and show considerable variation in mineralogical content and chemical composition. Reserves of individual lenses do not exceed a few tens of thousand tonnes in each case and the total iron content of an average ore sample is always less than 50 percent. As such these occurrences are not considered to be of economic significance for the foreseeable future.
The small scale mineralization of magnetite in the investigated area owes its origin to partial metasomatic replacement of the erratically distributed marble/ crystalline limestone lenses in the Paleozoic (?) schistose group, in contact with the latter granite.
Key words: Magnetite, Kohistan, Hazara.

A/62. Afridi, A.G.K., Khan, R.N. & Shah, H., 1983. Regional geology of Mingora and Charbagh Quadrangle, NWFP, Pakistan, with the geological map on 1:50,000 Scale. GSP Information Release 132.

This paper, with a nicely produced geological map, covers the rock assemblages on the two sides of the Indus suture. The southern part is represented by metamorphic rocks and granitoids of the Indian plate, and the northern by metabasites of the Kohistan arc. The suture mélange occurs as a sandwich between the two.
Key words: Regional geology, geological map, Mingora, Swat.

A/63. Afridi, A.Z.K., Anwar, J., & Hashmat, S.M., 1976. Fluorite deposits of Chakdara area, District Dir: Internal report of the Pakistan Mineral development Corporation, 57pp.

The flourite deposits of Chakdara area in Dir District are found near the villages of Chatpat and Tsapparuna. Both the occurrences are about 4 miles apart. Chemical tests of both the deposits have classified them as of metallurgical grade. The Chatpat deposit is of better quality and colour. The flourite mineralization at Chatpat is occurring in the form of thin multiple veins in granitic gneiss. Major zone of mineralization is 30 to 38 feet thick and 60 to 80 feet long. The flourite veins which range in thickness from 1/8th of an inch to 4-1/2 feet, and are distributed alternatively with barren granitic gneiss. Some minor dissemination of flourite is also observed in the intervening gneiss layers. Pinching and swelling is typical character of these lenticular flourite deposits. Chemical analysis revealed ln a xinuln content of 51.3% CaO and 33.9% F. The flourite deposits of Tsapparuna also occur in gneissic rocks which are northeastern extension of the Chatpat outcrops. Three main flourite veins have been located in Tsapparuna area, which strictly follow the foliation joints. The veins range in thickness from 6 inches to 11 -1/2 inches. The flourite in

this area is violet to dark violet in colour and is associated with quartz. Chemical analyses indicate 51.2% to 44.9% CaO and 33.7% to 29.2% F. Lead, Vanadium, Titanium, Molybdenum and strontium' have also been found in Chatpat deposit. The reserves assessment has revealed that the proved reserves are 3544 tonnes whereas inferred reserves are about 7552 tonnes.
Key words: Mineral deposits, flourite, Chakdara, Dir.

A/64. Afridi, M.I., Badshah, M.S. & Ihsanullah, M., 1991. Copper occurrence in Waziristan. Proceedings First SEGMITE Symposium, Peshawar, Pakistan, March 1991, 70–73.

The geology of the Shinkai area, North Waziristan is described, with a help of a geological map. Copper mineralization exists in the form of stock works, stringers, and cavity/vesical/void fillings, and as dissemination of primary sulphides including pyrite, chalcopyrite and bornite associated with hypogene secondary sulphides and oxides of iron and copper including malachite, azurite, cuprite, tenorite, limonite, jerosite and goethite etc. the copper is of volcanogentic and syngenetic origin. The deposits are genetically similar to Cyprus type. Average copper content is about 0.386 %.
Key words: Copper Mineralization, Waziristan.

A/65. Afzaal, P.A., Din, N., Rashid, C.M. & Majid, A.A., 1995. Influence of basement Tectonic on the structural trends of Himalayas, A case study in Potwar Plateau. Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich), Switzerland.

Potwar Plateau (PP) of Pakistan lies in the western Sub-Himalayan tectonic zone and is bounded (a) to the north and south by north dipping Main Boundary Thrust (MBT) and Salt Range Thrust (SRT) respectively (b) to the east and west by Jhelum and Kalabagh wrench faults with associated syntaxial bends respectively (Fig. 1). These bounding structures are different from one another in timing, intensity and causes of deformation, structural styles and their impact on the tectonics of PP.
The present tectonic setting of PP has resulted from the northward underthrusting of Indian Plate under its own sedimentary cover. Major structures of the Sub-Himalayas are the result of reactivation of the preexisting tectonic features of the Indian Shield, in Neogene time, due to flexural bending caused by loading of the basement from southward advancing thrust sheets. The tectonics of the Pre-Cambrian crystalline basement has largely controlled the structural styles of PP in particular and higher Himalayan Ranges in general. The controlling factors are;

i. Pre-Himalayan tectonic features/directions of the Basement.
ii. Dip of the Basement.
iii. Grain of the Basement.
iv. Segmentation of the Basement resulting from partial docking with Afghan Plate in the north-west.

There are two main tectonic directions, i.e. NW & NE in the Indian Shield rocks exposed at Kirana Hills (surface expression of Sargodha Basement High) and Aravalli Ranges. These directions are reflected in the major tectonic trends of the PP and higher Himalayan Ranges (Fig. 2). In PP, east of 73º - O' Longitude the major structures like Riwat, Adhi-Ghungrilla, Pamal - Domeli, Rohtas and seismically interpreted basement offsets are aligned in a NE-SW direction. West of 73º Longitude the Kallar Kahar fault with its inferred extension, Kalabagh fault, Dhadumbur anticline, Joyamair structure show a NW-SE trend.
Internally PP can be divided into 3 parts on the basis of intensity, type and trend of deformation. These are (i) North Potwar Deformed Zone (NPDZ) (ii) East PP (iii) Southwest PP.
NPDZ represents severest and oldest phase of deformation within PP. It is marked by imbricate stack of thrust faults, tight isoclinal folding, vertical dips and thrust bound ridges. The Eastern PP is characterized by NE-SW trending tight anticlines and intervening broad synclines. In southwest PP there are a series of gentle folds, incipient in nature. A variation in dip of the basement is responsible for the difference in structural style and frequency of structures from east to west of the PP. In the eastern PP dip is <1º, so the structures in eastern PP are viewed as response to a too narrowly tapered wedge in order to increase the taper. In southwestern PP higher dip of the basement i.e. 3.6º allow the thrust sheet to slide without undergoing internal deformation. In NPDZ inspite of higher dip of the basement (3.6º) the area is strongly deformed. This zone is probably an allochthonous block, thrusted southwards to its present position.
Seismic data across PP show presence of north facing basement normal faults, some of which have been noted to exist beneath the Chak Beli Khan, Chak Naurang, Qazian and south of Bhaun structures. These faults were pre-

existing weaker zones, reactivated due to loading of the basement, and influenced the deformation of east PP. Fault propagation folds in this area are produced by the movement on these faults. Similarly ramping of eastern Salt Range has been controlled by the basement normal fault south of Bhaun.

Many areas of the PP show evidence of counter clockwise rotation which was more intense in SE PP (maximum 35º) and did not occur simultaneously in all parts of the PP. This indicate the segmented nature of the basement. Taking the example of south PP where data shows differential rotation, both in time and space, of south-east, south-central and south-west PP. These blocks are separated from each other by Domeli -Diljabba and Kallar Kahar faults. The two faults are aligned in NE and NW direction respectively, which are the main tectonic directions of Indian Shield and Himalayas. These faults are interpreted as the surface expressions of deep seated basement fractures which have divided the south PP into three segments each showing differential rotation due to tectonic movement along Jhelum fault, Salt Range Thrust (SRT) and Hazara Kashmir Syntaxis (HKS). East of 730 Longitude, magnitude of SRT appear to diminish near Jalalpur. This is due to the transfer of deformation from SRT to NE-SW trending Domeli - Diljabba thrust which is the resultant of basement fault at Qazian - Bhubar structure. The Domeli-Dabba thrust ultimately merges into Jhelum fault.

The north-south trending left lateral Jhelum fault has been a long lived active feature of the Indian Shield. Synsedimentary movement on this fault may have affected the Siwalik sedimentation and later movement have cause the counter clockwise rotation in east PP. The structures in east PP were originally formed in E-W direction due to movement on the basement normal faults, and rotation have changed their direction to NE-SW. Formation of HKS is due to movement on Jhelum fault and thrusting along MBT and SRT.

Kalabagh right lateral fault is also a basement fault affecting the formation of Kalabagh Syntaxis (KS), which is considered as northwestern spur of Sargodha basement high.

Finally it is concluded that the tectonic features of the Indian shield have been duplicated in the deformation of cover rocks of the Himalayas. The basement normal/reverse faults have been reactivated to cause major thrusting, while the movement on the wrench faults due to segmentation of the Indian Plate, have produced various syntaxial bends.

Key words: Tectonics, structure, Potwar plateau, Himalaya.

A/66. Afzal, M.S., 1983-85. Geology and tectonics of Burawai Area, Upper Kaghan valley, District Mansehra, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 125p.

Nearly 114 sq. km. in the vicinity of Burawai, upper Kaghan valley has been geologically mapped, at the first time. This thesis presents first time accounts of geomorphology, lithostratigraphy, petrography and economic geology of the area. The area constitutes rocks representing old Indo-Pak basement rocks, comprising pelites, calc-pelites and marbles have been metamorphosed to kyanite and sillimanite grades. These are intruded by para-autochthonous sheet granites also metamorphosed.

Major structure comprises an open synform possibly part of a larger structural basin. The western part comprises the nose of a larger antiform.

Marble, biotite mica and kyanite are important mineral deposits which deem further exploration and evaluation. This thesis also includes petrogenesis of the rock units as well as numerous sketch sections and photographs, illustrating the geology of the area.

Key words: Tectonics, geology, geomorphology, Kaghan valley, Mansehra.

A/67. Afzal, S., 1990-92. Geological study for petrography and geology of Atia Qala (District Swat). M.Sc. Thesis, Punjab University, Lahore, 57p.

Rocks of Atia Qala (Distt. Swat) are part of metamorphic hornblend complex. The area lies within the southern portion of Swat. These rocks are probably the extentions of rocks of Dir in the form of a belt running approximately in East-West direction. The area given for field work comprises thirty kilometers in the North-West of Mangora. The area mainly comprises the main rock units are Norite, Diorite, Quartz-O-Feldspar and Pegamatite veins. But at some places patches of Amphibolite are also found but can be considered negligible. As the field evidences, and the laboratory study shows that the Diorite and Norite were formed from basic magma, which have under gone regional metamorphism under the intense orogenic conditions.

Quartz-O-Feldspathic and pegmatite veins are extensively distributed all over the area, indicating the evidence of Diorite magma. Major minerals are Plagioclase, Hornblend, Epidote and Quartz with accessories as Sphene and Magnetite. These are products of regionally metamorphosed igneous rocks.

Key words: Petrography, Geology, Swat.

A/68. Ahmad, A., 1976. The classification of hazard zones in Pakistan. Proceedings, CENTO Symposium on Earth Quake Engineering, 186-196.

Abstract not available to the authors.
Key words: Earthquake, Hazards.

A/69. Ahmad, A., 1961. Olcastephanus Astriecrianus newly recorded from Hazara. Punjab University, Geological Bulletin 1, 65-66.

Key words: Fossils, Hazara.

A/70. Ahmad, A., 1962. Waagen and Wynnes 'Triassic' of the Hazara Mountains. Punjab University Geological Bulletin 2, 52-53.

Assignment of a Triassic age to a section in the Hazara mountains (Pakistan) was based on fossils which could not be found during later field studies. Fossils that were found, however, have been identified by the British Museum as forms ranging from Oxfordian (Jurassic) to upper Cretaceous. A Jurassic age is suggested for the section in question.
Key words: Triassic, Hazara.

A/71. Ahmad, A., 1979-81. Detailed mapping, petrology and structure of Gulpato-Banda Saoni area, Tehsil Kohistan, District Dir, NWFP. M.Sc. Thesis, Punjab University, Lahore, 78p.

Gulpato banda-Saoni area is a part of Hindu Kush range. The total investigated area is about 30 miles^2. The rocks in the area are composed of metasedimentary complexes with igneous intrusions. The main units in the area are calcareous quartzite, chlorite schist and biotite schist.
It is believed that chlorite schist and biotite schistose are the product of regional metamorphism on argillaceous and calcareous rocks. The contact of calcareous quartzites with schist is gradational. After this the granodiorite magma intruded in the area. In the second phase the intrusion on the magma was siliceous and of granitic composition. It formed small patch schist.
There are extensive quartzo-feldspathic and pegmatitic veins and dykes in granodiorite and schist indicating late residuals of granodiorite magma.
Fossils of larger foraminifera (Assilina, Nummulites, and Alveolina) were collected in calcareous quartzites. They are of lower Eocene age.
Key words: Petrology, maps, Structure, Kohistan, Dir.

A/72. Ahmad, A., 1982-84. Geology and petrotectonic study of Shino-Kaghan-Batal Area, Kaghan valley District Mansehra, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 40p.

Further data for this account was not available to the authors.
Key Words: Petrology, Tectonics, Kaghan, Mansehra.

A/73. Ahmad, A., 2000. Thermal maturity modeling of Kohat-Potwar Basin, Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.1.

One - dimensional maturity modeling of three wells, Tolanj-1, Meyal-10 and Pandori-1 was carried out. All available geological, geochemical and geophysical concepts and data were integrated for making this model. Using this model, the timing and amount of hydrocarbons generated from different potential source rocks were evaluated. Vitrinite reflectance measurements of whole of the stratigraphic sequences in Tolanj-1 and Pandori-1 were carried out and used for maturity modeling, while for Meyal-10 only 2 measurements of Jurassic Formations were used. Results of maturity modeling of individual wells and their correlation with other wells indicate that maturity

increases from East and southeast to West and northwest. Salt Range Formation is not mature in eastern Potwar (Khewra gorge) and lies in gas window in central Potwar (Meyal-lo), and is late mature for gas in Kohat (Tolanj-1) area. The time of hydrocarbon generation is also different at different locations e.g., Salt Range Formation was in the peak oil generation phase in middle Eocene time in Tolanj-1 (Kohat area) and it reached at this stage in Late Miocene in Meyal-10 (central Potwar).
Key words: Thermal Modelling, Hydrocarbons, Kohat-Potwar basin.

A/74. Ahmad, A., Jamal, T., Yusaf, S. & Younis, R., 1986. Geology and structure of a part of Kohat Quadrangle, Kohat. M.Sc. Thesis, University of Peshawar, 54p.

The present work describes the stratigraphy and structure of a part of Kohat Quadrangle bounded by lat. 33. 15. 33. 25 N and long 71. 30. 71. 40 E. This part lies in the western corner of Pakistan Survey topographic sheet No. 38-O/11.
The area under investigation is composed of sedimentary rocks ranging in the age from Early Eocene to Pliocene.
The Fol1owing formations are exposed in the mapped area.
(8) Dhok Pathan Formation ..... Middle Pliocene.
(7) Nayri Formation . . . . . Early Pliocene.
(6) Chinji Formation of Siwalik group . . . . . Late Miocene
. .. .. Late Tortonian age.
(5) Kamlial Formation ..... Middle Late Miocene.
(4) Murree Formation of Rawalpindi group . . . . . Miocene.
(3) Kohat Formation . . . . . Eocene.
(2) Kuldana Formation..... Early-Early Middle Eocene.
(1) Jatta Gypsum . . . . . Early Eocene.
The area shows moderate folding and faulting, the folds are mostly open. The faults reveal the significant movement that has taken place on the regional scale. Folds are moderately plunging East or West. The limestone is highly effected by weathering and fracturing. Doubly plunging nature of folds, fracturing and downward slipping of mass of rock or unconsolidated material of any size of limestone are the direct result of the plastic behavior of the gypsum.
Structurally the area under investigation is suitable for Oil and Gas accumulation. It has potential for non-metallic minerals i.e. limestone, common salt and gypsum.
Key words: Stratigraphy, Structure, Kohat.

A/75. Ahmad, A.K., 1884. Account of Dardistan with map of the country surveyed during 1882-83 in connection with Trignometrical Branch. Survey of India, Dehra Dun.

Key words: Mapping, Dardistan, Baltistan.

A/76. Ahmad, C.R., 1975. Geology and petrology of Battal Baleja and Sathangali area of Mansehra district, Hazara Division. M.Sc. Thesis, Punjab University, Lahore.

Key words: Petrology, Mansehra, Hazara.

A/77. Ahmad, D., 1995. Tectonics analyses of the southern Kohat plateau, NWFP, Pakistan. M.Phil. Thesis, University of Peshawar, 52p.

The studied area constitutes part of the southern Kohat plateau and exposes a suit of sedimentary rocks which includes evaporates, shelf sediments and a thick sequence of mollase sediments. The rocks in the area belong to the Eocene age and consists of Panoba shale, Bahaderkhel salt and Jatta Gypsum, followed by Kuldana and Kohat Formation. These units are overlain by mollase sediments of Miocene to Pleistocene age which comprises Kamlial Formation of Rawalpindi group overlain by the complete stratigraphic sequence of the Siwalik group.
The studies area constitutes the western half of the southern structural boundary of the Kohat Plateau, herein named as “Kohat Plateau Boundary Zone”. It is about 120 km long with width ranging from 5-10 km and trends east-west. The studies area is characterized by the large scale east-west trending open, synclinal and tight anticlinal trends.

These compressional structures are superimposed by a Plio-Pleistocene phase of strike-slip deformation. This deformation is displayed on the surface of the formation of two large scale strike-slip faults with apparent dip-slip movements. The Zarwam fault is the northern most structural discontinuity and is believed to be a strike-slip fault with left lateral movement. The bannu-surgad fault lies south of Zarwam faulty and is also characterized by strike-slip movement with the sense of movement being right lateral. Both these faults are Rheidal shears which eminates from the Kurram fault.
Key words: Tectonics, Stratigraphy, Kohat Plateau, Siwaliks.

A/78. Ahmad, E., 1960. The Indus - a study in river geography. Geoprapher 8 (Aligarh).

Further information not available to the authors.
Key words: Geography, Indus.

A/79. Ahmad, F., 1996. Evolution and changes in Indus River system. Programme and Abstracts, 8th All Pakistan Geographic Conference, Peshawar, 7-10 April, p.22.

Key words: Evolution, Geomorphology, Indus River.

A/80. Ahmad, H.A., 1987-89. Geology, petrography and structure of Harno Area District, Abbottabad. M.Sc. Thesis, Punjab University, Lahore, 247p.

Further information not available to the authors.
Key words: Petrography, Structure, Abbottabad.

A/81. Ahmad, H.I., 1971. Geology and petrology of the area on right bank of Tarbela Dam. M.Sc. Thesis, Punjab University, 90p.

Further information is not available to the authors.
Key words: Petrology, Tarbela Dam.

A/82. Ahmad, H.M., Javed, A., Javed, A. & Parvaiz, M., 1976. Mineralogy, petrology and economic geology with emphasis on ore mineral deposits of Lahor Pazzang area, Swat–Kohistan. M.Sc. Thesis, Punjab University, Lahore.

Key words: Mineralogy, petrology, ore minerals, Swat-Kohistan.

A/83. Ahmad, I., 1980. Petrography of Ambela Syenite, Buner Area. M.Sc. Thesis, University of Peshawar, 44p.

This work presents petrographic details of a part of the Ambela Syenite, occupying 12 sq. miles of area in the Bunair. The rocks of the thesis area, occupy north central portion of the Ambela complex, which is considered to be a part of the Peshawar Palin Alkaline Igneous province.
The intrusive rocks of this area comprises dominantly of alkali quartz Syenite with subordinate occurrence of quartz syenite and granite. Texturally the alkali quartz syenites are coarse-grained, hypidiomorphic and sub-inequigranular. Major primary minerals of these rocks are alkali feldspar, quartz and plagioclase, with varying proportions of biotite, sphene, apatite, zircon, muscovite and opaque minerals. Epidote and chlorite are rarely found as secondary minerals.
Key words: Petrography, Ambela complex, Buner.

A/84. Ahmad, I., 1986. Petrochemistry of the Shewa Shahbazgarhi Complex, Mardan. M.Phil. Thesis, University of Peshawar, 130p.

The Shewa-Shahbazgarhi complex is an isolated triangular outcrop, occurring about 12 krn north- east of Mardan. The complex consists of acidic rocks, intruded by basic rocks such as metagabbro, metadolerite and local quartz monzonite dykes and sills, The acidic rocks, in order of decreasing relative ages, are microporphyry, porphyritic granite, riebeckite gneiss and aegirine riebeckite porphyry.

The common minerals in basic rocks include hastingsite, clinopyroxene, orthopyroxene (in meta-dolerite), magnetite, biotite, epidote, apatite and leucoxene. The acidic rocks contain perthisized orthoclase, orthoclase, perthite, plagioclase, with riebzckite and aegirine as the common ferromagnesian minerals, (Specially in riebeckite porphyry) and the presence of the alkali amphibole and alkali pyroxene is indicative of their alkaline character, Chemical analyses of the amphibole grains obtained with electron probe closely correspond to riebeckite composition. The rocks show considerable degree of deformation and alteration (cataclasis and/or mylonitization). Two types of metamorphism (a) an amphibolite facies metamorphism and (b) retrogressive epidote amphibolite facies metamorphism has been

Noticed. Assessment of the chemical data on conventional two dimension plots and CMAS model, suggest the control of fractional crystallization over the major and trace element distribution in both the rock types, Fractional control of olivine, clinopyroxene and plagioclase is conspicuous in the basic rocks and plagioclase fractionation in the acidic rocks. Major and trace element data suggest that the basic and the acidic rocks are not comagmatic. These are derivative from two different parent liquids. A magma of subalkaline character is proposed for the basic rocks and alkaline to peralkaline for the acidic rocks, both, however, being emplaced in continental rift environments. A rift valley origin is proposed for the complex with the generation of felsic magma, probably as the result of partial melting in the lower crust. The rocks so formed were later intruded by basic dykes of continental flood basalt type.

Key words: Geochemistry, Shewa-Shahbazgarhi, Mardan.

A/85. Ahmad, I., 1987. Geology of Jowar area, Karakar Pass, Swat District, N.W.F.P., Pakistan. M.Phil. Thesis, University of Peshawar, 144p.

The Jowar area, Karakar pass in the Swat District marks the northern edge of the Indo-Pakistan plate. It is predominantly composed of highly deformed and metamorphosed, Precambrian to Cambrian granitic rocks and Paleozoic metasediments. The granitic rocks are distinguished into augen gneisses and tourmaline granites, each belonging to distinct chemical variety. The matasediments are grouped into Alpurai schist, and Nikanai Ghar marble, which are separated by the "Nikanai Ghar Fault".

Both the granitic rocks and the metasediments have undergone at least two phases of deformation and metamorphism. The first phase of deformation (D1) and the associated metamorphism (Mi) produced regional foliation (Sl), mineral lineation (L1) and small scale, tight to isoclinal folds (F1), throughout the Lower Swat-Buner region. During MI, the rocks are regionally metamorphosed, and the Hbl+Plag+Gt assemblages in amphibolites suggest an almandine-amphibolite facies metamorphism. The second phase of deformation (D2) is associated with retrograde metamorphism (M2), and folded S1 into mesocopic to macroscopic scale F2 folds. It also produced crenulation lineation (L2), and locally S2 foliations.

Regional studies in the Lower Swat-Buner region suggest that the Alpurai schist and Granitic rocks formed a large recumbent fold, due to which the stratigraphic sequence in the study area is upside down. The geochemical study suggest that the amphibolite from study area are derivative from a basic igneous parent of continental tholeiitic affinity.

Key words: Geology, Karakar pass, Swat.

A/86. Ahmad, I., 1999. Structure and metamorphism south of the Malakand and adjoining area, North Pakistan. Ph.D. Thesis, University of Peshawar, 151p.

Detailed field, structure and petrographic data show that the stratigraphy in Swat extends into the northern fringe of the Peshawar basin. Two major faults, the Kishora thrust and a back thrust, dominate the structure of the studied area. The Kishora thrust divides the area into two tectonic terranes, the Indus mélanges, and the Indian shelf terrane. Located within the latter, the back thrust brings higher-grade almandine zone rocks in contact with low-grade chlorite zone rocks near Bar Bazdara and Zormandai villages.

Four deformation phases, Dl, D2, D3, and D4 are recorded from north to south, each characterized by distinct fabric and folding. In the north Domains 1 and 2, Dl formed S1. The earliest recognizable fabric S1 occurs as relict intrafolial in the S2 fabric, pressure shadows and porphyroblasts. No macroscopic folding event related to S1 has been recognized. This event occurred under greenschist facies metamorphism. During D2, F2, folds (large and small

scale) were formed. F1 and F2 are coaxial and coplanar with isoclinal, recumbent axial surfaces and fold axes, which plunge gently toward the NNW, and are associated with movement on the Kishora thrust. The dominant S2 foliation developed following the interkinematic phase.
The grade of metamorphism varies from greenschist facies in the south to amphibolite facies in the north. Fractures and brittle shearing in the schists and annealing recrystallization in the granite gneiss and marbles dominate the post S2 phase. During D3 crenulation of S2 garnet growth and the formation of the S3 occurred. F3 folds are upright, open and plunge gently, but variably towards north or less commonly the south or southeast. This event occurred under amphibolite facies, and was followed by the retrograde phase (where garnet and biotite altered to chlorite) and development of east-west trending, south vergent F, folds. F, is related to the change of forces from westward to southward in the lower Swat when Kohistan was thrust southward to its present position. The superposition of the E-W trending F, folds on the generally N-S trending F, folds resulted in a dome and basin structure near Mora Kandao. In the south, Domain 3 preserves the last two deformation phases. During D, S, developed. During D, S, was transposed and also involved the growth of the magnetite porphyroblasts. The' minerals chlorite, actinolite, biotite and muscovite indicate metamorphism of greenschist facies. F, and F, folds are best preserved. The large-scale F, folds are mainly E-W, but at Rustam and Budal I they are deflected into a broad arc near the Ambela complex. This is related to the back thrust in that the Ambela complex acts as buttress that deflects the later folds towards north. Matrix schist records two periods of metamorphism. During the D, deformation, which produced a transposed foliation, is also involved with the formation of greenschist facies minerals chlorite, plagioclase, and muscovite. During D, the early S, was folded. During D, the S, was folded to produce local - S, space crenulation cleavage. The Dargai ultramafic complex has been emplaced along the Kishora thrust with the ophiolitic mélange. Greenschist facies metamorphism of blocks in the mélange reached its maximum during D, and phased out by the end of D, Low P-T minerals chlorite, albite, and epidote developed during D, and early D, D, related F, folds are not present. The ultrarnafic blocks show prograde overprinting on greenschist facies assemblage, evident from the formation of fresh olivine in bastite.
Key words: Structure, Metamorphism, Malakand.

A/87. Ahmad, I. & Ahmad, S., 1975-76. The study of pebble features orientation and petrography of Tanaki conglomerate in Hazara N.W.F.P. M.Sc. Thesis, University of Peshawar, 123p.

Tanakki Conglomerate which is exposed at several localities in Hazara district is a heterogenous mixture of fragments of different shapes, sizes and rock types, embedded in a coarse sandy matrix. It is almost a structureless rock unit with very poorly developed bedding. The thickness varies from a few feet to a maximum of 40 feet in the area of investigation. Tanakki Conglomerate has disconformable contact with underlying Hazara slate formation (Precambrian) or at places with Tanawal formation (early Paleozoic). The upper contact is conformable with Infra Triassic group of Middlemiss (1896).
The age of Tanakki Conglomerate has been regarded by all the workers as Permian on the basis of its so-called close similarity with the Tobra Formation of Salt Range. However, the present study revealed that this correlation cannot be justified. Besides the discovery of some conodont fossils in the Sirban formation has changed the entire ages of Paleozoic rocks in Hazara. The rocks which were regarded as Permian, now fall below in Cambrian and as such Tanakki Conglomerate must belong to Precambrian - Cambrian age.
The external appearance of rock fragments constituting Tanakki Conglomerate has contrasting features. Some rock fragments have entirely smooth surface and lack any surface feature whatsoever. A considerable number of the surfaces are irregular and rough. Grooves, striations, and facets on pebble surfaces pointing towards their glacial origin are also observed,
The dominant size of rock fragments falls in the category of pebbles. Cobbles and occasional boulder size fragments are also present. There is a variety of shapes exhibited by the pebbles but more often they are of irregular shape. The average roundness and sphericity of the pebble is 0.401 and 0.703 respectively.
The bearings of long axes of pebbles show entirely random orientation but the orientation are essentially subhorizontal. Tanakki Conglomerate is composed of sedimentary rocks only. The most dominant lithology is sand stone.
Following are the different rock types met in Tanakki Conglomerate:
(a) Sandstone
(b) Slate/Argillite
(c) Limestone

(d) Quartzite
(e) Quartz
(f) Siltstone
Key words: Petrography, Tanakki Formation, Hazara.

A/88. Ahmad, I. & DiPietro, J.A., 2000. Analysis of folds south of Malakand and adjoining areas, North Pakistan. Earth Science Frontiers 7 Abstract Volume, 15th Himalaya-Karakoram-Tibet Workshop, Chengdu, China, 72-73.

North of the study area in Lower Swat, the rocks have been found to have undergone multiple deformations with at least four periods of folding during a single Paleogene metamorphism (DiPietro and Lawrence, 1991). The earliest folds are composite W-SW vergent, syn-metamorphism F1/F2 folds associated with the formation of the regional foliation. Late-metamorphic, N-S trending open upright F3 folds are associated with local foliation development, and E-W trending open F4 folds are associated with retrograde metamorphism. These interfere with each other to produce dome/basin structure.

The northern part of the study area preserves all the four superposed small-scale folds (F1 through F4). F1 and F2 are coaxial and coplanar with isoclinal, recumbent axial surfaces and fold axes that plunge gently toward the NNW. Where they are superposed, the F1 folds, they deform bedding but not foliation, whereas F2 folds deforms a bedding parallel foliation. The similar geometry and orientation suggests that F1 and F2 developed at about the same time during progressive deformation. F3 and F4 are the same as described above. They determine the map pattern of the area. In the south the earlier folds F1 and F2 fold phases are not preserved. Only the large scale F3 and F4 fold phases are well developed. Large-scale F3 folds are closed to tight with variably dipping axial surfaces, whereas large-scale F3 axes plunge gently but variably towards north or, less commonly, the south or southeast.

Large-scale F4 folds are best developed near Thakht-i-Bahai and Mian Khan where they have broadly have broadly folded the Marghazar (Duma), Kashala and the Saidu formations. F4 folds are open and E-W trending. The F4 folds are asymmetric. They have a different vergence in the different domains. In northern and southern part they are south vergent whereas they are north vergent north of Rustam. These large-scale F4 folds trend mainly E-W, but near Rustam they trend NE and near Budal they trend WNW. Thus they appear deflected into a broad arc near the Ambela complex (Fig. 1). North of Rustam, F4 folds gently deflect the northerly trending structures. South of the Rustam, they are the most obvious folds present and become south vergent. The superposition of the east-west trending F4 folds on the generally north-south trending earlier F3 folds has created the dome and basin structure in the Mora area.

The fold sequence implies an early period of E-W compression prior to the development of south verging structures. The small-scale F1 and F2 folds represent a progressive F1/F2 deformation that is associated with a single set of west-southwest vergent large-scale folds (F2). The large-scale F3 folds may have developed in intense localized shear strain related to ophiolite emplacement on the Kishora Thrust. F4 folds are upright and open with east-west axial trends. They may correlate with early doming of the lower Swat sequence and with strike slip displacement in the northern part of the MMT, north of the Swat (DiPietro and Lawrence, 1991).

The reverse vergence of the F4 folds north of Rustam may be better explained by a back thrust. Back thrust is interpreted from the structural profile AA-across Rustam to Mora area. The fault appears on the north edge of the map. This fault is also supported by the abrupt change in the metamorphic grade across the fault. Rocks north of the village of Bar Bazdara and Zormandai are in epidote amphibolite facies whereas those immediately in the south are lower greenschist. In addition, the sheared contact relationship is intrusive, but on the NW margin of the Ambela Complex the base of the Marghazar is strongly sheared. We interpret this to be related to the back thrust. F4 folds are deflected into a north convex arc from Rustam to Budal (Fig. 1). This is probably related to the back thrust in that the Ambela Complex acts as a buttress that deflects the later folds towards north. In effect, the high-grade metamorphics are underthrusting the Ambela Complex.

Key word: Structure, Folds, Malakand.

A/89. Ahmad, I., DiPietro, J.A., & Jan, M.Q., 1999. Structure and metamorphism south of the Malakand and adjoining areas, Northern Pakistan. Terra Nostra 99. Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 1-2.

Four deformation phases (Dl, D2, D3, D4), three fabrics (S1, S2, S3), and four folding events (Fl, F2, F3, F4) are recorded from north to south (Figure 1). Near Malakand, Dl formed S1. The earliest recognizable fabric S1 is preserved in the S2 fabric as pressure shadows against garnet porphyroblasts and as inclusion trails in garnet and amphibole porphyroblasts within the calc-mica-garnet schist and graphitic schist. Inclusion trails are straight or rotated within garnets and are oblique to the external S2 fabric. No macroscopic folding event related to the S1 fabric has been recognized. This event probably occurred under greenschist facies metamorphism. During D2, F2 folds (large and small scale) were formed. Fl and F2 are coaxial and coplanar with isoclinal, recumbent axial surfaces and fold axes that plunge gently toward the NNW. S2 is defined by calcite, muscovite, plagioclase, quartz, and garnet. The grade of metamorphism varies from greenschist facies in the south to amphibolite facies in the north. During D3 crenulation of S2, garnet growth, and the formation of the S3 occurred. This event occurred under amphibolite facies. This event was followed by a retrograde phase where garnet and biotite were altered to chloride.

In the south, near Rustam and Takht-i-Bahai, the last two deformation phases are preserved. S1 developed during the D3 deformation. During D4, S1 was transposed and also involved with the growth cf magnetite porphyroblasts. The minerals, chlorite, actinolite, biotite and muscovite indicate metamorphism of greenschist facies.

Greenschist facies metamorphism of blocks in the mélange and Dargai ultramafics reached its maximum during D2 and was phased out by the end of D3. Low P/T minerals, chlorite, plagioclase, and epidote developed during D2 and early during D3. F2 folds of the D2 deformational phase are not present. The temperature of metamorphism was in the range of 250^0C to 350^0C and pressures probably up to 3.5 kbar. Evidence of retrograde metamorphism overprinting D2 and D3 minerals is not observed.

Matrix schist within the mélange record two periods of metamorphism. The D2 deformation, which produced a transposed foliation, is also involved with the formation of the greenschist facies minerals, chlorite, plagioclase, and muscovite. During D3, the early S1 was folded and garnets were developed. During D4, the S2 foliation was folded to produce a local S3 spaced crenulation cleavage. This probably occurred during the greenschist facies metamorphism.

Vein mineral assemblages in both blocks and matrix rocks of the mélange provide evidence of P/T uplift paths and conditions, perhaps during emplacement of the Dargai ultramafics and the various blocks in the mélange. Vein minerals common in the talc-carbonate blocks include fuchsite, calcite, quartz and feldspar. The mineral assemblages are indicative of greenschist facies metamorphic conditions. Vein mineral assemblages common in the matrix rocks include calcite and quartz, and are also characteristic of low-grade metamorphism or hydrothermal alteration.

In the north of the study area the earliest superposed small scale folds (Fl and F2), are co-axial and co-planar with isoclinal, recumbent axial surfaces and fold axes that plunge gently toward east. Fl and F2 folds, with localized shear strain, are related to movement on the Kishora thrust. The Kishora thrust is folded by F3 folds. F4 is related to the change of forces from westward to southward in Lower Swat after the Kohistan arc was in its present position. The features described above were noticed during the present study. The Kohora Thrust is folded north of Chakdarra and near Dargai.

Key words: Structure, metamorphism, Malakand

A/90. Ahmad, I., DiPietro, J.A., Lawrence, C.P. & Jehan, N., 2001. Stratigraphy of schistose rocks near Rustam and surrounding area, district, Mardan, North Pakistan. Journal of Asian Earth Sciences 19, p.1.

Rustam is located about 24 km northeast of Mardan. The area comprises of low-grade greenschist facies rocks (schists, marbles) of the Indian shelf. The rocks have been grouped from base upward as Jafar Kandao, Duma, Kashala, Saidu and Nikanai Ghar formations (DiPietro et al., 1993, 1999; Pogue et al., 1992), and assigned Late Paleozoic (Carboniferous) to Mesozoic (at least Triassic) ages. Present study reports two more Conodont ages north of Rustam from the lower part of the Kashala formation (348 260 29.400N 728 110 16.300E) and the upper part of the Marghazar formation (348 230 5600N 728 130 5100E). The age of the Kashala is confirmed as Triassic whereas the Marghazar has the upper Famennian age (Late Devonian). Pogue et al. (1992) reported Carboniferous age for the Jafar Kandao formation below the Marghazar. The upper Famennian age for the Marghazar compared to the Conodont age (Carboniferous) from the Jafar Kandao formation equivalent to Marghazar formation (DiPietro et al., 1993) confirm that the stratigraphy near Rustam is inverted. Work is in progress to locate

Permo-Carboniferous boundary. Important aspect of the recent radiometric ages on Mora and Ilam gneisses (Ahmed et al., 1997), and Chakdara gneiss (DiPietro pers. com.) placed them in Early Permian, and thus provides better control on the stratigraphy. The overlying unconformable relationship of Marghazar formation with Mora and Ilam

gneisses and the intrusive relationship of Chakdara gneiss with Marghazar put it in Late Permian or Early Triassic. The overlying Kashala and stratigraphic equivalent Saidu and Nikanai Ghar may be placed as late Triassic or younger. We interpret the major structure to be north±south trending F4 folds of the Indian plate. The grade of metamorphism increases from south to north. The Karapa greenschist previously considered a single stratigraphic horizon below the Kashala formation (Pogue et al., 1992), Duma formation (DiPietro et al., 1993, 1999) and Jafar Kandao formation (Pogue et al., 1992) are grouped as Marghazar formation (equivalent to higher grade, amphibolites facies in Swat) representing the lower limb of the F4 fold. The core is occupied by the Nikanai Ghar formation (calcic and dolomitic marbles) the youngest unit in the area. The Marghazar formation (psammitic schist, greenschist, graphitic phyllite) is overlain by calcareous schists and marbles of Kashala formation, and followed by stratigraphic equivalent Saidu graphitic phyllite and Nikanai Ghar marbles.
Key words: Stratigraphy, Metamorphism, Rustam, Mardan.

A/91. Ahmad, I., Hamidullah, S. & Jehan, N., 1990a. Petrology and petrochemistry of the Shewa Shahbaz Garhi complex, Mardan, north Pakistan. Abstract, 2nd Pakistan Geological Congress, University of Peshawar, p.46.

The Shewa Shahbaz Garhi Complex occurs as an isolated triangular outcrop about 12 km north-east of Mardan. It consists of a group of acidic rocks intruded by basic rocks, including metagabbro, metadolerite and local quartz monzonite and sills. In order of decreasing relative ages, the acidic rocks are microporphyry, porphyritic granite, riebeckite granite gneiss and aegirine riebeckite porphyry.
The basic rocks are generally composed of hastingsite, clinopyroxene, orthopyroxene (in metadoleritc), magnetite, biotite, epidote, apatite and leocoxane. The acidic types contain potash feldspar, plagioclase with riebeckite and aegirine as the common ferromagnesium mineral, indicating alkaline character. The mineralogy of the rocks indicates an amphibolite facies and a retrogressive epidote amphibolite facies metamorphism.
The major and trace element chemistry of both the basic and acidic types are indicative of their primary development as a result of fractional crystallization with olivine, clinopyroxene and plagioclase as the dominant crystallizing phases in basic rocks and plagioclase as the dominant crystallizing phase in acidic rocks.
The chemistry also indicates the derivation of the basic rocks from a sub-alkaline magma and of the acidic rocks from magma with characters in between alkaline and per-alkaline, both types emplaced in continental rift environment followed by the emplacement of basic dykes of continental flood basalt type.
Key words: Petrology, petrochemistry, basic rocks, acidic rocks, alkaline rocks, Mardan.

A/92. Ahmad, I., Hamidullah, S. & Jehan, N., 1990b. Petrology of the Shewa-Shabazgarhi complex Mardan, north Pakistan. Geological Bulletin, University of Peshawar 23, 135-159.

The Shewa-Shabazgarhi complex is an isolated triangular outcrop, occur-ring about 12 km northeast of Mardan. The complex resides 60 km south of Main Mantle Thrust as part of the Indo-Pak plate and consists of basic and acidic rocks including microporphyry, metagabbro, metadolerite and local quartz monzonite, reibeckite gneiss, aegirine riebeckite porphyry and porphyritic microgranite, together with basic and acidic dykes and sills.
The common minerals in basic rocks include hornblende, clinopyroxene, magnetite, biotite, epidote and apatite. The acidic rocks contain orthoclase, perthite and plagioclase together with riebeckite and aegirine, indicating alkaline characters. The mineralogy reflects amphibolite facies metamorphism followed by retrogression down to at least the upper greenschist facies environment in basic as well as in acidic rocks. Following metamorphism a considerable degree of deformation (cataclasis and /or mylonisation) is indicated in the acidic rocks.
Assessment of the chemical data suggest two different parent magmas; a rift-related tholeiitic type for the basic rocks and an alkaline to peralkaline type for the acidic rocks; both being emplaced in continental environments. The chemistry also suggests the control of fractional crystallization on the initial distribution of elements among the minerals of the two groups. A plagioclase-magnetite-clinopyroxene dominant assemblage on the liquidus in basic rocks and a plagioclase-hornblende dominant assemblage on the liquidus in acidic rocks, during fractionation, are suggested. A rift valley origin proposed by previous workers is supported.
Key words: Petrology, alkaline rocks, Shewa-Shahbazgarhi, Mardan.

A/93. Ahmad, I. & Jan, M.Q., 2000. Barium, titanium and manganese-bearing silicate mineral phases from Shewa-Shahbazgarhi complex, Mardan, Northern Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, 131-133.

This paper describes unusual Barium titanium and manganese silicates, similar in composition to bafertisite $BaFe_2TiSi_2O_9$, from sodic alkaline rocks. Two microprobe analyses are compared with bafertisite from Mangolia.
Key words: Mineralogy, alkaline rocks, Paleozoic, granites, Mardan

A/94. Ahmad, I., Jan, M.Q. & LeFort, P., 1999. Unusual Ti, Fe, Mn and Ba silicates in alkaline granites from Mardan, Northern Pakistan. Geological Bulletin University of Peshawar 33, 57-62.

The Shewa Shahbazgarhi complex is a late Paleozoic intrusion covering 80^2 km area. It consists predominantly of silicic rocks (reibikite ± aegirine gneisses, aegirine-reibikite porphyry, porphyritic microgranite and local quartz monzonite) that have been intruded locally by metadolerite. One variety of granitic rocks contains unusual barium-, titanium- and manganese-bearing phases resembling bafersitite from magnolia. The mineral occurs in trace amount as fibre (up to 0.7 mm in length) in feldspar, biotite and rarely groundmass. It is faintly pleochroic from pale yellow to golden yellow. This mineral may be a product of hydrothermal process or automatasomatism related to residual fluids in the granitic magma. Six microprobe analyses are compared with bafertisite from Mangolia.
Key words: Mineralogy, alkaline rocks, granites, Paleozoic, Mardan.

A/95. Ahmad, I. & Lawrence, R.D., 1992. Structure and metamorphism of the Chakdara area, NW of Swat River, Pakistan. Geological Bulletin, University of Peshawar 25, 95-112.

Two major faults, the Kohistan and Kishora thrust, divide the study area into three tectonic terranes, the Indian shelf, Garai mélange, and Kohistan arc. Stratigraphy, deformation, and metamorphism within each of these terranes developed independently until they were juxtaposed during Eocene-Oligocene collision. An important aspect of this study is the documentation of youngest deformation phases related with Himalayan orogen.
Three deformation phases (D_1, D_2, D_3) are recorded in the Indian shelf and the mélange matrix, each characterized by distinct fabrics and folding. S_1 occurs as relict intrafolial in the S_2 fabric as well as in the porphyroblasts and pressure shadows, in the Indian shelf rocks. F_1 are locally preserved and are found associated with movement on the Kishora thrust. S_2 is defined by the orientation of platy or elongated minerals and axial planes of F_2 folds. F_2 folds are strongly developed and strike NNE and SSW. These are associated with southeastward movement on the Kishora thrust. S_3 developed as minor crenulation cleavage when S_2 was folded during later deformation D_3. F3 strikes NNW and NS. It may probably be associated with the Kohistan thrust during the development of the Indus syntaxis. These deformation phases took place under conditions of amphibolite facies in the Indian shelf and greenschist facies in the mélange matrix.
The mélange blocks and the Kohistan rocks record different deformation events. Apparently they preserve pre-emplacement structures. Two deformation phases are recorded. During D_1, S_1 and F_1 developed. S_1 occurs as relicts in the S_2 foliation. D_1 occurred independently in the mélange blocks and Kohistan arc. During D_2, the S_1 foliation was folded. D_2 in the blocks is associated with the Kishora thrust while that in the Kohistan rocks is consistent with the D_2 of the mélange matrix and the Indian Shelf. D_1 and D_2 took place under conditions of greenschist facies in the mélange blocks and of amphibolite facies in the Kohistan arc.
Key words: Structure, stratigraphy, deformation, metamorphism, Malakand.

A/96. Ahmad, I., Lawrence, R.D. & DiPietro, J.A., 1998. Olistostromal blocks in metamorphosed Saidu mélange, Malakand Agency, north Pakistan. Geological Bulletin, University of Peshawar 31. Abstract Volume, 13th Himalaya-Karakoram-Tibet International Workshop. 1-3.

In Swat, the Indus suture zone contains mélanges of diverse origins. [1] distinguished the Shangla blueschist mélange, Charbagh greenschist mélange, and the Mingora ophiolitic mélange. The subduction-related Shangla blueschist mélange contains blocks of blueschist, serpentinite, piemontite schist, greenschist, metadolerite, metagreywacke and metachert in a sedimentary matrix. The Charbagh greenschist mélange is mainly greenschist which is best interpreted as a very large block in the Shangla mélange. The obduction-related Mingora ophiolitic mélange is composed of tectonized blocks and clasts of serpentinite, emerald-bearing talc-carbonate, greenstone, metapyroclastic, metagabbro, metachert and metasedimentary rock in a talc-carbonate matrix. The structurally underlying Indian shelf rocks are Precambrian Manglaur schist (mostly quartz-mica-garnet schist), Carboniferous to Triassic Alpurai group (calc-mica-garnet schist), and Triassic Saidu formation (graphitic phyllite and marbles). These units along with the mélange units were metamorphosed between the latest Cretaceous and late Eocene.

New field work in the area southeast of Malakand Pass (Fig. 1), where the Saidu formation is widely exposed structurally beneath the Dargai ultramafic complex, suggests that this unit contains large olistrostromal marble blocks and is in whole or in part a sedimentary matrix mélange. Immediately under the Dargai complex ultramafic fragments are sheared into graphitic schists of the Saidu. However to the east near Kharkai village the Saidu is composed of 2 members. The lower member is the graphitic schist previously described as the only unit of the Saidu; the upper member is mainly a quartz-muscovite-talc schist with minor quartz-biotite schists with lensoid inclusions of gray to black marble (Fig. 2). Block dimensions up to 500 m by 50 m are present. The contact between the members is gradational over more than 10 meters. The marble is equigranular, coarse-grained and sugary textured. Much of it is internally brecciated in fragments with the same composition as their matrix. A few fragments contain some mica. These fragments are slightly flattened, but not dramatically strained. Massive, unbrecciated marble layers extend into the marble bodies in various orientations, commonly not parallel to the contact between the marble and the adjacent schists. The quartz-muscovite-talc schists contain small amphibolite layers that may be metavolcanic and a few horizons that look like possible meta-tuffaceous material. This upper member of the Saidu does not resemble any of the units previously mapped in the region.

The Saidu, including the marble lenses, is multiply folded. The several blocks are the noses of tight asymmetric folds overturned toward the SSW. The best documented fold west of Palai has an axis trending S70°E, plunging 30° and an axial plane dipping about 45° to the north. Another lens is made up of 4 boudin shaped fragments. No connection, such as attenuated limbs have been observed between blocks, although several blocks appear to occupy the same horizon in at least one case. Contacts between the marble blocks and the enclosing schists are mostly sheared.

Our best interpretation of this upper member of the Saidu is that it is a slope/rise sedimentary accumulation with olistostromal limestone blocks derived from reefal limestone bodies on the outer edge of the adjacent Gondwana shelf. Much of the internal brecciation may be derived from debris deposits on the reef. Lack of major strain of these features suggests that the folds in which the bodies are found developed under conditions in which the limestone was a competent unit relative to the enclosing clastic materials.

We suggest that the Saidu formation is a metamorphosed olistostromal (sedimentary type) mélange analogous to the "Oman Exotics" of Hawasina complex of Oman Mountains. The "Oman Exotics" form isolated masses from boulder size to 1000 m thick Middle to Upper Permian and Upper Triassic fossiliferous limestones that crop out within imbricated thrust slices beneath the Semail ophiolite in the Oman mountains. They are commonly associated with a substrate of alkalic and transitional tholeiitic basalts and are interpreted as a series of reef-associated carbonate buildups deposited in part on oceanic islands or seamounts close to the site of initial rifting of the Oman continental margin. These blocks slid into the deep sea sediments being deposited to the north. Most of these features are present in the Saidu, but obscured by metamorphism.

Key words: Indus Suture, Mélange, Malakand, Swat.

A/97. Ahmad, I., Rosenberg, P.S., Lawrence, R.D., Ghauri, A.A.K. & Majid, M., 1987. Lithostratigraphy of the Karakar Pass section, south of the Main Mantle Thrust, Swat, N. W. Pakistan. Geological Bulletin, University of Peshawar 20, 199-208.

The Karakar Pass section marks the northern edge of Indo-Pakistan plate. It is predominantly composed of highly deformed and metamorphosed Cambrian and Tertiary (?) granitic rocks and Paleozoic (?) metasediments. The granitic rocks of the area are divided into augen gneisses and tourmaline granites, each belonging to a different age group. The metasedimentary rocks are grouped into Alpurai schists and Nikanai Ghar Marbles.

The augen gneisses are unconformably overlain by the Alpurai schists and tourmaline granites occur as an intrusive sill-like body into the augen gneisses and the surrounding quartzose metasediments. The Alpurai schists include three members: 1) quartz-mica schist and amphibolites, 2) calc-schists and schistose marbles, and 3) graphitic schist. The whole sequence is terminated in the southeast by the Nikanai Ghar fault, which juxtaposes these units against the Nikanai Ghar Marbles.

Key words: Metamorphic rocks, granites, Precambrian, Cambrian, metasediments, Karakar pass, Swat.

A/98. Ahmad, I., Rosenberg, P.S., Lawrence, R.D., Majid, M. & Ghauri, A.A.K., 1987. Evidence of multiple deformation in the rocks of Karakar pass area, Swat, NW Pakistan. Geological Bulletin, University of Peshawar 20, 189-198.

Lithologically the Karakar Pass area is divided into Swat granitic rocks, Alpuri schists, and Nikanai Ghar Marbles. These rocks units have undergone at least three different phases of deformation (D1, D2, D3).
D1 produced a pervasive regional foliation S1, mineral lineation L1, and tight to isoclinal, NW-SE oriented F1 folds. S1 is generally parallel to original layering (So) and axial-plane to F1 folds. D2 folded S1 into open, upright F2 folds, with north-south axes. It locally caused the development of an S2 crenulation cleavage. D3 resulted into small to large scale, east west oriented, cross folds (F3).
In the Karakar Pass area the Swat granitic rocks and the Alpurai schists from the hinge and the southern limb of the east west oriented large recumbent F3 fold. To the south, the Nikanai Ghar Marbles are interpreted to form a large fault-and-fold nappe, herein named as the Nikanai Ghar Nappe.
Key words: Structure, deformation, Swat.

A/99. Ahmad, J., 1993-95. Electrical Resistivity Survey for groundwater exploration in Zulmkot Area, District Malakand, NWFP, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 82p.

The electrical technique is the most powerful tool to explore groundwater, the buried channels and the bedrock in the subsurface.
This technique was applied to explore the ground water potential in Zulmkot area District Malakand, NWFP Pakistan. Eighteen VES stations were selected for said purpose where Schlumberger and Wenner electrode configurations were used for vertical electrical sounding. The Wenner profiling was also carried out at different locations to detect buried channels of the main stream as well as to observe the lateral variations of the subsurface materials.
In order to have first hand information of material distribution in the subsurface, iso-resistivity maps for different L/2 spacing were prepared by using WINSURF computer program. These maps were used to identify the locations of high and low resistive material in the subsurface.
Later, the field data was processed in order to have the true resistivities and true depths of the subsurface formations by four different methods of interpretation.
Firstly, the field data was processed using quantitative methods such as a complete curve matching and partial curve matching using auxiliary point method. The true depths and true resistivities of the subsurface layers were obtained by using RESIST-87 computer program. The field data was also interpreted by the iterative interpretation technique using A.A.R. ZHODY'S program. Based on the results obtained from these methods of interpretation five different resistivity zones were established such as very high, high, medium, low and very low.
On the basis of true resistivities and true depths of the subsurface layers, geoelectric sections as well as profiles of transverse resistance 'T' and longitudinal conductance 'S' were constructed which helped to interpret the subsurface geology of the Zulmkot area along different lines.
Different aquifer zones have been identified in different geoelectric sections, which were constructed along different lines. There identified aquifer zones generally fall within the medium and high resistive zones, which were further confirmed by the lithologic logs of test wells at different locations. The test well data of project area reveals that the water table, generally, varies from 10 m to 25 m. On the identification of aquifer zones in the project area, different locations have been recommended for test drilling to confirm the results of the survey carried out in the Zulmkot area. In order to get more detailed information of the subsurface geology in Zulmkot area, integrated geophysical survey has also been recommended.
Key words: Geophysics, groundwater, Malakand

A/100. Ahmad, J., Ahmad, I. & Abid, A., 1980. Geology of the area between Manglaur Kishora (Malam Jabba), Swat. M.Sc. Thesis, University of Peshawar, 99p.

This report represents a comprehensive geological study of about 210 square kilometer area which lies 8 kilometer northwest of Mingora (Swat).
The area has been mapped and detailed petrography is presented. The area is occupied mainly by regional metamorphic rocks which represent the extreme northern edge of the lower Swat Buner schistose group and consists of a succession of silicious schist, amphibolite schist, calcareous schist with abundant marbles, phyllite schist and green schist.
The acidic rocks are represented by granitic gneiss and augen gneiss which mainly occupy the area under investigation and towards north have a tectonic contact with the ultramafic rocks of the Shangla Ophiolites.
The structure of the rea is complex. The rocks are highly joined and folded. Plunging folds as well as recumbent folds are commonly seen in the calcareous schist which are produced mainly due to the tectonic relationship of lower Swat Buner Schistose Group (Indian Mass) with the Hornblendic Group (Asian Mass). Besides these folds, the rocks are well foliated and lineated. Graphitic schist and phyllitic schist horizons are highly jointed as compared to the other units. The area investigated does not have much economical potentials, however, kayanite, Granite and building stone is of some importance.
Key words: Petrography, granitic rocks, Malam Jabba, Swat.

A/101. Ahmad, J., Khaliq, A. & Khan, T.M., 2001. Uranium potential of graphitic metapelites of Gandghar Range N.W. Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, 12-13.

The graphitic metapelite belonging to Manki Formation of Gandghar Range, due to its radioactive nature, was investigated in detail including surface and subsurface exploration through drilling and aditing. The surface and subsurface data revealed that the metapelites are highly anomalous in uranium and contain an average of 40 ppm uranium compared to the uraniferous black shales in the world, which generally contain 5-11 ppm uranium. Chemical analysis of water samples collected from springs and streams located within the graphitic metapelites of Gandghar Range include highly anomalous concentration of uranium at certain localities with evidence of active leaching of uranium. This leaching process is favourable for supergene concentration of uranium within suitable structural traps formed due to intraformational deformation in metapelites and below water table.
The U-Pb isotopes have been successfully used in China to locate blind ore deposits in black shales. The same method was employed and a total of 39 rock samples from metapelites were collected and anlaysed in China. The results indicated radiogenic lead anomalies at five localities.
The R.O.A.C. survey at selected sites revealed strong anomalous halos at certain places along a linear zone indicating uranium concentration at depth. The chemical composition of rocks of metapelites of Gandghar Range indicate that they are more siliceous and contain high organic carbon content compared to other metapelites in the region. Moreover, these rocks are also enriched in U, Y, Ba, and Pb. The enrichment of some of the elements took place in association with detrital fraction of the rock while the rest of the enriched elements were concentrated from normal seawater in oxygenated transitional environment close to the continent. The graphitic metapelites were probably deposited in a basin fed by various source materials.
Unlike typical black shales deposit uranium does not indicate any correlation with organic carbon. The absence of relationship is primarily caused by dissolution of some elements in ground water circulating freely in otherwise impermeable rocks, made permeable by structure movement in the region. The data collected from metapelites of Gandghar Range show high potential for uranium like other black shale uranium deposits elsewhere in the world.
Key words: Gandghar Range, Uranium mineralization.

A/102. Ahmad, J., Syed, S.A. & Khaliq, A., 2000. Geological appraisal of uranium-thorium occurrences in Ambela granitic complex, NW Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.133.

U-Th anomalies (orthomagmatic, pegmatitic/appletic, hydrothermal) related to granitic rocks have been described. It is proposed that primary Uranium in the complex has been fractionated and remobalized in latter differentiates during cataclastic deformation. The Uranium bearing solution followed the channels so produced.
Key words: Buner, Uranium-Thorium mineralization, Ambela granite.

A/103. Ahmad, K., 1977. Geology and petrology of Mara Granites and its environments. M.Sc. Thesis, Peshawar University, 11p.

Key words: Granites, Petrology, Mara, Swabi.

A/104. Ahmad, K.G., 1967. A petrographic study of the Malakand granite. Pakistan Journal of Scientific and Industrial Research 10, 89-91.

The Malakand albite granite (Pakistan) is described petrographically. Migmatization is common. The enclosing rocks are mica-quartz schist, with abundant garnet near the contact.
Key words: Petrography, Granites, Malakand.

A/105. Ahmad, K.N., 1987. Major peaks, passes and glaciers of Pakistan. In: Shams, F.A. & Khan, K. (Eds.), Resource Potential of Mountainous Region of Pakistan. Centre for Integrated Mountain Research, Punjab University, Lahore, 8-19.

Key words: Glaciers, geography.

A/106. Ahmad, M., 1965. Marbles in Pakistan. GSP 17(1), 12p.

Key words: Marble deposits, economic geology, Swabi, Mullagori.

A/107. Ahmad, M., 1981. Earthquake of 3rd September, 1972 in Gupis–Tangir area. Gilgit Agency, Pakistan. GSP Information Release 154, 15p.

Key words: Earthquake, Gupis, Tangir, Gilgit.

A/108. Ahmad, M., 1981-83. Lithostructural mapping of Mansehra Susal and Matial Area, District Mansehra. M.Sc. Thesis, Punjab University, Lahore, 84p.

Lithostructural mapping with preliminary structural studies have been made of Mansehra, Khaki, Rihar area district Mansehra at a scale of 1:1000. An attempt has been made to delineate the boundaries of igneous and metamorphic rocks precisely. Physiographic/stratigraphic studies and various structural contour diagrams have been drawn to determine axis of minor folds. Orientation has been determined with the help of Rose diagram. Thin section has been studied to determine different phases of deformation. Attempt has been made to analysis the strain with Flinn's and Ramsay's plots.
On the basis of microscopic and mesoscopic analysis it has been tried to interpret the structural and macroscopic scale. On the basis of Kinematics Study, structure of the area is interpreted.
Key words: Structure, Mapping, Mansehra.

A/109. Ahmad, M., 1983-85. Report on geology and structure of Balakot-Kummi Area. M.Sc. Thesis, Punjab University, Lahore, 100p.

The present work constitutes a comprehensive report on the geology of Balakot -Kummi area and is submitted in partial fulfillment of the requirements for the degree of M.Sc. at the University of the Punjab. The report includes a detailed geological map at 1:6,000 of about 65 km. sq. area along with a number of geologic sections and sketches. The various chapters include geomorphology, stratigraphy, structure and tectonics. Stratigraphically, the Balakot-Kummi area includes a number of diverse sedimentary and metamorphic elements ranging in age from Precambrian to Miocene with a fairly large gap in .the Mesozoic period. Structurally, the area incorporates part of the core and western limb of the Hazara-Kashmir syntaxis and through it pass the major Murree and Panjal Faults. The Balakot-Muzaffarabad anticline is the major fold overturned and overthrust to the southwest. No major economic mineral

deposit was found within the project area, although a lot of material is available as rock crush, aggregate components and building stones.
Key words: Geology, structure, Balakot.

A/110. Ahmad, M., 1985. Integrated geophysical survey along the Karakoram Highway between Harbon and Gayal. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 99p.

Key words: Geophysics, KKH.

A/111. Ahmad, M., 1985-87. The geology and petrography of volcanic and carbonate rocks of upper Haveli (District Bagh) and Balgiran-Manjhoter, District Muzaffarabad with special emphasis on lead-zinc mineralization. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 110p.

The project area covers about 417 square kilometers located in District Bagh and Muzaffarabad, Azad Kashmir. The work has involved geological mapping of the area on a scale of 1:25,000 and 1:15,000 respectively.
This thesis deals with the geology and petrography of Panjal Volcanics and carbonate rocks of the area. The geological sequence of the area consists of sedimentary, volcanics and metamorphic rocks. Lithologically metamorphic rocks present in the area are Schist, Slates, Phyllites, Quartzite and marble while sedimentary rocks comprise Sand stone, shales, silt stone, lime stone. Volcanic rocks belong to two distinct ages. Dogra trap are of Precambrian age and occur within the Dogra Slates. Panjal volcanics or Panjal trap flows are of Upper Carboniferous age and basaltic to andesitic in composition, while mineralogical studies of Dogra trap shows that they are of basaltic composition. Petrographic analysis of Panjal volcanics, Agglomeratic slates, limestone and marble have been carried out. The mineral assemblage in volcanics is plagioclase + chlorite + epidote+ Quartz + Calcite, while of agglomeratic slates is Quartz + epidote + chlorite + Calcite + plagioclase the mineralogical assemblage of lime stone and marble is calcite + quartz + muscovite + magnetite. Pb-Zn mineralization in carbonate rocks of Khetar-Treri areas has been interpreted. The evidences are strongly supporting that Pb-Zn mineralization is the result of hydrothermal solution.
Petrogenesis of Panjal Volcanics has been carried out. The evidences reveal shallow water or submarine origin of the Panjal Volcanics. Tectonically the area is highly disturbed, being involved in Himalayan orogeny.
Key words: Geology, petrography, lead-zinc, Muzaffarabad.

A/112. Ahmad, M., 1985-87. Electrical resistivity survey for groundwater potentials in Masal Talao, Amir Khan Talao, Khachar Talao and Haji Talao, District Peshawar. M.Sc. Thesis, Punjab University, Lahore, 60p.

Electrical resistivity survey in Masal Talao, Amir Khan Talao, Khachar Talao and Haji Talao (District Peshawar) was carried out in collaboration with Hydrogeology Directorate WAPDA Peshawar. The main purpose of the survey was to determine hydrogeological features such as depth to the bed rock, nature and thickness of aquifers, the quality of groundwater, and to select suitable sites for tubewell installation in the project area.
According to resistivity survey and drilling data the entire area is underlain by low resistive clay with occasional gravels. The overlying alluvium is composed of alternating layers of gravels and clays. Ground water appears to be quite fresh in the entire project area. Water table depth varies from 13m to 40m in the area under investigation.
In the project area, twenty seven probes were carried out. After interpreting the data, the V.E.S. No. 95, 93, 51, 40, 15 and 17 have been selected for the test drilling, however other probe sites also indicate the presence of aquifers in the area but of varying thickness.
The entire area appears to be favourable for tubewell installation, however the yield of water depends upon the nature of aquifers, may range from half cusec to one and half cusec project area.
Key words: Resistivity, groundwater, Peshawar.

A/113. Ahmad, M., 1986-88. Electrical resistivity survey for ground water potentials in Kheshgi Area (N.W.F.P.). M.Sc. Thesis, Punjab University, Lahore, 70p.

Electrical resistivity survey in the project area includes prominent villages Kheshgi Bala, Goddu kili, Mala Kili (N.W.F.P) was carried out in collaboration with Hydrogeology directorate WAPDA, Peshawar. The main purpose of the survey was to determine hydrogeological features such as nature and thickness of aquifers, the quality of groundwater, and to select suitable sites for tubewell installations in the project area.
According to resistivity survey and drilling data the entire area is underlain by low resistive clay, with occasional gravels. The overlying alluvium is composed of alternating layers of clays and sand with gravels. Ground water appears to be quite fresh in the entire project area. Water table depth varies from 11 ft to 75 ft. in the area under investigation. In the project area 32 probes were carried out. After interpreting the data, the V.E.S No. 5 has been selected for the test drilling, however other probe sites also indicate the presence of aquifer in the area but of varying thickness. The area appears to be favourable for tubewell installation; however the yield of water depends upon the nature of aquifer.
Key words: Resistivity, ground water, Kheshgi, Nowshera.

A/114. Ahmad, M., 1999. Seismic reflection data interpretation Chak Naurange area. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 45p.

Key words: Seismology, seismic reflection, Potwar.

A/115. Ahmad, M., Ali, K.S.S., Khan, B., Shah, M.A. & Ullah, I., 1969. The geology of the Warsak area, Peshawar, West Pakistan. Geological Bulletin, University of Peshawar 4, 44-78.

The Warsak Area, Peshawar, West Pakistan, has been geologically mapped and the petrography of the rocks described in detail. The area consists of a series of metasediments of the greenschist facies (slates, phyllites, mica schists, garnet schists, hornblende schists, calcareous schists and marbles), which have been divided into a Lower, Middle and Upper Series. On the eastern side the metasediments disappear under the alluvium of the Peshawar plain. They range from Siluro-Devonian to Upper Palaeozoic in age, and are intruded by sills of metagabbro and metadolerite (? Cretaceous), porphyritic microgranite (?Upper Cretaceous to Lower Tertiary) and the Warsak alkaline granite (?Lower Tertiary).
The chemistry and alkaline nature of the granites (which contain aegirine, riebeckite and astrophyllite) is briefly discussed. The structure of the, area is shown to be a northwards plunging syncline faulted on the east on the northern side of the Kabul River. The joint patterns and other structural features are described, and the economic geology of the area discussed.
Key words: Geology, Warsak, Peshawar.

A/116. Ahmad, M. & Ali, L., 1979. The geology of the right abutment of Terbela Dam area, reference to porosity and permeability. M.Sc. Thesis, University of Peshawar, 40p.

The Terbela Dam has been constructed on the river Indus in the Terbella quadrangle. The right bank or right abutment from the right side of the Terbella Dam area. It occurs towards the Topi, in Mardan Distt.
The Topi Terbella and Gandaf roads are two accessible routes to this area. The right abutment is originally a sedimentary unit which is later metamorphosed and intruded by some basic igneous rocks. Hence it consists of all the three major types of rock, which are sedimentary, igneous and metamorphic rock. Of the sedimentary rocks limestone is common. Metamorphic rocks dominates the area and the main representatives are quardzites, chlorite schist and phyllites. Basic igneous rocks are found in the form of intrusions. The area is folded and foliated to various extent. The oldest fault occurs beyond the tunnel outlet one trends east-west.
A series of small and compressed folds occur at the power house. The area where these folds occur is occupied by limestone, gypsum and carbonaceous schist.
Key words: Porosity, permeability, Tarbela Dam.

A/117. Ahmad, M. & Ibrahim, M., 1991. A study of mineralogy and physico-chemical properties of Swat clay project (Fine slip). Pakistan Journal of Scientific and Industrial Research 34, 12, 500-00.

Mineralogy, chemical and physical investigations of “Fine slip” a by-product of Swat clay reject, have been carried out in order to evaluate and find out the areas of its utilization. The results indicate that it can be utilized in the manufacture of pressed ceramic wares and tiles in particular.
Key words: Physiography, Clay, Swat

A/118. Ahmad, M., & Rehman, A., 2000. Understanding tectonic movements within Pakistan Northern region. Abstracts, Third South Asia Geological Congress, Lahore, 142-143.

The regional movements caused by continuous complex movements along numerous faults need to be understood. This study will lead to the analysis of the processes and sources which cause major earthquakes in this region. The region is characterized by dramatic changes in the azimuth of structural trends involving thrust faults, graben, strike slip faults and folding, and is obviously under continuing severe distortions. In the recent past, magnitude 7 earthquakes have occurred in this region. Larger events (Chatkal 1946, Alai 1974) and magnitude 8 (Kashgar
1902) have been experienced. Cambridge Expedition of 1980, resurveyed the original survey network of triangles and polygons in 191 3 by Mason. Armbruster, Seeber & Jacob (1 978) estimated activity from micro earthquakes of the order of 37 mm per year of the northward movement of the Indian Plate relative to Eurasian Plate.
Although 1913 survey was not accurate enough as the noise level of survey should be less than 4 cm/year to confirm the movements. The 1980 survey results can be used as datum. The movements are clearly not uniform and then there is the factor of larger earthquakes. Also much of the plate tectonics convergence is definitely being absorbed as sporadic slip on extensive thrust faults and strike slip faults. There will be some locations where strains will be several times the accuracy of survey results can be used as datum. The movements are clearly not uniform and then there is the factor of larger earthquakes. Also much of the plate tectonics convergence is definitely being absorbed as sporadic slip on extensive thrust faults and strike slip faults. There will be some locations where strains will be several times the accuracy of survey observations. With the revolution in survey techniques (GPS), it is now possible not only to have the level of accuracy required but also the observations can be much quicker enough to have repeat observation. Cambridge Expedition recommended that observation be repeated after about 10 years. It will be invaluable to geologists, geophysicists and geodesists to know the deformation pattern and history.
Key words: Tectonics, North Pakistan.

A/119. Ahmad, M., Rehman, S., Khan, M.A. & Naeem, M., 1976. Study of the waterlogged and saline land of Pabbi area. M.Sc. Thesis, University of Peshawar, 72p.

Key words: Water logging, salinity, Pabbi**.**

A/120. Ahmad, M., Ryan, J. & Paeth, R.C., 1977. Soil development as a function of time in the Punjab river plains of Pakistan. Soil Science Society of America (Madison), 41, 1162-1166.

This is a study that relates the development and composition of soils with time in the Punjab plains. Studies of the soils since the late Pleistocene give an estimate of the time required for the formation of semiarid soils. The authors found secondary accumulations of calcium carbonate in the subsurface of 10,000 to 20,000 year old soils, while 23,00 year old soils had none. The older soils also exhibited clay illuviation and low organic matter.
Key words: Soil, Punjab.

A/121. Ahmad, M., Sahi, M.A. & Qureshi, A.A., 1967. Exploitation of indigenous copper ore: 1. Pakistan Journal of Scientific and Industrial Research 19, 57-60. 69-215.

Key words: Copper, Ore, Economic geology.

A/122. Ahmad, M.A., 1973. Seismic refraction investigations at Tarbela dam site and Pihur area of Hazara and Mardan districts, Peshawar division, NWFP, Pakistan. Geological Survey of Pakistan Records, 21(2), 7.

Seismic refraction survey was carried out during October- November 1970 at Tarbela damsite and Pihur-Topi Gap, Hazara and Mardan districts. The objective of the study was to determine if concealed Indus fault precisely delineated at the damsite maintains its southerly trend along the river course in Pihur-Topi area. Four refraction traverse in Pihure-Topi Gap area and one at the damsite were observed. The subsurface configuration of the bed-rock has been determined and shown in the form of sections.
It is concluded that the main Indus fault extends southwards from the Damsite towards profile AB about 9500 feet down stream from the central axis, under the gravels. Further downstream from profile AB it was not possible to trace the trend of the concealed fault as there was no positive indication on the profile CD, EF & GH which were located west and southward of profile AB in Pihur-Topi Gap.
Key words: Seismicity, Tarbela dam, Swabi, Hazara.

A/123. Ahmad, M.A., Nazirullah, R., Sakhawat, M., & Khadim, I.M., 1988. Geophysical investigations of Degan Paikhel copper prospects in Boya area, North Waziristan Agency, FATA, Pakistan. Geological Survey of Pakistan Information Release 338.

Key words: Geophysics, copper mineralization, North Waziristan.

A/124. Ahmad, M.I., 1962. Radioactivity of the Hunza River alluvium, Gilgit Agency, West Pakistan. GSP, Mineral Information Circular 6, 13p.

Key words: Radioactivity, Alluviam, Hunza river, Gilgit.

A/125. Ahmad, M.K. 1988-90. Petrology and mineralogy of the area (Gokdara-Ghaligai), District Swat. M.Sc. Thesis.

The detailed geological map of the project area has been prepared. The project area has been mapped on a scale 1" = 12500" = 12,500'
This thesis consists of two sections. Section No.1 deals with the general geology of the project area. Introduction, Physiography, Structural Geology & Tectonics and the lithologic units of the project area have been discussed in this part. In Section No.2, Petrography, Chemical analysis, Petrogenesis, Discussion on Petrogenesis, Economic Geology and some thing, new one (Dolomite/Wollastonite Skarn) in the project area is discussed.
The project area is consisting upon the metasedimentary and metamorphic rocks which lie in the Higher Himalaya Crystallines of the MMT Zone. The rock units belong to Lower Swat Buner Schistose Group and are of Lower Palaeozoic age.
Key words: Petrology, petrography, Swat.

A/126. Ahmad, M.N., 1995. Magnetic mineralogy of Khunjerab batholith in Hunza area, northern Pakistan, with special reference to its paleomagnetic reliability. In: Khadim, I.M. & Yoshida, M. (Eds.), Rock Magnetism and Paleomagnetism. Recent Progress in Pakistan, Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad, 13, 23-41.

Rock and mineral magnetic properties are examined for altered granites collected from Khunjerab Batholith, Hunza area, Northern Pakistan. The major magnetic carriers in the granites are determined ilmenite-hematite intergrowth, goethite, maghemite, and trace amount of pyrite on the basis of results of optical microscopy, thermomagnetic analysis, magnetic hysteresis analysis, and IRM measurement. The contents of ferromagnetic minerals are very small but the grain size is rather multidomain state, and the distribution is not homogeneous even in hand sample. All the samples are strongly overprinted by recent local geomagnetic field, but neither thermal nor alternating demagnetization is effective to separate the characteristic component (CgRM) from the NRM because of its magnetic phase transition in heating experiments and high coercivity, respectively. The magnetic phase transition is generally observed at above 350•‹ C in non-oxygen environment, which may be derived from inversion of à-phase maghemite to β-phase magnetite and/or fmm decomposition of pyrite. Therefore, paleomagnetic data of the Khunjerab Batholith, especially the direction of ancient magnetic field during the formation of the granite body can hardly be obtained.

Key words: Magnetism, paleomagnetism, Khunjerab.

A/127. Ahmad, M.N., Fujiwara, Y. & Paudel, L.P., 2000. Paleomagnetic study of igneous rocks of Gupis-Shamran area, Kohistan arc, Pakistan, NW Pakistan. Earth Science Frontiers 7, Abstract Volume, 15th Himalaya-Karakoram-Tibet Workshop, Chengdu China, 120-121.

Kohistan Sequence has been considered as island arc formed during the subduction of oceanic lithosphere at the leading edge of northward moving Indian Continent. Sedimentary sequences indicate that formation of the intra-oceanic Kohistan arc began in early Cretaceous time. The isotopic data demonstrate the involvement of enriched, DUPAL type mantle, suggesting that Kohistan arc was formed at or south of the present equator (Khan et al., 1997). The Intra-oceanic phase of Kohistan lasted until sometime between 102 and 85 Ma, when Kohistan collided with Asia. From this time until collision with India about 50 Ma ago, Kohistan existed as Andean-type margin.

This paleomagnetic study is from the volcanic and plutonic rocks exposed in Gupis-Shamran area (west of Gilgit) in northern part of the Kohistan arc. According to geochronological data these rocks were formed 61~55 Ma ago (Treloar et al., 1989), when Kohistan was existing as Andean-type margin. Seven to nine samples were collected from nine sites of Shamran volcanics (58±1) Ma and from five sites of Pingal, Gupis, and Yasin plutons (Ar-Ar hornblende ages ranges from 61~52 Ma). On the basis of one Rb-Sr age (59±2) Ma from these plutons, the above-mentioned Ar/Ar ages may be regarded as reasonable intrusion ages of these plutons (Searle, 1991).

Magnetic mineralogical study i.e. IRM analysis followed by stepwise thermal demagnetization and microscopic study reveal that magnetite is major magnetic remanent carrier in these rocks. The other opaque minerals observed are ilmenite and pyrite. Opaque minerals occur as both primary magmatic product and secondary product of mafic minerals in all the samples. The primary magnetite is found as irregular grains in interstices of other minerals. Sometimes it is also occurred as inclusions in hornblende and biotite. Secondary magnetite is alteration product of pyroxene, hornblende and biotite. In general in mafic rocks (diorite, andesite, and tuff) secondary opaques are common as compared to felsic rocks (granodiorite and granite). Slight deformation and low-grade metamorphism have affected all rocks. The mafic minerals like pyroxene, hornblende, and biotite have been partially or completely altered to chlorite, epidote, calcite and opaques. The mineralogical evidences show retrograde type metamorphism at relatively higher fluid pressure and low temperature conditions.

In most of cases two magnetic remanent components are revealed from Zijderveld diagrams of progressive thermal demagnetization. First component is a low temperature component having unblocking temperature ranging from 400~500ºC, yielding remanent magnetization directions parallel to present earth's magnetic field in geographic coordinates. This remanent direction is interpreted as viscous remanent magnetizations of recent origin, carried by multidomain magnetite grains. In samples of 11 sites (8 from volcanics and 3 from plutonic rocks) characteristic remanent magnetization component with NNW and SSE pointing directions of moderate inclinations of normal and reverse polarity in geographic coordinates is obtained. The unblocking temperature in all of these cases is 570~580ºC. This magnetic remanent component may not be of primary origin as mean directions are scattered after the application of the structure correction. This post-folding component may be carried by secondary magnetite, which was formed by the flow of fluids at low temperatures as observed in microscopic study. Hence this secondary remanent magnetization is chemical remanent magnetization (CRM) or thermochemical remanent magnetizations (TCRM). All the plutonic activity in the area is pre-tilting of the volcanics; therefore the secondary magnetite giving post folding remanent magnetizations cannot be produced at the time of intrusion of any pluton. The K-Ar biotite age of Gupis pluton is about 40 Ma. This is giving the evidence that at 40 Ma the area is still hot at about 300ºC (closure temperature of biotite). We interpret the formation of this secondary magnetite by hydrothermal processes; due to release of water from water saturated solidus magma, during the uplift of the area. The mean direction for this secondary component along with Fisherian statistics is as follows:

Dec=339.5 Inc=43.6 k=24 Alpha-95=9.5

The calculated mean paleolatitude is about 25ºN, which is 10ºC south of the present position. Hence the area moved 10ºC northward after the acquisition of remanent magnetization. The comparison of calculated paleolatitude of the area with Indian apparent polar wander path (APWP) indicates the acquisition age of these magnetizations is 40~35 Ma. In this comparison 470-km north south shortening south of the Kohistan arc is also taken in account to assign age of magnetizations correctly.

In samples of only three sites pre-tilt characteristic remanent magnetization is obtained. The calculated paleolatitude (6.6ºN) for this pre-tilt component is well in agreement with pre-tilt remanent magnetizations of red beds of Kohistan arc. The Ar-Ar hornblende age of the volcanics is about (58±1) Ma. This component may be acquired during the original cooling of the rocks before the tilting of the studied volcanics. Comparing paleolatitude with

present latitude of the area, it can be inferred that area has moved northward about 300-km since the acquisition (about 58 Ma) of remanent magnetization.
Key words: Paleomagnetism, Igneous rocks, Kohistan arc.

A/128. Ahmad, M.N., Fujiwara, Y., & Paudel, L.P. 2001. Remagnetization of igneous rocks in Gupis area of Kohistan arc, northern Pakistan. Earth Planets Space, 53, 373–384.

The Kohistan arc was formed due to subduction of neo-Tethyan oceanic crust beneath Asia. The arc is comprised of volcanic, plutonic and sedimentary rocks of Mesozoic to Tertiary age, formed prior and after the suturing of the Indian and Asian continents. Paleomagnetic investigations have been carried out on Paleocene volcanic and plutonic rocks exposed in the northern part of the arc. A total of 110 samples from 16 sites were drilled. According to rock-magnetic studies the main magnetic carrier is magnetite. Optical microscopy study reveals that low-grade metamorphism have effected all rocks. Magnetite is found as both a primary magmatic mineral and secondary alteration product in all samples. Samples of volcanics yield post tilting characteristic remanent magnetizations (ChRM). The in situ mean direction of the ChRMs of the intrusives is similar to the in situ mean direction of volcanics. The presence of secondary magnetite in plutons, the similarity of in situ mean ChRM of plutons with that of post-tilting ChRMs of similar age volcanics and dissimilarity of the mean ChRM of plutons from expected directions at the time of formation of plutons support a secondary origin for the ChRM of plutons. As the ChRM directions of the volcanics and intrusives are the same, it implies that both ChRMs were acquired during the same remagnetization event. Comparing the mean paleolatitude ($25 \pm 6^\circ$ N) from Gupis area with those from Indian APWP and considering the fact that there was prevailing heating event in Lower Tertiary in the area, the acquisition age of this secondary remanent magnetization can be bracketed between 50 and 35 Ma.
Key words: Paleomagnetism, Igneous rocks, Kohistan arc.

A/129. Ahmad, M.N. & Yoshida, M., 1995a. Paleomagnetic studies of Paleogene pyroclastic flow deposits of Utror Volcanic Formation, Kohistan arc, northern Pakistan. In: Khadim, I.M. & Yoshida, M. (Eds.), Rock Magnetism and Paleomagnetism. Recent Progress in Pakistan, Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad, 13, 149-168.

Calc-alkaline volcanic rocks are distributed in the Kohistan arc, the northwestern margin of the Himalayan range. The sequence of Kohistan arc has been interpreted as a mature island arc formed by subduction during Mesozoic time between the indo-Pakistan Subcontinent and Asian Continent and obducted onto Indian plate in Eocene time. The Utror volcanics Formation is probably the upper most part of the island arc sequence. Total 23 oriented samples (5 sites) from altered plagio-rhyolitic pyroclastic flow deposits of this formation to the southwest of Kalam village, upper swat valley. According to the results of progressive thermal demagnetization (THD), almost all samples possess mainly three components of remnant magnetization; the components 1, 2, and 3. The component 1 is generally unstable remanence and it can be observed in the steps less than THD 300 C. the component 2 is identified in the THD interval between 300 C and 540 C. the component 3 is detected in the final THD steps above 540 C. on the basis of results of optical ore-microscopy, thermomagnetic analysis, and coercivity spectrum analysis, origins of these magnetic components can be interpreted as follows: the component 1 is a recent magnetization of the goethite-maghemite assemblages formed by hydration and low-temperature oxidization processes.
Key words: Paleomagnetism, Utror volcanics, Kohistan arc.

A/130. Ahmad, M.N. & Yoshida, M., 1995b. Paleomagnetic studies of Paleogene pyroclastic flow deposits of Utror Volcanic Formation, Kohistan arc, northern Pakistan. Extended Abstracts, International Seminar on Paleomagnetic Studies in Himalaya-Karakoram Collision Belt and Surrounding Continents, November 20-21, 1996, Islamabad. Geoscience Lab, GSP, Islamabad, 5-8.

Consult the preceding account for further details.
Key words: Paleomagnetism, Volcanics, Utror, Kohistan arc.

A/131. Ahmad, M.N. & Yoshida, M., 1996. Subsurface structures of Northern Suture Zone modeled by geomagnetic and VLF-EM soundings. Geologica 2, 195-202.

Key words: Structure, Tectonics, Northern Suture.

A/132. Ahmad, M.N. & Yoshida, M., 1997a. Paleomagnetic of Upper Cretaceous granite and Paleogene volcanics in Kalam area, northern Pakistan. In: Khadim, I.M., Zaman, H. & Yoshida, M. (Eds.), Paleomagnetism of Collision Belts. Geoscience Laboratory, GSP, Islamabad, 1-11.

Consult the following account for further details.
Key words: Paleomagnetism, Cretaceous, Granites, Volcanics, Kalam, Swat.

A/133. Ahmad, M.N. & Yoshida, M., 1997b. Paleomagnetic study of Upper Cretaceous and Paleogene igneous rocks in Kalam area, Kohistan arc, North Western Himalaya. Abstract volume, 12^{th} Himalaya-Karakorum-Tibet International Workshop, Rome, Italy, 67-68.

The Himalayan mountain belt was formed by a crustal deformation caused by the collision of the Indo-Pakistan subcontinent with the Eurasian continent during the early Tertiary. In the northwestern part of the Himalayan belt, this collision is not simple because Ladakh-Kohistan arc was captured between the two colliding continental blocks. Different types of igneous rocks such as calc-alkaline volcanic rocks and granites are distributed in Kalam area, Pakistan, west centre part of Kohistan arc, northwestern margin of Himalayan Range. Two types of igneous rocks were selected for paleomagnetic study i.e. from altered plagio-rhyolitic pyroclastic flow deposits of Utror volcanics and Stage-1 granitic (Sullivan, 1993). Total 23 samples (5 sites) of the Utror volcanics and 10 samples of the granite were selected for the paleomagnetic study. Ar-Ar dates of the Utror volcanics and the granite are 55 Ma and 78 Ma respectively (Zeitler, 1985, and Treloar et al., 1989). Magnetic mineralogical studies such as optical microscopy, thermomagnetic analysis, IRM acquisition analysis reveals that goethite, titanomagnetite, and hematite are the major ferro magnetic carrier of natural remnant magnetization (NRM) in pyroclastic flow deposits of Utror volcanics while in the granite magnetite is the major carrier of NRM. Progressive thermal demagnetization (THD) analysis was carried out in 13-16 steps up to 675°C for the Utror volcanics while for the granite thermal demagnetization analysis was carried out up to 575°C in 14 steps. Zijderveld diagrams for the Utror volcanics are indicating three components of remnant magnetization; the Component-1, -2, -3. The Component-1 is generally unstable remanance and it can be observed up to THD 300°C. The Component-2 is from 300-540°C, and the Component-3 is above 549°C. On the basis of magnetic mineralogical studies, the Component-1 is recent magnetization due to the presence of goethite-maghemite assemblages which might be formed because of low temperature oxidation. The Component-2 is the magnetization of Ti-poor titanomagnetite in anatase-magnetite assemblages produced from a hydrothermal alteration. The Component-3 is remnant magnetization of hematite in ilmenite-hematite intergrowth, which might be developed because of thermal activity. In the granitic samples there is one component in Zijderveld diagrams it is stable up to 300°C then there is drastic decrease in the NRM intensity u to the 575°C. In the case of Utror volcanics negative fold test as well as optical study reveal that the nature of the remnant magnetization (Comp-2 and 3) is secondary and the mean direction are Declination=139°, Inclination=34° and Declination=138°, Inclination=-30 for the Component-2 and –3. The Paleolatitude of the Component-2 and 3 are 19°N and 16°N. The acquisition of these remanences might be due to the obduction of Kohistan arc on to the Indian continent. By comparing with the present day latitude of the study area it is estimated that there is about 2000-km crustal shortening after the collision. The ChRM in the case of granite is considered to be of primary nature and tilted corrected direction are Declination=114° and Inclination=-14°, therefore the formation of the granite was at lower latitudes i.e., 7°N in 75-78 Ma. The comparison of paleolatitudes of the granitic rocks and Utror volcanics shows that there is about 900-km northward movement after the formation of the granite till the Indian-Kohistan collision. The declination data indicate that there is a counter clockwise rotation after the formation of the granite and the collision.
Key words: Palaeomagnetism, Upper Cretaceous, Kalam, Kohistan Arc.

A/134. Ahmad, M.N., Yoshida, M., Ali, M., Khadim, I.M., Kaneda, H., Karim, T. & Aslam, A., 1993. Geomagnetic and VLF-EM survey of some mineralized zones in Chitral District. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad, 7, 44-71.

The above interpretation can be concluded in following points:
The magnetic method is useful for the exploration of copper deposits as copper is associated with magnetic minerals. The dimensions of the magnetic body associating copper mineralization can be calculated with the help of magnetic anomaly. In Kaldam Gol site estimated reserves are 3400 tons. Siderite ore deposits in limestone are also detectable by geomagnetic method, but modeling is not possible due to weak susceptibility contrast. Geomagnetic method is useful to explore the suture and faulted zones when some serpentinization develops along them.
In case of VLF-EM data there is a strong anomaly of QUAD and PHASE over siderite deposit. However there is little positive response over other ores either because of shallow depth of penetration of VLF waves because of high frequency **(**23.4 KHz) or some transmitter problem.
Key words: Paleomagnetism, Northern Suture, sulphide, Hunza.

A/135. Ahmad, M.N., Yoshida, M. & Fujiwara, Y., 1999. Paleomagnetic study of Utror Volcanic Formation and Deosai volcanics of Kohistan-Ladakh arc, Pakistan, North Western Himalaya. Terra Nostra 99, Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 2-3.

The Kohistan-Ladakh sequence has been considered as an island arc formed during the subduction of oceanic lithosphere at the leading edge of the northward moving Indian plate. The northward movement after collision of Indian plate and the arc led to the formation of the western Himalayan syntaxis.
In order to get information on the tectonic history of the terrane, paleomagnetic study have been carried out on two different volcanic units I) Paleogene Utror Volcanic Formation (55±2 Ma) along with later stage granitic intrusions (45-48 Ma) west of the Nanga Parbat syntaxis, and 2) Late Cretaceous Deosai Volcanics east of Nanga Parbat syntaxis. 210 samples from 20 sites of Utror Volcanic Formation and 55 samples from 10 sites of Desoai Volcanics were collected.
In case of the Utror Volcanic Formation magnetic mineralogical studies, i.e. Curie temperature analysis, IRM analysis and optical microscopic study indicate the presence of various magnetic minerals such as goethite, maghemite, titanomagnetite/magnetite, and titanohematite/hematite. Three magnetic remanence components are revealed from Zijderveld diagrams if progressive thermal demagnetization. All three remanence directions may not be of primary nature as they show scattering after the application of structural correction. The Comp-l is of recent field and may be carried by geothite and maghemite. In the Comp-2 (Declination = 275.6, Inclination 18, α-95= 13.5) and Comp-3 (Declination = 325.3, Inclination = 28.4, α-95=9.6) the mineralogical situation is rather complicated both have magnetite/titanomagnetite and a hematite/titanohematite as magnetic carriers in different sites. Only in two sites are both components observed otherwise one or the other of these is observed. The nature of these two components is seem to be CRM acquired during some hydrothermal processes as the mean paleomagnetic direction of Comp-2 and ChRM of granitic intrusion are the same. Besides this, in optical studies secondary minerals such as zeolite, which is indicator of hydrothermal alterations, is observed. Hence these rocks may possess magnetic minerals which are the result of alterations varying with micro-environmental conditions and time.
The mean paleomagnetic direction of Comp-2 of the Utror Volcanic Formation and the ChRM of granitic rocks of 48~45 Ma is the same, therefore Comp-2 may have been acquired at the time of granitic intrusion. The paleolatitude of Comp-2 (10° N) is in good agreement with the paleolatitude of Ladakh intrusives of 49~45 Ma (Klootwijk et al., 1979). The Comp-3 may be acquired during some latter stage hydrothermal alteration. The constraint on timing of acquisition of Comp-3 can be provided by zircon fission track age 35.9 Ma of these volcanics. Annealing temperature of zircon is more than 200°C suggesting some thermal or hydrothermal activity at 35.9 Ma. By comparing the paleolatitudes with the present latitude, it is calculated that after the acquisition of Comp-2 and Comp-3 there is about 2500-km and 2000-km crustal shortening respectively. There are 850° and 350° counterclockwise rotations after the acquisition of Comp-2 and Comp-3 respectively.
Magnetic mineralogical study of Deosai volcanics reveals maghemite and titano magnetite as the major magnetic carriers. The in situ mean direction of ChRM is Declination = 347°, Inclination 24.3° (α-95 l0°). The comparison of directions before and after structural correction indicates that they are post deformation magnetizations. By comparing the paleolatitude of Deosai volcanics with that of Comp-2, Comp-3, and the Ladakh intrusive ChRM directions, it can be inferred that these magnetization may be acquired between 40~35Ma. The mean of ChRM directions shows about 13° counterclockwise rotation since the time if acquisition of remanence. This is a

discrepancy, when compared with most of paleomagnetic data from the east of western Himalayan syntaxis having clockwise rotation. The similar counterclockwise rotation is also reported from Tethyan sediments from Zanskar range (Appel et al., 1995). Hence much detail paleomagnetic study is required to know the tectonic rotations related to the formation of the western Himalayan syntaxis.
Key words: Paleomagnetism, Utror Volcanics, Deosai volcanics, Kohistan-Ladakh arc.

A/136. Ahmad, M.N., Yoshida, M. & Fujiwara, Y. 2000. Paleomagnetic study of Utror Volcanic Formation: Remagnetizations and postfolding rotations in Utror area, Kohistan arc, northern Pakistan

The Utror Volcanic Formation forms a NE-SW belt with in Kohistan island arc, which lies between the Indian and Eurasian continents in the western Himalayas of northern Pakistan. The Utror Volcanic Formation formed during Late Paleocene, when Kohistan existed as an Andean-type arc on the southern margin of Eurasia. Five to ten block samples were collected from 17 sites of the formation for paleomagnetic studies. Magnetic minerals that serve as remanent carriers are maghemite, magnetite, hematite and titanohematite. Magnetite, hematite, and titanohematite carry the characteristic remanent magnetization (ChRM). The declination values of ChRM are highly discordant before and after structural correction. While inclination values show uniformity in geographic coordinates. The ChRM carried by magnetite yields downward inclinations, whereas the ChRM carried by hematite or titanohematite have upward inclinations in geographic coordinates. The correlation between polarity state and magnetic mineralogy suggests that the acquisition of magnetization occurred during two distinct time intervals. An inclination only fold test of ChRM of these two mineral assemblages indicates that they are post-folding magnetizations. The calculated paleolatitudes for ChRM carried by magnetite and hematite or titanohematite are $9 \pm 4^{\circ}$ N and $13 \pm 4^{\circ}$ N respectively. A comparison of these paleolatitudes with the Indian apparent polar wander path (APWP) shows that the remagnetization likely happened between 55 to 45 Ma. Discordant declinations indicate that these volcanics suffered local rotations after remagnetization event.
Key words: Paleomagnetism, Utror Volcanics, Kohistan.

A/137. Ahmad, M.N., Yoshida, M., Khadim, I.M. & Ali, M., 1993. Preliminary report of paleomagnetic study of Kalam (Utror) volcanics, Kalam area, upper Swat valley, N.W.F.P. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad, 6, 42-59.

Paleomagnetic studies have been performed on the Utror volcanics in order to get information on the tectonic history of the Kohistan island arc. It has been concluded that the Kohistan arc drifted about 10 degree (ca. 1000 km) northward and made 40 degree counterclockwise rotation.
Key words: Paleomagnetism, Utror Volcanics, Swat.

A/138. Ahmad, M.N., Yoshida, M., Khadim, I.M., & Ali, M., 1996a. Magnetic susceptibility observation across Himalaya–Karakoram Range, northern Pakistan with special reference to magnetic modeling of Kohistan Island Arc Crust. In: Khadim, I.M. & Yoshida, M. (Eds.) Rock Magnetism and palaeomagnetism – recent progress in Pakistan. Proceedings Geoscience Colloquium, Geoscience Lab. Geological Survey of Pakistan, Islamabad. 13, 5-21.

Consult the following for further details.
Key words: Geophysics, magnetic susceptibility, Kohistan arc, Himalaya, Karakoram.

A/139. Ahmad, M.N., Yoshida, M., Khadim, I.M., & Ali, M., 1996b. Magnetic susceptibility observation across Himalaya–Karakoram Range, northern Pakistan with special reference to magnetic modeling of Kohistan Island Arc Crust. Trans. American Geophysics Union, EOS, 77 (22), Western Pacific Geophysics Meeting. Suppl., W28.

Bulk magnetic susceptibility observation was performed for rocks exposed along the Karakoram Highway, northern Pakistan, traversing from Hasan Abdal town, the north-western margin of Indo-Pakistan subcontinent, to the

Ghujerab River, southern part of the Karakoram block which is a part of the Eurasian continent. The variation of magnetic susceptibility corresponds well to the rock type, and in general the Kohistan island arc occupying between the subcontinent and the Eurasian continent appears as a relative higher susceptibility zone. This anomalous contrast in magnetic susceptibility is derived from lithologic contrast, i.e. the Kohistan island arc sequence mainly consisting of igneous rocks which are often rich in iron bearing minerals as compared to the surrounding terranes. The magnetic susceptibility is high over Main Mantle Thrust (MMT) and Main Karakoram Thrust (MKT) because of the presence of serpentinite bodies. On the basis of the susceptibility variation data of Kohistan island arc, a five layer model of magnetic structures of island arc crust is proposed. Köensberger ratio of the rocks is less than 1.0 except that of mafic igneous rocks, gabbro and, norite of Chilas complex. Most of granitic rocks in the area are correlated with ilmenite-series showing low magnetic susceptibility while the granitoid body in the northern part of the Kohistan batholith arc solely belongs to magnetite-series, which is probably the indication of deep angle subduction.
Key words: Magnetism, Kohistan Island Arc, Himalaya, Karakoram.

A/140. Ahmad, M.N., Yoshida, M., Khadim, I.M., Ali, M. & Kausar, A.B., 1994. Geomagnetic and VLF-EM survey over northern Suture Zone and Nomal sulphid mineralized zone, Hunza, northern Pakistan. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad, 8, 57-70.

On the basis of the discussions, the following points can be inferred.
1. The magnetic anomalies over the Northern Suture zone look to be strongly, effected by the lithologies. Geomagnetic field shows anomaly in the suture zone, hence geomagnetic method is useful to recognize the suture zone because of their typical magnetic character and subsurface structure modeling of the suture zone is also possible.
2 In- Phase parameter of VLF-EM sounding shows anomaly over mélange in the suture zone due to the conductivity contrast. Therefore the VLF-EM survey is useful to survey in the suture zone.
3 There is no magnetic anomaly over the sulphide zone, hence it can be said that geomagnetic method cannot be used for the evaluation of Nomal sulphide
Key words: Paleomagnetism, Northern Suture, sulphide, Hunza.

A/141. Ahmad, M.U., 1981. Jadeed sciency Nazriat ki bunyad per Pakistan main madaniat ke talash. (Urdu report). GSP Information Release 153.

Key Words: Mineralization, economic geology.

A/142. Ahmad, M.U., 1992a. Porphyry copper in Pakistan. GSP, Mineral Information Release 9.

Key words: Mineralization, copper.

A/143. Ahmad, M.U., 1992b. Industrial minerals of Pakistan (A Resume). GSP, Mineral Information Release 12.

Key words: Industrial Minerals.

A/144. Ahmad, M.U., & Calkins, J.A., 1969. Geology of the Terbela damsite area, Peshawar division, West Pakistan. GSP and U.S. Geological Survey Project Report PK (IR)–47.

Key words: Tarbela, Damsite.

A/145. Ahmad, M.U., Khan, A.L., & Abbas, S.G., 1992. Industrial mineral potential of Pakistan. GSP Information Release 534, 8p.

Key words: Industrial minerals, economic geology.

A/146. Ahmad, N., 1960. Soil erosion by the Indus and its tributaries. Pakistan Geographical Review 15, 5-17.

Key words: Soil, Erosion, Indus.

A/147. Ahmad, N., 1972. Geological report on Khanpur Hazara Dam area. M.Sc. Thesis, Punjab University, 110p.

Key words: Khanpur dam, Hazara.

A/148. Ahmad, N., 1983-85. Geology and Petrology of Burawai Area, Upper Kaghan Valley, District Mansehra, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 119p.

Nearly 114 km^2 area in the vicinity of Burawai, upper Kaghan Valley has been geologically mapped, at 1:18,000 for the first time. This thesis presents first time accounts of geomorphology, lithostratigraphy, petrography and economic geology of the area. The area constitutes rocks representing old Indo-Pak basement rocks, comprising pelites, calc-pelites and marbles, have been metamorphosed to kyanite and sillimanite grades. These are intruded by para-autochthonous sheet granites also metamorphosed. Major structure comprises an open synform possibly part of a larger structural basin. The western part comprises the nose of a larger antiform.
Marble, biotite mica and kyanite are important mineral deposits, which deem further exploration and evaluation. This thesis also includes petrogenesis of the rock units as well as numerous sketch and photographs, illustrating the geology of the area.

Key words: Petrology, Kaghan, Mansehra.

A/149. Ahmad, N., 1985-87. Geology and petrography of Luat-Thod Area, Neelum valley (Azad Kashmir) with special emphasis on metamorphites. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 111p.

The project area is a part of Middle Himalayas and covers about 350 sq. km. located between Doarian and Thod in Neelum Valley (Azad Kashmir) at the scale 1: 25,000 of topographic sheet No. 43 F/13, 43 F/14 and 43 J/2 of survey of Pakistan. The studied area comprises of broader lithology of Salkhala formation containing predominantly metapelites, psammites and calcareous material. Various granitic and basic bodies are also outcroping the area. Basic bodies are present as dykes and sills. The metasediments of Salkhala formation have witnessed metamorphism and deformation. The metamorphism undergone by metasediments is of regional reverted character involved from green schist to Almandine- Amphibolite facies. The area is rich in economic rocks and mineral deposits are discussed briefly.
Key words: Petrography, Metamorphism, Neelum, Azad Kashmir.

A/150. Ahmad, N., 1986-88. Petrofabrics, facies analysis and basin studies of Samana Suk Formation in Hazara and Margalla Hills of Pakistan, along a tentative study of its source? Reservoir potential. M.Sc. Thesis, Punjab University, Lahore, 95p.

Key words: Basin analyses, Samana Suk, Margalla, Mansehra.

A/151. Ahmad, N. 1990. Rock phosphate of Kakul area of Hazara District. Abstract, 2nd Pakistan Geological Congress, University of Peshawar, p.10.

Phosphorite deposits are present at Kakul area in Hazara District. The chemical analysis and various techniques employed show that P_20_5 contents are in the range of *25-30%;* other impurities are well within the permissible limits except at some horizons, where carbonate and iron contents are on the high side. Moreover, acid volume, concentration and temperature effect have also been studied, and for the maximum recovery of P_20_5 contents,

suitable volume, concentration and temperature have been determined. The techniques used are Gravimetric, Volumetric, Spectrophotometric and atomic absorption spectroscopy. A comparison of all the four methods has been made and advantages of each method have been pointed out.
Key words: Geochemistry, Phospahte, Hazara

A/152. Ahmad, N. & Ali, D., 1961. Sediments characteristics of Indus with reference to erosion of the catchment. Pakistan Journal of Forestry 11.

Key words: Sediments, Erosion, Indus.

A/153. Ahmad, N. & Ali, D., 1962. Sediments of the Indus. Journal, West Pakistan Water and Power Development Authority.

Key words: Sedimentology, Indus.

A/154. Ahmad, N. & Ali, D., 1968. Sediment production, transport and an estimate of soil erosion for West Pakistan. Proceedings, First West Pakistan Watershed Management Conference, Peshawar, 151-174.

Key words: Sediments, erosion, West Pakistan.

A/155. Ahmad, N. & Chaudhry, M.N., 1999. A study of oil shales of Kohat Basin, Pakistan. Pakistan Journal of Geology 10 & 11, 1-8.

Key words: Oil shale, Kohat.

A/156. Ahmad, N. & Chisti, H.M., 2000a. Thermogravimetric analysis of selected samples of Pakistani oil shales in dynamic air atmosphere. Abstracts, Third South Asia Geological Congress, Lahore, p.148.

Thermogravimetry is a rapid and widely used technique for the characterization of oil shale and other rocks with organic content of any extent. The thermal behavior of such rocks in a-dynamic air environment may show characteristic of both the organic and inorganic (mineral) content of the sample. This study presents oxidative profiles of five samples of the Cambrian and the Early Eocene oil shales of Pakistan. These profiles showed extra peaks in comparison to the profiles in an inert atmosphere, which believed to due to loss of inter-layer water from clay minerals, and oxidation of organic matter in the samples.
Some samples of the Early Eocene oil shale showed a major carbonate decomposition 'peak (> 600º C), some samples indicated minor carbonate decomposition in the same region, while the sample from the Cambrian oil shale was completely devoid of any carbonate peak. Thermogravimetric analysis of these oil shales in an inert atmosphere showed that the major DTG pyrolysis peak for all the samples was singular in nature, with an average T_{man} of 475º C for the Cambrian oil shale. However, the oxidative characteristics of the organic components of these oil shales in the 230ºC – 520º C region are multi-step in nature, with two major oxidative events at about 350º C – 450º C and 480º C, The rate of weight loss of the first oxidative events was greater than the second event for all samples. Also, a shouldering effect was observed at about 346º C in the Cambrian oil shale.
Key words: Thermogravimetry, Oil shale.

A/157. Ahmad, N. & Chisti, H.M., 2000b. Geochemistry of oil shale deposits of Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.149.

The Eocene and Cambrian oil shales are found in the Kohat Basin and the Sat Range Formation of Pakistan. Little has been done to characterize these deposits or to estimate their economic potential and their upgrading as a viable

energy source. These oil shales were deposited in a hydrologically restricted, shallow marine, land locked sea, representing a hypersaline environment. The Jutta gypsum unit in the Kohat Basin contained an oil shale horizon occurring at about 27-30 m below the top of this unit, the gypsiferous shales of the Salt Range Formation contained 3-5 m thick layer of oil shale. The mineralogical composition varies significantly between two deposits; the Eocene oil shales consist of clays-mainly an illite/smectite mixed layer, and quartz with a subordinate amount of dolomite and pyrite, whereas the Cambrian oil shale mainly contains quartz and gypsum with a minor content of chlorite and pyrite. Major and trace element contents of both deposits also differ significantly, in particular the exceptionally higher concentrations of vanadium and chromium in the Cambrian oil shales. The oil shales were retorted in a fixed bed pyrolysis unit to determine the yield of oil. The spent shale, oil and retort water were also analyzed for trace metal content to determine the partitioning of the trace metals between the product streams. These deposits were characterized by high concentrations of alginate rich organic matter. The carbon and hydrogen content of both oil shales were similar, but the Eocene oil shale, on average, gave higher yields of oil during the retorting of the oil. The Eocene oil shale had an average oil yield of 13% with a maximum value of 20%, whereas the Cambrian oil shale exhibited an average yield of 1 1 % with a maximum value of 14%.
Key words: Geochemistry, Oil shale.

A/158. Ahmad, N. & Pervez, S.D., 1960. Soil erosion in northern region of West Pakistan. Indus 1(7).

Key words: Soil, erosion, West Pakistan.

A/159. Ahmad, N. & Pervez, S.D., 1963. Soil erosion in northern regions of West Pakistan. Pakistan Journal of Forestry 13, 291-195.

Key words: Soil, Erosion, West Pakistan.

A/160. Ahmad, N., Qaiser, M.A. & Amin, M., 1990. Comparative evaluation of laterite deposits of Pakistan. Pakistan Journal of Scientific and Industrial Research 33, 7, 265-00.

Studies on various samples of laterites from Cherat, Attock, Abbottabad, Sargodha and Ziarat areas of Pakistan were carried out by chemical, X-ray powder diffraction and thermal analysis for comparative evaluation. The minerals identified in these laterites are vermiculite, goethite, calcite, limonite, hematite, quartz, kaolinite, diaspore, boehmite and illite.
Key words: Laterite deposits.

A/161. Ahmad, N. & Williams, P.T., 1998. Influence of particle grain size on the yield and composition of products from the pyrolysis of oil shales. Journal of Analytical and Applied Pyrolysis 46, 31-49.

Oil shales from two regions of Pakistan have been pyrolysed in a fixed bed reactor in relation to particle grain size. Five size ranges were investigated, <0.5, 0.5–1.0, 1.0–1.7, 1.7–2.8 and 6.0–10 mm. The pyrolysis system consisted of a 200 cm3 stainless steel fixed bed reactor externally electrically heated. The samples were heated to 520°C at 10 K min−1 and the oil shale sample was continuously purged with nitrogen to remove the pyrolysis products from the reactor and to minimise secondary reactions. The gases were analysed for their content of CO, CO_2, H_2, CH_4 and other hydrocarbons up to C4. The derived pyrolysis oil was condensed in a series of cold traps and the total oil yield determined. In addition, experiments were carried out on a thermogravimetric analyser using the three smallest particle grain sizes under identical heating conditions to the fixed bed reactor. It was found that increasing the particle size up to the largest size used of 10 mm resulted in an increase in oil yield. The total gaseous yield was decreased, reflecting a decrease in concentration for H_2, CO, CO_2 and the majority of the hydrocarbon gases. The raw oil shale samples of various particle size ranges were analysed to determine the elemental composition and surface area to determine their influence on the compositional changes in oil and gaseous yield with particle size range.
Keywords: Oil shale, Pyrolysis, TGA.

A/162. Ahmad, R., 1957. Radioactive minerals in parts of Hazara District. Abstract, 9th All Pakistan Science Conference, Peshawar, p.118.

Key words: Radioactivity, Hazara.

A/163. Ahmad, R., 1963. A Cassidulid Achnoid from the so-called “Triassic Limestone” of Hazara District. Geological Bulletin, Punjab University 3, p.35.

During the 1963 summer field season the writer worked in the Thandiani locality and collected some echinoid remains from the upper beds of the so- called "Triassic Limestone" of the Hazara District. Complete specimens were not obtainable, but the evidence furnished by the fragments shows that they belong to the genus Pygurus of the family of the cassidulidae of the irregular echinoids (Zittel, 1900). A drawing of one of the pieces is shown in Fig. 1. The range of this genus is from upper Jurassic to Cretaceous. Its presence in the Nerinea Horizon confirms the view that at least, the upper part, of the limestone is of Jurassic age, as was indicated by the forms of Nerinea reported on by Aftab Ahmad (1962). This is the first time that cassidulids have been recorded in this formation.
Key words: Palaeontology, limestone, Hazara.

A/164. Ahmad, R., 1981-83. Geological mapping with special studies of discontinuities in rocks and their effect on the rockmass strength at Kalabagh Damsite. M.Sc. Thesis, Punjab University, Lahore, 124p.

The Department of Geology was upgraded to an Institute in 1979. According to the new rules and regulations three year B.Sc. Applied Geology Courses were introduced. In accordance, with these rules 1 1/2 year courses in studies were established leading to M.Sc. Applied Geology Degree. This comprehensive research report about a particular geological project has been submitted as a part of the M.Sc. Examination.
Our group comprising four students was allotted a Geo-Engineering problem, with special emphasis on the study of discontinuities at the proposed Kalabagh Dam site. Kalabagh dam site is 10 miles upstream of Kalabagh Town, situated just below the confluence of Soan and the Indus River. According to initial investigation height of the dam is proposed 945 feet above mean sea level, with reservoir level 925 feet above mean sea level. This dam is going to be constructed for hydro-electric, irrigation and flood control purposes.
We spent about one and a half month at the site in July and August, 1984. Again we made a short visit in the middle of December, 1984, to review our previous work. Extensive studies relating to our problem were made under the guidance of Mr. M.H. Malik, Assistant professor, Institute of Geology.
In this Research Report conventional topics like History, Physiography Stratigraphy, Damsite Geology, and Structural Setting of the area and Hydrology have been discussed in detail. These topics are spread in six chapters i.e. from Chapter No.2 to 7.
Key words: Mapping, damsites, Kalabagh.

A/165. Ahmad, R. & Ahmad, F., 1962. Geology of Rupper area south-west Hazara. M.Sc. Thesis, Punjab University, Lahore, 30p.

Key words: Geology, Hazara.

A/166. Ahmad, R., & Ali, S.T., 1977. Occurrence of Phosphate in Loe–Shilman Carbonatite, Khyber Agency, NWFP, Pakistan. GSP Information Release 101, 19p.

Key words: Phosphate, carbonatite, Khyber Agency.

A/167. Ahmad, S., 1972. Geochemistry and physical properties of chromites from Pakistan. Ph.D. Thesis, Punjab University, Lahore, 212p.

Seventy two chromite specimens have been studied from Hindubagh, Harichand and Fort Sandeman areas of Pakistan. Out of these sixty seven samples were selected from Hindubagh area comprising Nisai, Saplai torghar, Jung troghar and North Hindubagh. Three samples from Harichand and two from Fort Sandeman were studied for purposes of comparison.
Chromites with different structures such as orbicular, nodular, banded, disseminated and chain, have been observed and are described briefly. Colour of chromites in thin section varies from brownish yellow to deep cherry red. Brownish yellow chromites have been found to have low Cr/Fe ratio as compared to deep cherry red chromites.
Some chromites showed alteration with opaque alteration products along cracks or along the grain boundaries. Such chromites showed the presence of abnormally high amount of Fe_2O_3 as compared to other chromites which are without such alteration. Such chromites gave a number of sizable chromite separation on an isodynamic separator. The variation in chemistry of fractions of a chromite specimen from mine 155 is described. The main inference is that chromite fractions obtained at 0.1 Amp has Fe_2O_3 16.28% as compared to the fraction separated at (0.4 Amp.) which has Fe_2O_3 10.35%.
An improved scheme for chromite analysis is presented, the accuracy of which has been checked on synthetic standard. A gradual change in chemical composition of chromites was observed from Nisai (Cr/Fe ratio 2.24-2.99) to Jungtorghar (Cr/Fe 2.52-3.75). A variation in chemistry has been found with in a mine e.g, in mine 7ML Cr/Fe ration varies. Certain physical properties such as, specific gravity and micro-indentation hardness, have been determined on all the specimens, whereas cell edge dimensions and Refractive indices were determined on some selected specimens. These physical properties were compared with chemistry and a relationship was found to be present, between specific gravity and chemistry of chromites from Hindubagh in the form of a mathematical expression. This can be used to estimate weight percentage of Cr_2O_3. Al_2O_3 and MgO in Hindubagh chromites from known values of weight percentages of FeO, Fe_2O_3 and specific gravity. The results obtained showed the error to be within 5% of the contained oxides.
A relationship was also found to exist between cell edge dimension and weights percentages of Cr_2O_3. This relationship helped to derive a method by means of which weight percentages of Cr_2O_3, FeO and MgO of Hinudbagh chromites can be determined within about 5% of the contained oxides. The other two physical properties, Micro-indentation hardness and refractive indices showed no definite relationship which could be sued determine the weight percentages of the constituents oxides. However a rough conclusion that can be drawn is that chromites with a higher Al_2O_3 weight percentages have higher values of Vickers hardness number and refractive index
Key words: Geochemistry, chromite.

A/168. Ahmad, S., 1976. Geochemistry of chromites from Harichand, Malakand Agency, Pakistan. Geological Bulletin, University of Punjab 12, 91-96.

Chemical analyses of three purified chromite samples from Harichand area Malakand agency are presented and compared with chromites from Muslimbagh. A number of diagrams have been drawn to present the chemical data. The analysed Harichand chromites are aluminian chromite with tendency towards chromian spinel due to high alumina. Micorhardness and specific gravities of all the specimens are presented whereas cell edge dimension and refractive indices of two samples are given.
Key words: Geochemistry, Chromite, Malakand.

A/169. Ahmad, S., 1980. A study of opaque minerals in rocks of Thak Valley igneous complex, North West Frontier Province, Pakistan. Pakistan Journal of Science 32, No. 3-4, 199-200.

Key words: Opaque minerals, Thak valley, Chilas complex, Kohistan arc.

A/170. Ahmad, S., 1981a. Preliminary account of the occurrence of Ni sulphides in serpentinites of Souch area, Kaghan Valley, District Mansehra, North West Frontier Province, Pakistan. Geological Bulletin, Punjab University 16, 172-174.

Souch area lies between longitude 73 40' -73 45 E and latitude 34 55'-34 59' 30" N. Qadir (1979) has described in detail the Petrology of the area and classified the area into three groups.

1. Metamorphic rocks consisting of garnet mica schist, graphitic schist, marble, amphibolites.
2. Quartzofeldspathic rocks consisting of granite gneiss, pegmatites, aplites.
3. Ultramafics, consisting of dunites, Serpentinites, Pyroxenites, Talc and Carbonates.

The first outcrop of the ultrabasic is at 19 km. above Lidi a small village on right bank side of river Kunhar. Chemical analysis of two serpentinite rock samples showed Ni--0.28 to 0.32%. The rock under study was weathered to greenish black and fine to medium grain size. The major minerals are antigorite, chrysotile, olivine forsterite, with small amounts of magnesite, magnetite heazlewoodite and pentlandite. The presence of heazlewoodite and pentlandite, was identified by the Ore-microscopic techniques, such as, reflectivity, microhardness and etch tests described by Cameron (1961) and Ramdohr (1969).

These two minerals occur as small disseminated among and molded about silicate minerals, and appears to be a primary accessory of the ultrabasics. The texture of mineral assemblages and their association favours the Phenomenon of Sulphide-silicate immiscibility and consequent magmatic differentiations in situ. Such sulfide disseminated in ultramafic rocks have been reported by many workers, such as Souch, Podolsky et a1 (1969), from Sudbury deposits Canada and Woodal and Travis (1969) from kambalden deposits in Western Australia. In these, sulfides grade from minor disseminations in ultramafic rocks to massive ores. The disseminated ores appear to represent an early stage of the process that formed massive ores. A detail work on the other ultramafic rocks of the area is in progress and will be published soon. The author is highly thankful to Mr. Qadir for providing samples.

Key words: Mineralogy, Ni sulphides, serpentinite, Kaghan, Mansehra.

A/171. Ahmad, S., 1981b. Physico-chemical method for determination of chemical composition of chromite. Geological Bulletin, Punjab University 16, 43-65.

Key words: Chromite, geochemistry.

A/172. Ahmad, S., 1983-85. Geotechnical studies of land slides with special emphasis on slope stability along Karakorum highway between Thakot and Besham, District Swat. M.Sc. Thesis, Punjab University, Lahore, 117p.

Engineering geological investigations were carried out about the land slides and slop stability problem along the Karakoram Highway between Thakot and Besham. The project area mainly comprises of Thakot metasediments, Lahor granite, Shang granite gneiss and mineralized scree (near Besham). These are mainly controlling the rugged topography and other geomorphological features of the project area. The general trend of stresses is SE-NW.

So far the stability of the region is concerned, the detailed analysis for critical slopes is performed. Among different modes of failure encountered, the plane failure is proved to be unstable particularly near Maira and at Kandaurgai. Other than this a large variation in discontinuities is observed that controls sliding in hard rocks and highly weathered rocks which are responsible for mass wasting and rock fall. Road alignments were studied keeping in view landslide problems and slop stability, for potentially unstable regions remedial measures are also given, for potentially unstable regions remedial measures are also given. 1h; 2v cut slopes and benches are proposed. Benches may be provided at each 8 meters interval.

Key words: Geotechnical study, land slides, Besham, Swat

A/173. Ahmad, S., 1984. Necessity for geochemical prospecting in Pakistan. Abstracts, First Pakistan Geological Congress, Lahore, 45-55.

The validity of geochemical methods in the exploration of new mineral resources and development of already known deposits is well established all over the world. An application of these methods in a number of areas from Pakistan such as Kirana Hills, Kaghan Valley, Malakand, Nomal-Chalt and Swat showed encouraging results. Regular geochemical survey of the country is recommended.

Key words: Geochmical prospecting, exploration.

A/174. Ahmad, S., 1988. Total magnetic survey of the central Potwar and adjoining area. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 42p.

Key words: Magnetism, Potwar.

A/175. Ahmad, S., 1989. Groundwater investigation in Rawalpindi. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 44p.

Key words: Ground water, Rawalpindi.

A/176. Ahmad, S., 1990. Geology of southern Tanawal area, north of Haripur, N.W.F.P., Pakistan. M.Phil. Thesis, University of Peshawar, 51p.

The southern Tanawal region exposes a suite of metasedimentary rocks comprising of conglomerate, argillite, quartzite and dolomite. The basala sequence –unfossiliferous quartzite of Precambrian age belongs to Tanawal Formation and is unconformably overlain by thick succession of argillite, quartzite and dolomite of Cambrian age. This assemblage of younger metasediments is named as Sherwan formation.
The southern tanawal area lies on the hanging wall side of the Panjal fault and is largely influenced by the deformational pattern associated with this fault.
Key words: Geology, stratigraphy, Tanawal, Hazara.

A/177. Ahmad, S., 1991. Distribution of major and trace elements in soils and adjoining rocks of Yasin valley. Culture Area Karakorum Newsletter (Tubingen) 1, p.11.

Key words: Geochemistry, trace elements, Yasin Valley.

A/178. Ahmad, S., 1992a. Distribution of major and trace elements in soils and adjoining rocks of Gilgit, Northern Areas. Culture Area Karakorum Newsletter (Tubingen) 2, p.20.

Key words: Geochemistry, soil, Gilgit.

A/179. Ahmad, S., 1992b. Distribution of major and trace elements in soils and adjoining rocks of Gilgit, Northern Areas. Mountnews (Lahore) 5, 30-31.

Key words: Geochemistry, soil, Gilgit.

A/180. Ahmad, S. & Farooq, U., 2000. The distribution behavior of trace elements during combustion of Surghar Range coal and their environmental effects. Abstracts, Third South Asia Geological Congress, Lahore, p.162.

The Surghar Range coal fields comprise of Makarwal, Gula Khel and Kurd coal fields, constituting the northernmost part of the Trans-Indus mountains. The distribution behavior of hazardous trace elements, As, Be, Cd, Cr, Cu, Pb, Mn, Hg, Ni, Sb, Se, V and Zn present in the Sughar Range coal deposits, indicate that these are concentrated within clay and sulphides minerals. During combustion of coal, these elements seggregate between flyash and coal ash. Although contents of trace elements in coal are only in parts per million, the amount of coal used for burning purposes is so great that quantity of elements released to the environment may become higher than the permissible among limits. As the human race is highly dependent on complex interrelations among the biosphere, atmosphere, hydrosphere and lithosphere, the dispersed particulate matter and the gaseous pollutants in general, present in the flyash could be injurious to health during mining in particular and to the environment.
Key words: Trace elements, coal, Surghar range.

A/181. Ahmad, S. & Ahmad, D., 1995. Tectonic Analysis of the Kohat plateau boundary zone, NW Himalayas, NWFP, Pakistan. Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

The southern most structural boundary of the Kohat Plateau is herein named as Kohat Plateau Boundary Zone. It is about 120 Km long with width ranging from 510 kms and trends East-West. Towards the west it is bounded by the Kurram fault whereas towards the East it joins the Kalabagh fault.
The Kohat Plateau Boundary Zone is characterized by strike slip, deformation in addition to the thrust slip deformation having transtensional and transpressional bends. Towards the west, the Boundary zone exhibits transtensional deformation with large-scale normal faults and form negative flower structure. Towards the east, north of Karak it exhibits transpressional deformation forming positive flower structure and is characterized by large-scale reverse faults.
All the kinematic indicators and ages of rocks involved in the deformation shows that the Kohat Plateau Boundary Zone has experienced a Plio-Pleistocene phase of strike slip deformation with sense of motion being right lateral.
Key words: Tectonics, structure, Kohat Plateau.

A/182. Ahmad, S., Ahmad, I. & Ghauri, A.A.K., 1990. The geology of southern Tanwal area, north of Haripur, Hazara, NWFP, Pakistan. Abstract, 2nd Pakistan Geological Congress, University of Peshawar, p.38.

The southern Tanawal area exposes a suite of metasedimentary rocks comprising quartzite, dolomite, argillite and conglomerate. These rock units are grouped into two stratigraphic units: (a) Lower Tanawal Formation and (b) Upper Sherwan Formation.
The Precambrian Tanawal Formation consists of unfossiliferous quartzite with thin intercalations of argillite; whereas the unconformably overlying Sherwan Formation comprises younger quartzite, dolomite, argillite and dolomite of Cambrian age. These rock units represent the hanging wall of the Panjal fault and constitute a series of north-east trending overturned folds and north dipping thrust/reverse faults. The overturned folds invariably verge; southward and the orientation of both the faults and folds vergence indicates a southward directed tectonic transport which is typical of the foreland fold-and-thrust belt of the Hazara Himalaya. The Panjal fault which runs south of the study area exhibits ramp and flat geometry beneath the southern Tanawal area and it is inferred that the structure of this region took shape during the development of Panjal fault.
Key words: Metasediments, Tanawal, Haripur, Hazara.

A/183. Ahmad, S., Ahmad, I., Ghauri, A.A.K. & Riaz, M., 1992. Revised stratigraphy of the southern Tanawal area, North of Haripur, NWFP, Pakistan. Kashmir Journal of Geology 10, 153-160.

The southern Tanawal area exposes a suite of metasedimentary rocks comprising quartzite, dolomite, argillite and conglomerate. The oldest rocks belong to the Tanawal Formation of Precambrian age. The Tanawal Formation is unconformably overlain by a thick sequence of quartzite, dolomite, argillite and conglomerate, previously named as Abbottabad Formation. Baig and Lawrence (1987) renamed this sequence as Sherwan Formation and considered it to be of Cambrian age. The stratigraphy of the area is revised in order to differentiate between the dolomite-quartzite sequence exposed north and south of the Panjal fault in the southern Hazara region.
Key words: Stratigraphy, Tanawal, Haripur, Hazara.

A/184. Ahmad, S. & Ahmed, Z., 1974. Petrochemistry of the Ambela granites, southern Swat District, Pakistan. Pakistan Journal of Scientific and industrial Research 26, 63-69.

This paper presents a petrographic and chemical study of the granites together with five chemical analyses. The rocks are discussed with reference to the Peshawar plain alkaline igneous province. The granites are considered to be comagmatic with the Warsak and Shewa-Sheh Baz Ghari microgranites and the Warsak alkaline granites.
Key words: Geochemistry, petrology, Ambela granites, Swat.

A/185. Ahmad, S., Ali, F., Ahmad, I. & Hamidullah, S., 2001. Geological map of Kohat Plateau North-West Himalayas, NWFP, Pakistan. Geological Bulletin, University of Peshawar 34.

This is a colored geological map at a scale of 1:133000. Structural elements are shown together with Main Boundary Thrust in the north of the map. The rocks range from Jurassic to Pleistocene (overlain by Quartarnary alluvium), with a hiatus of Oligocene.
Key words: Geological Map, Kohat Plateau, Himalaya,

A/186. Ahmad, S., Ali, F., Ahmad, I. & Hamidullah, S., 2001. Structural geometry of the Himalayan frontal thrust zone: Surghar Range, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.32.

Surghar Range of the outer Himalayas in Pakistan represents the active deformational front of Kohat fold-thrust belt, which is migrating southward in response to the underthrusting of Indian craton underneath its sedimentary cover. The surface expression of the range in the vicinity of Chichali pass is characterized by south facing Surghar anticline at the level of Jurassic. Its southern limb is dissected by Surghar thrust, which moderately dips towards north and is detached within or at the base of Triassic sequence. Several out of sequence thrust faults are mapped south of the major ramp structure representing migration and structural disruption from the main locus of crustal shortening in the range interior towards Punjab foreland. Variations in the structural geometries along the range front suggest that it is a strongly emergent thrust in the west (north of Kutki village) and translates into a tip-stick thrust front in the east (north of Chapri and ToIa Mangli village). The restored cross-section along Kutki section reveals that 5.6 Km overall shortening has taken place along the Surghar Thrust. The available constraints on the timing of deformation suggest that the uplift along the range front started 2.3 Ma ago.
Key Words: Structural Geometry, frontal thrust zone, Surghar Range.

A/187. Ahmad, S., Ali, F., Ghauri, A.A.K. & Danishwar, S., 1994. Imprints of transpressional deformation on the southern Kohat plateau, NW Himalayas, NWFP Pakistan. Journal of Nepal Geological Society 10, Abstract Volume 9th Himalaya-Karakoram-Tibet Workshop, Kathmandu, 5.

We present evidence for Plio-Pleistocene transperssional deformation in the Kohat Plateau, which is part of the NW Himalayan foreland Fold and thrust belt of N. Pakistan. The Karak structure in the SW Kohat Plateau is interpreted as an E-W trending positive flower structure, which is exposed for 20-km along strike and is about 5-km wide. It is bounded by the N-dipping Karak thrust in the south and the S-dipping Nari Panos backthrust in the north and internally subdivided by the south dipping Banda Kunghara backthrust. All these faults trend E-W and have moderate surface dips. A right lateral component of deformation along the Karak structure is indicated by ENE directed trends of the Daggar syncline in the footwall of the Nari Panos backthrust and of small scale thrusts in the core of this syncline. A strong lateral component of deformation along the Karak structure is also in accordance with seismic data (906-NSK-47) which indicate rapid steepening of the Karak and Nari Panos thrusts to near vertical with depth.
Right lateral transpression along the Karak structure is also supported by ENE trending en-echelon folds south of Banda Charpara. This work emphasizes the importance of transpression within the NW-Himalaya on a regional scale. Recent work by Beck et al. (in prep.) has suggested transpressive deformation along the Main Boundary Zone (MHZ) to the west of the Kohat Plateau.
Key words: Structure, deformation, Kohat Plateau.

A/188. Ahmad, S., Ali, F., Rehman, N. & Gul, J., 2000. Lithostratigraphy of the Kurram Group rocks along Mirali-Miran Shah road, North Waziristan Agency, NWFP, Pakistan. Geological Bulletin, University of Peshawar 33, 79-86.

This study focuses on the identification and description of a thick Mesozoic sequence exposed along Mirali-Miran Shah road in North Waziristan Agency, previously named Kurram Group. The detailed field investigation have resulted in establishing six distinct lithostratigraphic units, ranging in age from Late Triassic to Late Cretaceous with Dominant lithologies being limestone, sandstone, shale, and siltstone. The oldest rocks i.e. Triassic of the area is named as Spalga Formation. The contact between the Triassic and the base of Jurassic is marked by a thrust fault in the entire mapped area. The Jurassic rocks are represented by a thick sequence of limestone and shale, which are divisible into two formations named as Sarobi Formation and Isha Formation. These rocks are discomformably overlain by the Cretaceous sequence, which includes Chashmai Kharsai Formation, Marsi Formation and Zerghar Formation. Except the Triassic, all the rocks assemblages have yielded fossils of their respective age. The fauna and lithology of the area is broadly correlative with Mesozoic rocks of Samana- Kohat area towards north and Baluchistan Province in the south.
Key words: Lithostratigraphy, Kurram group, Miran shah, North Waziristan.

A/189. Ahmad, S., Ali, F., Sayab, M., Ahmad, I. & Hamidullah, S., 1999. Structural geometry of the Himalayan Frontal Thrust Zone: Surghar Range, Pakistan. Geological Bulletin, University of Peshawar 32, 13-23.

Surghar Range of the outer Himalayas in Pakistan represents the active deformational front of Kohat fold and thrust belt. The range is migrating southwards in response to the underthrusting of Indian craton underneath its sedimentary cover. The structural geometry of the range, in the vicinity of Chichali pass area is chractersied by a south facing anticline i.e. Surghar anticline at the level of Jurassic. It is interpreted to be a fault bend fold above a major ramp detached within or at the base of Triassic rocks. The range front is thrust southwards over Punjab foreland along Surghar fault, which is interpreted as south verging fore thrust. The thrust sheet above Surghar fault displays contrasting structural geometries along strike. The Surghar fault is believed to be a strongly emergent thrust in the west (north of Kutki village) having shallowly folded thrust sheet. Eastwards, the Surghar fault translates into a tipstick thrust front (north of Chapri and Tola Mangli village) with its thrust sheet being tightly folded and disrupted by several out of sequenced thrust faults. The restored cross section along Kutki section reveals that 5.6 km shortening has taken place along Surghar Fault. The constraints upon the timing of deformation suggest that uplift along range front started about 2.3 Ma ago.
Key words: Structure, Surghar Range, Himalaya.

A/190. Ahmad, S. & Humayun, Q.M., 1980. Detail Geology of phosphorite bearing rocks of southern Lagarban area, Abbottabad. M.Sc. Thesis, Peshawar University, 65p.

This report gives details of the area south west of Garhi Habibullah. The thesis area is a synclinorium. The rocks deposited are folded. Some details of the stratigraphy and structure is given.
Key words: Structure, Phosphorite, Abbottabad.

A/191. Ahmad, S. & Mirza, K., 1999. Palynostratigraphy of the Lower Jurassic Datta Formation from the Salt Range, a major tectonic unit of Pakistan Himalaya. Terra Nostra 99 (Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany), 3-4.

The Salt Range, the most well studied area of the Upper Indus Basin, is one of the major tectonic units of the Pakistan Himalayas. It is regarded as a key region for understanding the stratigraphy of Pakistan. It is known as the "Field Museum of Geology" because of its almost complete stratigraphic sequence with excellent exposures from the pre-Cambrian through the Pleistocene. The Salt Range is situated between the Sargodha High and the Jhelum plain in the south and the Potwar Plateau in the north, respectively. The Salt Range and its Trans-Indus extensions are the result of tectonic forces imposed during the collision of the Indian and Eurasian plates. The exposed stratigraphic units are mainly unmetamorphosed sediments. The Lower Jurassic rocks belonging to the Datta Formation in this area are represented by thick sequence of variable lithological characters including shale, siltstone, sandstone, and mudstone of red, maroon, grey and white colors deposited in continental environments.
The present state of knowledge concerning stratigraphy and palynology of the Datta Formation of the Salt Range and Hazara of north Pakistan is reviewed. Detailed studies of the Datta Formation have revealed abundant and

varied palynomorphs assemblages. This unit is well developed in the western Salt Range, Trans-Indus Range, Surghar Range and a few exposures in the Hazara area are also found. Fifty samples have been collected from Gorge, Makerwal and Hazara areas. These are regarded as classical localities for palynostratigraphical investigations. In general, the preservation of the species recorded is good. Miospores from the Hazara are in an inferior state of preservation when compared ‘vith the Salt Range. It is of interest to note that saccate pollen grains have rarely been encountered. Ubiquitous forms of trilete and monolete miospores have frequently been observed. However, some endemic elements have also been recorded during the present investigations. The Datta Formation is characterized by the presence of pollen grains, i.e. *Classopollis*, together with a trilete miospere genus. These forms have been recorded in the Lower part of Datta Formation. The absence of phytoplankton (acritarchs and algae) in this unit is in harmony with respect to the continental facies. Some of the index taxa that are regarded as indicator of the Lower Jurassic of Pakistan includes: *Gleicheniidites, Divisisporites, Densoisporites, Lycospora* and *Matonisporites.* Long ranging genera of Laevigate forms such as *Punctatisporites* and *Leiotrlletes* are also profusely represented. Another miospore genus *Convolutispora* belonging to the infraturma *Murornati* has also been found occurring in the Lower Jurassic of Pakistan. These miospore forms have also been reported from the Upper Devonian of many parts of the world including North America, North Africa, Europe, Asia and Australia.
Key words: Stratigraphy, Lower Jurassic, Datta formation, Salt Range.

A/192. Ahmad, S., Sheikh, R.A., Haque, I. & Naeem, M., 1992. Lead-zinc-copper mineralization in Treri-Manjhotar area, District Muzaffarabad (Azad Kashmir), Pakistan. Acta Mineralogica Pakistanica 6, 164-166.

Key words: Lead-zinc-copper, Muzaffarabad.

A/193. Ahmad, S.A., 1999. Catalogue of GSP Publication. GSP. Special Issue, 34p.

Lists all Memoirs, Records, Information Releases, Miscellaneous Publications (USGS Professional papers, Mineral Information Series, Special Issues), and Geological Map Series produced until the middle of 1999 by the GSP.
Key words: Bilbiliography, GSP.

A/194. Ahmad, S.A., Hafeez, M.A. & Ahmed, R. 1991. Publications of GSP. GSP Information Release 518, 29p.

Lists all Memoirs, Records, Information Releases, Miscellaneous Publications (USGS Professional papers, Mineral Information Series, Special Issues), and Geological Map Series produced until 1991 by the GSP.
Key words: Bilbiliography, GSP.

A/195. Ahmad, S.A., Hafeez, M.A. & Khan, S.H., 1994. Status of geological mapping on 1:50,000 in Pakistan. GSP, Information Release 552.

One of the principal activities of the Geological Survey of Pakistan (GSP) has been mapping of the Pakistan territory. Much of the country was poorly mapped, and some of the mountainous areas had been studied only along stream courses. Over the 37 years period, the GSP has been engaged actively in preparation of the geological maps on various scales. This is an account of the areas which have been mapped at 1:50,000 scale.
Key words: Mapping.

A/196. Ahmad, S.A., Mahmood, A. & Khan, A.R., 1985. Geology and petrology of Gulpatobanda-Saoni area, Dir District, Pakistan. Acta Mineralogica Pakistanica 1, 90-94.

Geological map covering about 30-km^2 area near Gulpatobanda-Saoni in Dir District is presented. The area is composed of metasedimentary complexes with igneous intrusions. The main units in the area calcareous quartzite, calcareous mica schist and siliceous mica schist. Detailed petrography of the major units is described.
Key words: Petrology, metasediments, Dir.

A/197. Ahmad, W., 1990-92. Geological study for petrography and geology of Atia Qala, District Swat. M.Sc. Thesis, Punjab University, Lahore, 57p.

Rocks of Atia Qala (Distt. Swat) are part of metamorphic hornblende complex. The area lies within the southern portion of Swat. These rocks are probably the extensions of rocks of Dir in the form of a belt running approximately in East-West direction. The area given for fieldwork comprises thirty kilometers in the Northwest of Mangora. The area mainly comprises the main rock units are Norite, Diorite, Quartz, Feldspar and Pegmatite veins. But at some places patches of Amphibolite are also found but can be considered negligible. As the field evidences and laboratory study shows that the Diorite and Norite were formed from basic magma, which have under gone regional metamorphism under the intense orogenic conditions. Quartz-O-Feldspathic and Pegmatite veins are extensively distributed all over the area, indicating the evidence of Diorite magma. Major minerals are Plagioclase, Hornblende, Epidote and Quartz with accessories as Sphene and Magnetite. These are products of regionally metamorphosed igneous rocks.
Key words: Petrography, Swat.

A/198. Ahmad, W., 1990. Sedimentologic and magnetostratigraphic studies of upper Siwalik group Sulaiman Range, Pakistan. M.Sc. Thesis, University of Peshawar, 88p.

Key words: Sedimentology, Magnetostratigraphy, Sulaiman Range, Siwaliks.

A/199. Ahmad, W. & Hamidullah, S., 1987. Island arc signatures from the Waziristan igneous complex, NWFP, Pakistan. Geological Bulletin, University of Peshawar 20, 161-180.

The Waziristan igneous complex consists of peridotite, gabbro, diorite, diabase and a variety of volcanic rocks. Petrographic studies and mineral chemistry of the rocks contradict their oceanic crust origin and evince an island arc parentage. The high Mg# (89-95) of the olivine and pyroxenes, and absence of plagioclase in the cumulus peridotite suggest crystallization at high pressures – not typical of oceanic crust. The calcic-plagioclase (An_{90-97}) and clinopyroxene (Wo_{44-46} En_{44-50} Fs_{5-12}) association in the gabbroic rocks of the Waziristan igneous complex is akin to other island arc-related gabbros. A variety of diagrams used for discrimination of clinopyroxenes form different tectonic environments, also indicate the island arc affinity of this complex.
Key words: Petrography, Geochemistry, Waziristan.

A/200. Ahmad, W. & Khan, M.J., 1990. Sedimentologic and magnetostratigraphic studies of the upper Siwalik Group, Sulaiman Range, Pakistan. Abstracts, 2nd Pakistan Geological Congress, University of Peshawar, 33-34.

The Siwalik Group exposed in the eastern foothills of the Suleiman Range includes Vihowa, Litra and Chaudhwan Formations. The Vihowa Formation consists of grey and brown sandstones and red to brownish-red siltstone. The overlying Litra Formation comprises light-grey sandstone with subordinate brown to reddish- brown siltstone. Chaudhwan Formation overlies Litra Formation and predominantly consists of conglomerates with ancillary interbedded pale-grey sandstone. Present studies are confined to the upper Litra and Chaudhwan Formations. Sandstone of the Litra Formation is characterized by the abundance of almandine garnet and blue-green hornblende, indicating substantial contribution from the northern provenance (i.e., Kohistan island arc). Whereas the petromict orthoconglomerates of Chaudhwan Formation indicate a western provenance (i.e., Fort Monro anticline).
Paleomagnetic studies of the overbank deposits from the upper Siwalik sequence show that NRM of most samples is composite of (a) a secondary component of magnetization, and (b) a stable, hopefully primary, component of remnant magnetization. Secondary magnetization was successfully removed by Partial Thermal Demagnetization at 400ºC, and thus the stable component of magnetization was isolated. Thereafter, all samples were subjected to a single step thermal demagnetization at 550ºC (one sample at 660ºC).
Considering the rates of sediment accumulation of the upper Siwaliks in general, and the faunal contents of the upper Siwaliks from a nearby locality, the observed normal magnetic- polarity is tentatively correlated with the Jaramillo subchorn of the Matuyama Chron. This correlation suggests that the upper Litra Formation was deposited

during 1.5 Ma. to 7 Ma. whereas the Chaudhwan Formation was deposited between .7 Ma. and 50,000 yr. BP., in consequence of the synchronous acute tectonic uplift along Fort Monro anticline.
The alluvial fan deposits, overlying the Chaudhwan Formation, are also tilted due to the formation of Zinda Pin and Sakhi Sarwar anticlines. This manifests active forelandward (eastward) migration of the deformation front of the Suleiman Range.
Key words: Sedimentology, Magnetism, Siwaliks, Sulaiman Range.

A/201. Ahmad, W. & Khan, M.J., 1991. Petrography of the upper Litra and Chaudhwan Formations, Upper Siwalik Group, Zinda Pir anticline, northern Sulaiman Range. Geological Bulletin, University of Peshawar 24, 191-202.

The Zinda Pir anticline of northern Sulaiman fold belt exposes, along its periphery, the Siwalik Group which comprises Vihowa, Litra and Chaudhwan Formations (in younging order). Petrographic studies of the upper Litra and Chaudhwan Formations indicate that the sandstones of these formations are texturally similar. Moderate angularity and sorting, along with high content of feldspar, indicate textural immaturity of these sandstones. The Litra Formation is characterized by the abundance of almandine garnet and blue-green hornblende, indicating substantial contribution from the northern provenance (i.e., Kohistan island arc). Whereas petromict ortho-conglomerates of the Chaudhwan Formation indicate a predominant western provenance (i.e. Fort Monro anticline).
Key words: Petrography, Siwaliks, Zinda Pir, Sulaiman Range.

A/202. Ahmad, Z., 1969. Directory of mineral deposits of Pakistan. GSP Records, 15(3), 220p.

The directory is an alphabetical listing of the known mineral deposits and showings in Pakistan. It also includes a brief description of the mineral deposits of chromite, asbestos and magnesite in ophiolitic rocks.
Key words: Mineral deposits.

A/203. Ahmad, Z., 1978a. Petrology of Taghma area, Swat district, NWFP. Pakistan. GSP Information Release 15, 31p.

Key words: Petrology, Taghma, Swat.

A/204. Ahmad, Z., 1978b. Bibliography and Index of the GSP Reports. GSP. Records, 42, 39p.

This is a compilation of GSP reports. It contains an index of all the reports collected in this bibiliography.
Key words: Bibiliography.

A/205. Ahmad, Z., 1981. Geological sketch and mineral deposits of Azad Kashmir. GSP, Record 57, 28p.

This report summarizes information on the geology and mineral deposits of Azad Kashmir. It contains brief descriptions of those mineral deposits that have some economic or geological significance. These include Boxite, bentonite, coal, fireclay, gemstones, graphite, gypsum, limestone and dolomite, mica, phosphatic rocks, pyrite, quartzite, radioactive minerals, slate and soapstone. There are two tables and an index map.
For further information, see Ali, S.T., 1984.
Key words: Mineral deposits, Azad Kashmir.

A/206. Ahmad, Z., 1987-89. Geotechnical study of proposed Ghazi-Gariala hydropower project and material testing of District Hazara and Attock. M.Sc. Thesis, Punjab University, Lahore, 142p.

Key words: Geotechnical, Material Testing, Hydel power, Hazara, Attock.

A/207. Ahmad, Z., 1992. Clays. GSP Mineral Information Series 11, 56p.

This is a general information on clay minerals, there uses, geology and origin along with distribution in Pakistan. Included are bentonitic clays of Azad Kashmir (Bhimber, Chanater, Chitta Dheri) and some parts of NWFP (Chashma Valley, Karak).
Key words: Clay minerals, Azad Kashmir, NWFP.

A/208. Ahmad, Z., 1995. Base metal deposits of Azad Kashmir, Pakistan. Abstracts, International Symposium on Himalayan Suture Zone of Pakistan. Pakistan Museum of Natural History, Islamabad, 26-27.

Base metal sulphide mineralization in Azad Kashmir is described from two main mineable deposits: one at Treri (lat. 34° 26. 48"N: long. 73" 43' 10"E) and the other at Lamnian (lat. 34° I4' 19"N: long. 73° 46' 52"E). Both occur in the Panjal Sequence which is developed along the eastern syntaxial limb of the Azad Kashmir Himalayas.
Various descriptive and genetic attributes of the leadzinc sulphide ore deposits of Treri area correspond to those of the Mississippi Valley type (MVT) deposits. The deposit formed as a stratabound Pb-Zn ore deposit in the shallow-water deposited platformal carbonates of Triassic age by epigenetic cystallizaton from solutions evolved in the sedin1enta1y basin. The process involved filing of preexisting open spaces as well as replacement of lithified carbonates. Upper part of the deposit also involved ponding beneath as impermeable shale cap. The solutions were not derived from high heat-producing intn1sivc bodies, but from the dewatering of associated shale especially the black carbonaceous shale. The incursion of saline warm brines carrying Pb-Zn-Cu-Fe from deeper shales basin to its margins and further into the fracture system in dolomite may have occurred by gravitaional flow, or by stratafugic dewatering by compaction or by episodic excess pore pressure. The sulphides precipitated by reduction of sulphate in the formational fluids with concomitant recrystallization of coarse calcite observed in the deposit. Unlike most MVT deposits, the Treri deposit is not associated with barite or fluorite mineralization.
Key words: Base metal, Azad Kashmir.

A/209. Ahmad, Z., Alam, G.S., Khan, R.N., Hussain, A., Khattak, A. K., Saleemi, B. A., Khan, R., Ahmad, S. & Qureshi, S.A., 1976. Investigation of placer mineral deposits in the Indus, Gilgit, Hunza and Chitral Rivers, Pakistan GSP Records 35, 25p.

The placer mineral deposits of parts of the Indus, Gilgit, Hunza and Chitral rivers of Pakistan were collected by spot sampling and analyzed. A few high terrace gravel deposits were also sampled. A measured volume of sand and gravel was washed and whatever gold was recovered from any sampling site was calculated as oz/l .ton for that site.
The gold contents of the alluvium deposits, as determined during the reconnaissance survey, are low. In the upper Indus Valley, between Thore and Sasi in Gilgit Agency range between the lowest of 0.0004 Oz/l. ton to the highest of 0.011 oz/l.ton. On the high side, there is only one exception; one sample from a high terrace in the Bunji-Jaglot area was found to contain 0.05 Ozjl .ton of gold. Among the lower Indus Valley deposits, the lowest and highest gold contents range between 0.002 Oz/l.ton and 0.014 Oz/l.ton, and in the Chitral and Mastuj Valleys, the same are 0.0003 and 0.0108 oz/l.ton, respectively. A few deposits are being recommended for detailed study to see if any portion of them contain values higher than the ones recorded during this survey.
Key words: Placer Minerals, Indus, Gilgit, Hunza, Chitral.

A/210. Ahmad, Z. & Bilgrami, S.A., 1987. Chromite deposits and ophiolites of Pakistan. In: Stowe, C.W. (Ed.), Evolution of Chromium Ore Deposits. Von Nostrand Reinhold Co., New York, 238-264.

Key words: Mineral Deposits (chromite), Ophiolites.

A/211. Ahmad, Z., Hussain, F., Iqbal, M.W.A., & Saleem, M., 1980. Bibliography of the geology of the Northern Pakistan. GSP Records, 48, 37p.

This is a geological bibliography of northern Pakistan. The references in this document were included in the Geological Bibliography of Pakistan by Khan and Khan, 2002.
Key words: Bibiliography, North Pakistan.

A/212. Ahmad, Z. & Khan, M.Y., 1980. Geology of Barwa quadrangle, N.W.F.P., Pakistan. GSP, Record 41, 16p.

Key words: Barwa, NWFP.

A/213. Ahmad, Z., Rehman, H. & Sheikh, M.A., 1991. Limestone and dolomite. GSP, Mineral Information Release 8.

Key words: Limestone, dolomite.

A/214. Ahmad, Z. & Siddiqi, R.A. (Eds.), 1991. Minerals and Rocks for Industry. GSP, Quetta, Volume 1.

This (and the following two accounts) are a series of three volumes, published in successive years. These accounts give a detail of the minerals and rocks used in the industries.
Key words: Industrial minerals and rocks.

A/215. Ahmad, Z. & Siddiqi, R.A. (Eds.), 1992. Minerals and Rocks for Industry. GSP, Quetta, Volume II, 325p. GSP Special Publication, 326–609.

Key words: Industrial minerals and rocks.

A/216. Ahmad, Z. & Siddiqi, R.A. (Eds.), 1993. Minerals and Rocks for Industry. GSP, Quetta, Volume III. GSP Special Publications, 610–802.

Key words: Industrial minerals and rocks.

A/217. Ahmad, Z.H. 1987-89. Geology, petrography and structure of Harno area District Abbottabad. M.Sc. Thesis. University of Azas Jammu & Kashmir.

A comprehensive geological study of Harno area (70 sq km), a northeastern section of the Attock Hazara Belt, including geological mapping 1:9434 is presented. In early Jurassic to Early Eocene shelf sedimentary sequences overlie metamorphosed Hazara slates. Possible depositional environments of various stratigraphic units interpreted on the basis of petrographic study. The area has suffered a 4 phase deformation. The first phase related to metamorphism of Hazara slates, the next two to the NE-SW trending structures and the fourth and final phase related to gentle NW-SE cross folds produced during formation of Hazara Kashmir syntaxis. Asymmetric to overturned tight to isoclinal folds and high angle dip slip strike faults of both normal and reverse type are related to the second and third phase of deformation. A chapter on the economic geologic potential of the area is also included.
Key words: Petrography, Structure, Abbottabad.

A/218. Ahmed, A., 1959. Salt Range, Potwar, Hazara and Swat. M.Sc. Thesis, Punjab University, Lahore.

Key words: Salt Range, Potwar, Hazara, Swat.

A/219. Ahmed, A., 1986. Geochemical characterization of the upper crust from southern Malakand Agency, Pakistan. Abstracts, Symposium/Workshop on Plate Tectonics and Crust of Pakistan. Institute of Geology, Punjab University, Lahore, p.3.

Whole rock major and trace element contents of extensive Proterozoic crystalline schists of the southern Malakand Agency and adjacent regions have been determined. The chemistry and mineralogy of samples, consistent with a sedimentary origin, display protolith variations. Chondrite normalized rare earth element 'petterns of all the samples show very steep LREE enriched gradients with LaN /YbN ranging from 11.311 to 119.536. All analyzed samples exhibit negative Eu anomalies which may be due to mixing of various source lithologies during sedimentation. The patterns are comparable to that of average post-Archean upper crust except the higher PEE contents of some samples.
Key words: Geochemistry, Malakand Agency.

A/220. Ahmed, A. 1989. Shallow seismic reflection investigation for determination of seismic velocities on exposed rock units S/W Margala Pass and Thatta Khalil area, District Rawalpindi. M.Sc. Thesis Quaid-i-Azam University, Islamabad.

The seismic velocities are determined on the exposed rock units in the area lying between Margalla Pass and Thatta Khalil, near Taxila in Rawalpindi District. These lithologies are limestone, sandstone and conglomerate. The experiment was carried out on sixteen points by laying spreads of varying length of 65 meters and 55 meters by using OYO, McSeis-1500 system. A 10 lbs hammer was used as energy source. The data was processed by computer package "Simple refraction" H.P. model 216. The results show that the seismic velocity on limestone of weathered layer ranges from 590 m/s to 1250 m/s and corresponding (average) thickness varies from 1.5m to 2m, sub-weathered layer ranges from 1900 m/s to 2910m/s and its thickness varies between 4.1m to 8m and the 3rd-layer velocities are 3200 m/s to 4400 m/s. The seismic velocity on sandstone, of surface layer ranges from 850 m/s to 1580 m/s and the (average) thickness varies from 4.4m to 7.2m. The velocity of 2nd-layer ranging from 2340m/s to 2900 m/s, could be of sandstone of Murree Formation in the area, and the seismic velocity of' surface layer on conglomerate.
Key words: Seismicity, Margala pass, Rawalpindi.

A/221. Ahmed, A., Mateen, A., Rogers, G., Chaudhry, M.N. & Butt, K.A., 1997. Rb-Sr geochronology of the Lower Swat granite gneiss, NW Himalaya, Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.6.

The regionally metamorphosed granites forming several plutons and loop-shaped bodies within the Pacha Formation and designated as "the Lower Swat Granite Gneiss", have been exposed in the Northern Buner district, Mingora and Manglaur areas. The augen gneisses were previously correlated to the Mansehra granites of Hazara (Jan et al1981, Shams 1983) and were believed to represent the granitoid magmatism related to the crustal evolution in the region during the Late Precambrian to Cambrian periods (Le Fort et al 1980). Some authors assigned Lower Cambrian age and have argued that these granite gneisses (e.g. Hum Granite Gneiss) occurred in different tectonostratigraphic framework, being emplaced in the Swat Higher Himalayan tectonic block between MMT and MCT as part of crystalline basement (Chaudhry et al 1992). Rival models concerning the geology of the Lower Swat area predict that the granite gneisses are either Precambrian or Paleozoic in age. In order to test these rival hypotheses a Rb-Sr whole-rock geochronological study of two sets of granite gneiss bodies has been undertaken. On the basis of existing major and trace element data, samples were selected which covered the compositional range in order to obtain a wide variation in Rb/Sr ratio. Five samples from Karaker area (Hum Granite Gneiss) gave an isochron age of 260 ± 52 with an initial 87Sr/86Sr ratio of 0.709 ± 10. While the second set of representative samples from Mura Kandao, Prona (Saidu) and Manglaur yielded age of285 ± 8 Ma with initial 87Sr/86Sr ratio of 0.7093 ± 7. The results obtained indicate that none of the studied granites are Precambrian or Cambrian in age, thus negating the views of Le Fort el al (1980). The Mura -Prona -Manglaur granite gneisses gave the best fit age of 285 ±8 Ma is Lower Permian. The age estimates of Hum granite gneiss could be the same as it shows considerable scatter of the data. The geochronological history of the Swat Granite Gneiss is discussed in context with the petrogenetic evolution of Permo-Carboniferous alkaline rocks from Buner Swat (e.g. 300 Ma Koga alkaline-carbonatite

complex). The granites are suggested to be related to the bimodal magmas of Eastern Australia and Europe emplaced in the India -Australia rift zone along the Tethyan margin.
Key words: Geochronology, granite gneisses, Buner, Swat.

A/222. Ahmed, B., 1988. Reservoir seismicity of Tarbela Dam. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 64p.

Tarbela reservoir located in a seismically active region of previously reported basement faults like IKSZ and HLSZ, and surficial faults like Punjal-Tarnawal fault and Hazara thrust system. The present study reveals that the presence of reservoir has caused induced seismicity to pad up the tectonic seismicity of the region. Initial period (1975-1979) energy release or seismic activity gradually decreases in middle of the period (1980-82) is increased and reached a maximum position. The energy release patterns over 8 years (1975-1982) period are largely uncorrelated with the cyclic fluctuation of reservoir. Whereas in the second cycle (1981- 1986) the pattern of reservoir fluctuation and energy release are not so widely uncorrelated. But energy release related with the immediate region of 10 km distance discloses a mild correlation between the patterns of energy release and lake fluctuations during 1981 to 1984 after which the energy release (1984- to 1986) is increased prominently without maintaining relationship with the reservoir fluctuation. As a result the reservoir fluctuation apparently has negative relations with energy release. However, within an immediate region of 10 Km distance or less positive relations may exist. The analysis of the region lying in 10 km radius in short-term changes reveals that a subtle relationship exists. Therefore, using an expanded area and the located earthquake epicentres occurring in a half cycle (below and above average water level of reservoir) in a specific time give very important results, i.e. seismicity related with water fluctuation is increasing (when water below average level) with the passage of time.
Key words: Seismicity, dams, Tarbela.

A/223. Ahmed, C.I., 1998-99. Geological mapping of Rawalpindi-Sihala (Islamabad) area with special emphasis on engineering geological impacts on quality of ground and surface water (Soan River Basin) Rawalpindi-Islamabad, Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 91p.

About 105 sq. km of Rawalpindi-Sihala area has been mapped on survey of Pakistan toposheet No. 43-J/2 on a scale of 1:12500. The investigated area lies in the Soan basin. There are two main available sources of water, wells and river water. The physio-chemical parameters have been investigated for ground and surface water (Soan River Basin). The quality of water is going on increasing and it is going on for beyond the limits established for standards by AEPA, WHO etc. Physiochemically the area is high risky. Chemically the quality of water is risky. The water quality is chemically beyond the safe limits in the upstream areas like upper Sihala area where as its quality is highly risky at Soan Bridge area and Morgah Town area. The test results show that the quality of the investigated ground and surface water is of sodium bicarbonate type.
Key words: Engineering geology, ground water, Soan River, Rawalpindi.

A/224. Ahmed, Ch.I., 1996. Combined geophysical and hydrogeological studies to delineate the water bearing aquifers in Q.A.U. Housing Scheme. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 85p.

Key words: Geophysics, Hydrogeology, Ground water, Islamabad.

A/225. Ahmed, F., 1997-98. Structure, stratigraphy, micropaleontology and petrography of Jabri-Bodla areas District Haripur & Abbottabad Hazara (NWFP), Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 78p.

The Jabri-Bodla area lies in the Attock-Hazara fold-and-thrust belt of the northwestern Himalaya of Pakistan. Precambrian to Cenozoic sedimentary rocks are folded and imbricated during the Tertiary-Himalayan collision.

The oldest exposed stratigraphic unit is the Precambrian Hazara Formation. The formation is composed of slates, shales and phyllites. The presence of ripple marks and graded bedding shows that the Formation is deposited in shallow water turbidity environments. The Middle Jurassic Samana Suk Formation, Late Jurassic to Early Cretaceous Chichali Formation and Early Cretaceous Lumshiwal Formation were deposited in shallow marine conditions. The late Cretaceous Kawagarh Formation was deposited in deep to shallow water shelf environment.
The late Cretaceous to Early Paleocene uplift in the area caused the regression of the Tethyan Sea. The Tethyan regression initiated the deposition of ferruginous sandstone of the Hangu Formation.
The lower Tertiary sequence of Early to Late Paleocene Lockhart limestone, Late Paleocene Patala Formation, Early Eocene Margala Hill Limestone and Early to Middle Eocene Chorgali formation mark the complete cycle of transgression and regression of the Tethyan Ocean. The presence of early Paleocene to Late Eocene foraminiferal assemblage like globorotalia, globogorina, lockharia, assilina and nummulites in the limestones and shales of the Lower Tertiary sequence show the tropical sub-tropical open sea upper slope to outer shelf environments.
The Paleocene-Eocene boundary cannot be marked on the basis of microfossils in the area because the Patala Formation lacks microfossils. However, the tentative Paleocene-Eocene boundary between the Patala Formation and the Margala Hill Limestone can be marked at the base of Margala Hill Limestone on the basis of first appearance of Early Eocene microfossils.
Key words: Structure, Stratigraphy, Micropaleontology, Petrography, Abbottabad, Hazara.

A/226. Ahmed, G., 1992-94. Lithostructural mapping and geology of the Sirgah and microfacies study of the Cretaceous Kawagarh Formation of Jabri Area, Hazara, Northwest Himalaya. M.Sc. Thesis, Punjab University, Lahore, 153p.

A comprehensive study of Geology and structure of the area around Dhamtaur and Sirgah is presented. There is also a special section on the sedimentology of Kawagarh Formation of Jabri area, some distance to the south of Dhamtaur area. Geological mapping at the scale (1:10,000) is presented. The lithostratigraphic units range from Precambrian Hazara Slate basement to the Paleocene Patala Formation. Structurally the area comprises NE-SW trending double plunging/cylindrical folds with a general vergence to the Southeast. The folded sequence has been disturbed by a series of reverse faults. A small number of normal faults also exist. Faulting is dip slip to oblique slip and in general involves a maximum displacement of few hundred meters. Apart from the regular fault, decoupling is frequently noted at the formational boundaries leading to the slip and discontinuity of thin marker horizons.
The Kawagarh Formation of Jabri is divided into three internal units and twenty-one microfacies for the first time. It is basically a transgressive unit deposited during Cretaceous global transgression. The maximum depth of the sea at that time was about 250 meters. On the basis of planktonic fossils the age of the unite ranges from upper Coniacian to lower Campanian.
Key words: Structure, Cretaceous, Kawagarh formation, Hazara.

A/227. Ahmed, I., 1986-88. The geology and petrology of Chilas ultramafics complex in the vicinity of Chilas (District Diamar) with special emphasis on geology of the area. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 113p.

The project area covers about 368 sq. Km. located in the vicinity of Chilas, District Diamar. The work has involved geological mapping of the area on a scale of 1:50.000. This thesis deals with the geology, petrography and petrogenesis of the Chilas complex and adjacent southern rock units. The possible relation of Chilas complex with the southern Jijal complex has also been discussed.
The geological sequence of the area consists of metadiorit rocks of the Chilas complex and granodiorite. The rocks of the Chilas complex are divided into two main associations, the ultramafic-anorthosite association and the main norite/gabbronorite association. Both the associations represent lower and upper cumulates respectively and are in a complicated contact possibly due to syndepositional folding-and faulting. Diorite is the most evolved unit of the Chilas complex.
Field evidences suggest that Chilas complex was intruded into an old pluton, the metadiorite which was included in Kamila amphibolite by Coward (1982). The relationship of Jijal with Kamila amphibolite also shows that the Jijal complex was accommodated in the rocks represented by Kamila amphibolites, suggesting an older age of Kamila rocks than Chilas and Jijal complexes.

The Chilas complex is unmetamorphosed and is present in an anticlinal position with ultramafics chiefly restricted to the core of the anticline. The ultramafics are overlain by more evolved rocks i.e. gabbronorite association and diorite capped on both limbs by metadiorite roof rock. On the southern limb, the metadiorite roof rock unit is intruded by a granodiorite pluton which seems to be younger in age than the Chilas complex.
Key words: Petrology, Ultramafics, Chilas Complex, Diamir.

A/228. Ahmed, I., 1991. Shallow seismic refraction survey to establish velocity-lithology relationship and to trace the nature of the refractor near Kuri village District Islamabad. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 38p.

Key words: Geophysics, lithology, Islamabad.

A/229. Ahmed, I., 2000. Fault plane solution studies of N-W Himalayan fold and thrust belt for the period 1992-1998. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 27p.

Key words: Structural geology, Himalayan fold and thrust belt.

A/230. Ahmed, M., 1959-61. Geology of the Murree and Abbottabad Areas. M.Sc. Thesis, Punjab University, Lahore.

Key words: Geology, Murree, Abbottabad.

A/231. Ahmed, M., 1965. Marble in Pakistan. GSP Records 17(1), 12p.

Key words: Marble.

A/232. Ahmed, M., 1979. Petrology and Economic Geology of Shangla Par Alpurai area. (Toposheet No, 43B/9; Scale 1:50,000), with special emphasis on ultrabasics. M.Sc. Thesis, Punjab University, Lahore.

Key words: Petrology, ultrabsics, Shangla, Alpurai, Swat.

A/233. Ahmed, M., 1989. Seismicity of Tarbela region. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 91p.

Nine year (1977-86) computerized earthquake data of magnitude range 3 to 5 on Richter scale when plotted on two maps with respective hypocentral depths less than 10 km and more than 10 km, gave very interesting results.
The map (fig. 5.1) showing seismic events (with hypocentral depth exceeding 10 km) shows that besides IKSZ and HLSZ, there could be a third basement structure parallel to them.
The other map (fig. 5.2) having seismic events of hypocentral depth range less than 10 km shows that the shallow seismicity is more scattered and can also be associated with the surface structures such as Darband fault, Punjal fault and Main Mantle Thrust. In this case it indicates that Darband/Thakot fault and Punjal fault are active in the north at a considerable distance from Tarbela Dam. In Tarbela region their activity is minor one, however, it may increase in future if southwards migration is believed to be in progress.
Key words: Seismicity, Tarbela.

A/234. Ahmed, M., Ali, K.S.S., Khan, B., Shah, M.A. & Ullah, I., 1969. The Geology of the Warsak area, Peshawar, West Pakistan. Geological Bulletin, University of Peshawar 4, 44-78.

The Warsak Area, Peshawar, West Pakistan, has been geologically mapped and the petrography of the area described in detail. The area consists of a series of metasediments of the greenschist facies (slates, phyllites, mica schists, garnet schists, hornblend schists, calcareous schists and marbles), which have been divided into a lower,

Middle and Upper Series. On the eastern side the metasediments disappear under the alluvium of the Peshawar plain. They range from Siluro-Devonian of Upper Paleozoic in age, and are intruded by sills of metagabbro and metadolerite (? Cretaceous), porphyritic microgranites (?Upper Cretaceous to Lower Tertiary) and the Warsak alkaline granite (? Lower Tertiary). The chemistry of alkaline nature of the granites (which contain aegirine, riebeckite and astrophyllite) is briefly discussed. The structure of the area is shown to be a northwards plunging syncline, faulted on the east on the northern side of the Kabul River. The joint patterns and other structural features are described, and the economic geology of the area discussed.
Key words: Warsak, Peshawar.

A/235. Ahmed, M. & Javed, M., 1992. Seismic risk evaluation for northern Pakistan using probabilistic approach. Abstracts, First South Asia Geological Congress, Islamabad, p.2.

The instrumental seismic data for Northern Pakistan recorded by world-wide seismological network during the current century was used to evaluate the seismic hazard through the probabilistic approach of seismic risk evaluation. For this purpose, seismic data was collected from various International and local agencies and a composite list of earthquakes was made. From this list, frequency-magnitude relationship for the area was developed and 'a' and 'b' parameter. det8rmined. A statistical analysis was performed using the recumbence relationship developed above and the popular attenuation law of Joyner & Boore (1981), horizontal ground acceleration for various probabilities of exceedance during the life time of a project were calculated and the results presented in the paper.
Key words: Seismicity, Northern Pakistan.

A/236. Ahmed, M.K., 1989-90. Petrology and Mineralogy of the Area (Gokdarra-Ghaligai) District Swat. M.Sc. Thesis, Punjab University, Lahore, 83p.

The detailed geological map of the project area has been prepared. The project area has been mapped on a scale 1″=12,500″. This thesis consists of two sections. Section No.1 deals with the general geology of the project area. Introduction, Physiography, Structural Geology and Tectonics and the lithologic units of the project area have been discussed in this part. In Section No.2, Petrography, Chemical analysis, Petrogenesis, Discussion on Petrogenesis, Economic Geology and some thing new one (Dolomite/Wollastonite Skarn) in the project area is discussed. The project area is consisting upon the metasedimentary and metamorphic rocks, which lie in the Higher Himalaya Crystalline of the MMT Zone.
Key words: Petrology, petrography, Swat

A/237. Ahmed, M.N., 1992. Gravity modeling of bed rock in Ghagriot area, Islamabad. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 33p.

Key words: Gravity modelling, Islamabad.

A/238. Ahmed, M.U., 1981. Earthquake of 3rd September, 1972 in Gupis-Tangir area, Gilgit Agency, Pakistan. GSP, Information Release 154.

Key words: Earthquake, Gupis, Gilgit.

A/239. Ahmed, N., 1989. Electrical resistivity survey for groundwater investigations in an area between Kot Hathial and Malpur. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 97p.

Key words: Resistivity, Groundwater.

A/240. Ahmed, N., 1990. Shallow seismic refraction survey to map the low velocity zone around the Minsa Kaswal (District Rawalpindi). M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 47p.

Key words: Seismology, Rawalpindi.

A/241. Ahmed, N., 1996. Shallow seismic refraction survey in Behrain area to delineate faulting in the bedrock. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 23p.

Key words: Seismology, faults, Behrain.

A/242. Ahmed, N., Qaiser, M.A., Alauddin, M. & Amin, M., 1987. Physico–chemical properties of some indigenous clays. Pakistan Journal of Scientific and Industrial Research, 30, 731–734.

Keywords: Clays.

A/243. Ahmed, N., Zareen, A., & Faridullah, 1980. Geology of the Marghazar area, Swat. M.Sc. Thesis. Peshawar University, 98p.

Keywords: Marghazar, Swat.

A/244. Ahmed, S., 1986. Magnetic studies in the Margala and Hazara Ranges. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 85p.

Keywords: Magnetism, Margala, Hazara.

A/245. Ahmed, S., 1989. Shallow seismic reflection investigation for determination of seismic velocities on exposed rock units between Margalla Pass and Thatta Khalil area District Rawalpindi. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 47p.

Keywords: Seismology, Margalla, Rawalpindi.

A/246. Ahmed, S.A., & Jan, A.R. (undated). Detailed mapping, petrology and structure of Gulpato Banda Saoni area (Tehsil Kohistan), District Dir, NWFP, with special emphasis on calcareous quartzites and Chlorite Schist. M.Sc. Thesis. Punjab Univ. Lahore.

Keywords: Mapping, petrology, structure, Kohistan, Dir.

A/247. Ahmed, S.A., Mazhar, F., Sayab, M. & Abbasi, I.A., 2001. Lithofacies, sedimentary cycles and depositional environments of the Miocene-Pliocene, Dhok Pathan Formation, Bannu Basin, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.22.

The molasse sediments of the Miocene-Pliocene Dhok Pathan Formation in the Qubul Khel and Mochimar areas, Bannu basin are studied to work out their origin and depositional setting. The formation has variable thickness in different parts of the basin and is comprised of interbedded siltstone, sandstone and conglomerate in variable proportions. The coarse to fine ratio is 1:3 in the lower part, which changes to *1:5* in the middle and upper part of the formation. Four main Iithofacies are recognized in the formation, comprising; a) massive, clast supported conglomerate (Gm), b) trough cross bedded coarse sandstone with hard bands (St), c) parallel bedded fine sandstone (Sh) and d) laminated siltstone/shale (F).
The lithofacies Gm is interpreted to have been deposited in the core of major longitudinal basin associated with wide and shallow braided river system. Lithofacies St and Sh were deposited in the sand flats/bars and channels of a sand rich river system, whereas, the lithofacies F resulted due to vertical accretion in the flood plain. Abundant clast supported exotic conglomerates; pebbly sandstone and common scouring at the base of the sandstone bodies reflect deposition under high-energy conditions usually associated with a trunk braided river system. High ratio of flood

plain sediments in the middle and upper part of the formation is due to gradual shifting of the trunk river from this area and deposition of fines in the flood plain.
Key words: Lithofacies, Miocene, Pliocene, Bannu basin.

A/248. Ahmed, S.M., 1975. Research report on a gravity survey of Gilgit valley. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 109p.

Key words: Gravity, Gilgit.

A/249. Ahmed, S.N., Mcgann, G.J. & Aizad, T., 1992. Dhurnal oil field, Potwar basin. Abstracts, First South Asia Geological Congress, Islamabad, p.3.

The Dhurnal Oilfield is located 74 kilometers southwest of Islamabad in the Potwar Basin, and was discovered in March, 1984. The total recoverable reserves are estimated at about 50 MMBO.
The field was developed with four producing wells and three water injection wells. Three main reservoirs are present, of Eocene, Paleocene and Permian age. All of the reservoirs are limestone.
The Limestones are extremely tectonically fractured and all production is derived from fractures. The average thickness of these carbonates are 430, 540 and 325 feet respectively. The overlying thick claystones and shale of Murree Formation (Miocene) provided a vertical and lateral seal to the Paleogene and Permian limestones.
The surface expression of the Dhurnal structure is an eastwest trending sinuous syncline. At Eocene level, the field is a WSW- ENE trending anticline with well define axial plunge. The northern and southern flank are bounded by major thrusts. The tectonic history of the Dhurnal structure is complex and resub from a combination of thrust faulting and flexing, modified by later salt flowage. The field has a maximum areal closure of 3325 acres at Eocene level. There are different original oil-water contacts in the Eocene, Paleocene and Permian reservoirs. The field began production in May 1984, reaching a mulmum rate of 19370 BOPD In November. 1989. The present average production is about 13,200 BOPD (3840 dog API) plus 31 MMSCFDP of gas. The cumulative production as of May 31, 1991 was 36.151 MMBO plus 87,658 MMSCF of gas. Cumulative water injection was 44.617 MMBW. Water injection for pressure maintenance was initiated in 1987, about three years after field was brought on stream. The current Injection rate is 30,000 BWPD.
Key words: Oilfields, Dhurnal, Potwar basin.

A/250. Ahmed, W., 1962a. Copper showings near Barwa-Kambat, Dir State. GSP, Mineral Information Circular 7, 11p.

Key words: Copper, Dir.

A/251. Ahmed, W., 1962b. Copper showings in the Usheri region, Dir State. GSP, Mineral Information Circular 8, 14p.

Key words: Copper, Dir.

A/252. Ahmed, W., 1962c. Mica deposit, blue beryl and radioactive rocks of Talash region, Dir State. GSP, Mineral Information 9, 14p.

Key words: Mica, Beryl, Radioactive, Dir.

A/253. Ahmed, W., 1962d. Lal Qila-Manial pyritiferous quartz-sericite-sedierite veins, Dir State. GSP, Mineral Information Circular 10, 9p.

Key words: Pyrite, quartz, Dir.

A/254. Ahmed, W., 1963. Celestite deposits of Pakistan. CENTO Symposium on Industrial Rocks and Mineral, Lahore, Proceedings, 440-445.

Key words: Celestite.

A/255. Ahmed, W. 1965. Preliminary Bibliography and Index of the Geology of Pakistan. GSP Records 12(2).

Key words: Bibiliography, Geology.

A/256. Ahmed, W., 1972. Tectonic and environmental study for exploration of mineral resources in Pakistan. GSP, Geonews 11, No.2, 77-82.

Key words: Mineral Resources.

A/257. Ahmed, W. 1981. Metallogenic Framework and Mineral Resources of Pakistan. Geological Survey of Japan, Chika Shigen Chosajo Hokkaido, Sapporo. 261, 47–76.

Key words: Mineral Resources.

A/258. Ahmed, W., Ahmed, K.O., Khan, M.A., Qureshi, Z.I. & Ali, F., 1989. Seismic refraction survey of Tarbela. M. Sc. Thesis, Punjab University, Lahore.

Key words: Seismicity, Tarbela.

A/259. Ahmed, W., & Alam, S., 1992. Geochemistry of saturated hydrocarbon biomarkers in crude oils of Potwar basins, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.3.

The Potwar basin is a productive oil province with reservoired oil present at a number of stratigraphic levels from Cambrian to Miocene. Distribution of sterane and triterpanes was determined to classify and correlate these oils. The samples were analysed at Federal Institute of Geosciences and Natural Resources (BGR), using 30 m fused silica capillery column coated with SE 54 and connected to mass spectrometer operated in the selected ion Monitoring mode. The mass ion fragments /mz 191 and 217 were recorded. Hopane, gammacerane, tricyclic diterpane and three steranes with 27, 28 and 29 carbon atoms are dominant biomarken. The mass fragmentograms of these biomarkers appears to be similar. There are little variations, which are probably caused by different maturity level and analytical variance. The results indicate that the oil produced from Potwar basin is similar and appears to be genetically related to one family.
Key words: Geochemistry, hydrocarbons, Potwar.

A/260. Ahmed, W., & Alam, S., 2000. Organic geochemistry and source rock characteristics of Salt Range Formation, Potwar Basin. Abstracts, Third South Asia Geological Congress, Lahore, 111-112.

Salt Range Formation which is widely distributed in Salt Range contain, low grade oil shales. These shales are developed in the middle part of the formation and are laterally quite persistent. In some localities, the top of the formation contain high grade shales, which are lenticular in nature and are highly localized.
To assess source rock potential of the formation, 64 outcrops and well samples were collected and analysed for TOC, extraction, pyrolysis vitrinite reflectance, and low temperature carbonization analysis (Fischer Assay).
The results indicated that the formation has best oil source rock potentials. The formation exposed in the eastern Salt Range is extremely rich in organic carbon, TOC up to 30% and has excellent geochemical source rock parametres

(HI upto 879 and EOM/TOC upto 255). Also the low grade oil shale encountered in west-central and western Salt Range are excellent potential Oil source rocks having TOC 2.5%, HI up to 746 and EOM/TOC up to 204. The organic matter consists predominantly of pre-bitumen and solid bitumen and partly contains major proportions of liptinite. The oil yield of high grade oil shale varied from 15 to 20% of rock weight.
Key words: Geochemistry, hydrocarbons, Potwar.

A/261. Ahmed, W. & Gauhar, S.H., 1986. Plate tectonics, crustal evolution and metallogeny of Pakistan. Abstracts, Symposium/Workshop on Plate Tectonics and Crust of Pakistan. Institute of Geology, Punjab University, Lahore, 8-9.

A study of the metallogenic zonation of different regions of Pakistan shows a close genetic and temporal relationship with various aspects of crustal dynamics and plate boundary features such as subduction, continental collision, rifting, and emplacement of ophiolites. In the perspective of delineating their exploration potential and priorities, these zones have been further classified into different 'metallotect' belts by combining the plate tectonic environments of each separately discernible geological region with its characteristic metallogenic imprints. Thus besides serving the general purpose of a review article of the state of art on the accumulated knowledge about the evolution of crust in this part of the world, the present paper also attempts to give a brief yet unified synthesis on the mineral potential of Pakistan as interpreted in terms of the current concepts of metallogenesis and plate tectonics.
Based on mineral prognosis and plate tectonic interpretations, a number of new target areas have been identified for initiating scientific exploration. Some of the more important of these include; copper and other base metals in shield protrusions and shield derived sediments in the Punjab and Sind; rifting-related hot spot and brine solutions in the Salt Range and the Punjab Plains for sucking and concentrating metals in early Paleozoic sediments; barite-fluorite associated lead-zinc-silver deposits in shelf sediment~ in parts of Baluchistan and NWFP; porphyry copper and massive sulphides in Chagai and Kohistan regions; epithermal gold in clay altered volcanic rocks in Chagai; Lithium in pegmatites in Chitral and adjoining areas; chromite in northern ophiolites; and tin, tungsten and base metals in porphyries of Chagai and in the magmatic granitoids and their contact Paleozoic carbonate rocks in NWFP and Northern Areas.
Key words: Tectonics, metallogeny.

A/262. Ahmed, W., Gauhar, S.H., & Siddiqui, R.A., 1986. Coal resources of Pakistan. GSP Records, 73, 55p.

Key words: Coal.

A/263. Ahmed, Z., 1977. Electron probe composition of the spinel phases from a lherzolite near Bar Bandai, Swat District, Pakistan. Geological Bulletin, University of Punjab 14, 45-50.

In the light of electron probe scanning photomicrographs, the textural and compositional features of the spinel phases and their surrounding silicates from an alpine type lherzolite body outcropping near Bar Bandai, Swat District, Pakistan, are discussed.
Key words: Mineralogy, spinel, Swat.

A/264. Ahmed, Z., 1978a. Petrology of Taghma area, Swat District, North West Frontier Province, Pakistan. Geological Bulletin, Punjab University 15, 25-31.

Key words: Petrology, Swat.

A/265. Ahmed, Z., 1978b. Geological Investigations of the Chromite Ore Deposits of Malakand Agency Pakistan. Pakistan Science Foundation Project Report, PU/Earth (17) 38p, Lahore.

Key words: Chromite, Malakand.

A/266. Ahmed, Z., 1978c. Chromite from Sakhakot-Qila area, Malakand Agency, Pakistan. Mineralogical Magazine 42, 155-157.

Unlike most podiform deposits, the chromite layers in the area show considerable lateral persistence. Chromite grains have always rounded outlines. Cataclastic shattering, healed by serpentine, is frequent. Octahedral cleavage is well developed in most samples. Chemical assay of seven cleaned chromite samples show that they contain 39.06% to 50.66% Cr203; the MFe ratio varies from 2.06 to 2.53. Plots of the chromites on "Stevens triangular diagram" show that six belong to the "alumina chromite" field and one to the "chromian spinel" field
Key words: Ophiolites, chromite, Sakhakot-Qila, Malakand.

A/267. Ahmed, Z., 1983. Geology and Chromite Deposits of the Sakhakot–Qila, Ultramafic Complex, Pakistan. Abstracts Ofioliti, 8 (2), 261–262.

Key words: Chromite, Ultramafics, Malakand.

A/268. Ahmed, Z., 1995. Ore occurrences in the Panjal Sequence in the Chham-Balgiran sector of the Lesser Himalaya, Azad Kashmir, Pakistan. In: Abstract volume, Dissanayake, C.B., Almond, D.C., and Cooray, P.G. (Eds.), Second South Asia Geological Congress, (GEOSAS-II), Colombo, Sri Lanka, p.7.

Consult the following account for further details.
Key words: Mineralization, Panjal, Lesser Himalaya, Azad Kashmir.

A/269. Ahmed, Z., 1997. Ore occurrences in the Panjal Sequence in the Balgiran-Chham transect of the Lesser Himalaya, Azad Kashmir, Pakistan. In: Wijayananda, M.P., Corray, P.G. and Mosley, P. (Eds.,), Geology in South Asia-II. Geological survey & Mines bureau, Sri Lanka, Professional paper 7, 281-299.

The Panjal Sequence along the eastern syntaxial limb of the Azad Kashmir Himalayas contains base metal deposits at Treri. Lamnian and certain other localities. The Treri deposits are of the Mississippi Valley type. Epithermal galena-rich sulphide ore of the Lamnian area occurs in epigenetic quartz veins in the carbonaceous phyllite. Some of the veins contain albite. Accessory tourmaline occurs extensively in rocks of the Panjal Sequence. The Precambrian augen-gneiss at Reshian resembles a para-gneiss and lacks the skarn mineralization reported by previous workers. The granitic orthogneiss occurs in the Chham area. Whereas at Nauseri the granitic gneiss is migmatitic. The pyrite- and pyrrhotite-rich silicified bodies of the Reshian area seem to be associated with a fault zone, which is traceable towards NW by similar bodies occurring at diverse stratigraphic levels in the Nera, Tara, Nauseri and Bagnad areas, respectively. On the Nera-Kafir Khan hillslope of the Hariala area, such bodies occure in Triassic metasediments above the limestone horizon. South of Tara, in the Panjkot area, such bodies occur at the upper contact of metavolcanics with the Triassic limestone. In the Nauseri area, they occur in the Panjal Thrust contact zone. At Bagnad, the silicified bodies occur within the Precambrian Nauseri gneiss. Another fault is revealed by the different stratigraphic levels of the zone of black, carbonaceous and pyritous with limonitic, gypsiferous and sulphurous weathering patches, and by slicaring effects and displacements of strata in the Reshian, Klietar, Treri, Nauseri, Hariala, Tararan and Jabre Saiyidan areas.
Key words: Mineralization, Panjal, Lesser Himalaya, Azad Kashmir.

A/270. Ahmed, Z., 1982. Porphyritic-nodular, nodular and orbicular chrome ores from the Sakhakot-Qila complex, Pakistan, and their chemical variation. Mineralogical Magazine 45, 167-178.

A new kind of chromitite texture—a porphyritic nodular texture, found in an alpine-type complex in Pakistan, is described. The chromite from phenocrystic nodules and that from their disseminated chromitite groundmass show comparable trivalent elements and postcumulus to subsolidus Mg–Fe^{2+} variations, which are also recorded from

'normal' nodular ore samples. The nodular ores differ from all other textural types of chromitite from this complex in an unusual, though slight, increase in Cr/(Cr+Al) with Mg/(Mg+Fe^{2+}) between stratigraphically different desposits, which is caused by magmatic differences. The implications of major element variations in chromites and olivines of nodular chromitites are discussed and a cumulus origin is supported. Temperatures of final chromite-olivine equilibration ranged from 750 to 900 °C the individual nominal values being higher for chromitite with coarser chromite crystals and, or, higher chromite/silicate ratio.
Key words: Chromite, ophiolites, Sakhakot-Qila, Malakand.

A/271. Ahmed, Z., 1983. Geology of chromite deposits of the Sakhakot-Qila Ophiolite, Pakistan. Ophiolite 8, 261-262.

Key words: Geology, Ophiolites, Sakhakot-Qila, Malakand.

A/272. Ahmed, Z., 1984. Stratigraphic and textural variations in the chromite composition of the ophiolitic Sakhakot-Qila complex, Pakistan. Economic Geology 79, 1334-1359.

The deposits and their host rocks compare well with podiform ores hosted by alpine-type peridotites of ophiolites. Unlike most alpine-type complexes, predominant stratigraphic variations in the chemical composition of chromite exist. The chromite deposits fall in two major zones, the first consisting of three subzones. Regular compositional correlations between the accessory chromites of the host rocks and the associated segregated chromites are drawn, indicating relatively later crystallization of the former. Relict cumulate chromitite textures cover the podiform range and are examined in the light of compositional data. The inequigranular textural varieties probably developed by crystallization of successive crops from magmatic fractionation, with their coarser grained, massive chromite components always being slightly higher in Mg/(Mg + Fe (super +2)) than the associated finer grained chromite components. The Mg-Fe (super +2) exchange between chromite and silicates seems to start during the cumulus stage and continues during the postcumulus stage, but is reduced to a very small intensity during the subsolidus stage until it ends at about 700 degrees C.
Key words: stratigraphy, chromite, ophiolites, Sakhakot, Malakand.

A/273. Ahmed, Z., 1985a. Ore-mineral composition from galena mines of Thelichi valley, Gilgit Agency, Pakistan. Acta Mineralogica Pakistanica 1, 10-16.

Microanalytical work on ore sample from small scale mine developed for galena at Thelichi Valley shows the presence of lead, silver, antimony, and, zinc. Mineralogical aspects are discussed. Mineralization probably occurred from low temperature hydrothermal solutions by fissure filling.
Key words: Ore, Galena, Thelichi, Gilgit.

A/274. Ahmed, Z., 1985b. A new occurrence of uranium-bearing thorian monazite, northern Pakistan. Acta Mineralogica Pakistanica 1, 27-33.

A new type of occurrence of uranium- and thorium-bearing monazite is described from a chloritic rock from near Musa Mena in Malakand Agency. The locality is being reported for the first time and may prove an economically viable mining area for uranium, thorium, and rare earth elements such as lanthanum, cerium, and neodymium, in addition to titanium-mineral rutile. Monazite forms euhedral porphyroblasts, which appear zoned and occur along with euhedral rutile in schist of low metamorphic grade. Microprobe analyses of rutile, monazite, apatite and chlorite are presented. The chlorites of monazite-bearing and adjacent monazite-lacking schists are chemically different. Zoned monazite crystals display increased Th and Ca and decreased Ce, Nd, Sm, Gd and Dy towards the rims. This is different from the usual trends.
Key words: Radioactive, Malakand.

A/275. Ahmed, Z., 1985c. Mineral chemistry of small intrusives from Mullabagh area, Kohi Safaid, Kurram Agency, Pakistan. Acta Mineralogica Pakistanica 1, 49-63.

Key words: Mineralogy, geochemistry, Kohi Safaid, Kurram Agency.

A/276. Ahmed, Z., 1985d. Petrology of the Niat Gah part of the Thak valley igneous complex, Gilgit Agency, Pakistan. Acta Mineralogica Pakistanica 1, 116-117.

Key words: Petrology, Niat Gah, Thak gah, Chilas Complex.

A/277. Ahmed, Z., 1985e. Basic pegmatite from near Chilas Diamir District, Pakistan. Acta Mineralogica Pakistanica 1, 118.

Key words: Pegmatite, Chilas.

A/278. Ahmed, Z., 1985f. Mineral microanalytical data on the doleritic dykes from Mansehra-Amb State area, Hazara Division, Pakistan. Acta Mineralogica Pakistanica 1, 98-115.

The mineral phases present in a suite of doleritic sills and dykes cutting across the granitic-pelitic metamorphic rocks of Mansehra-Amb State area, have been analyzed by electron microprobe. Doleritic rocks represent a variety of rocks produced by magmatic differentiation, subsequent metamorphism of varying intensity and rock alteration. Plagioclase and biopyribole compositions exhibit strong variations in different doleritic samples. Sphene, epidote and hydrogrossular, found in small amounts in some samples, may indicate some auto-metasomatism. Magnetic and ilmenite are abundant among opaques and oxidized titanomagnetite is also present. A large part of magnetite formed from pyrite and chalcopyrite.
Key words: Mineralogy, dolerite, Mansehra.

A/279. Ahmed, Z., 1986a. Mineralogy of Proterozoic metamorphites of southern Malakand Agency, Pakistan. Acta Mineralogica Pakistanica 2, 24-46.

Mineral assemblages of a variety of lithological samples of the greenschist facies metamorphic rocks that occur widespread in southern Malakand Agency and adjacent areas, have been investigated and chemically analyzed by microprobe. Mineral chemical data is presented in respect of chloritoid, chlorite, muscovite, fuchsite, talc, biotite, spessartine, Mn-bearing garnet, apatite, sphene, ilmenite, monazite and rutile. Data on fuchsite is supplemented by its lattice parameters. Chlorite zone is extensively developed with regional metamorphic chloritoid found in a portion. The chloritoid has low Mg, Mn and inferred Fe^{3+}. It equilibrated with chlorite at a temperature higher than that of the comparable rocks from Turkey. The celadonite and Ti contents in muscovite show progressive increase with metamorphic grade. From under the base of an ophiolite an even higher-grade spessartine-bearing rock is found affected more by higher pressure than by higher temperature. Its chlorite has relatively high MnO and CaO contents. At or near the contact of ophiolitic rocks, evidence of metasomatic and hydrothermal activity is noticed.
Key words: Mineralogy, metamorphism, Malakand.

A/280. Ahmed, Z., 1986b. Ophiolites and chromites deposits of Pakistan. In: Chromites. UNESCO’s IGCP-197 Project, Metallogeny of Ophiolites. Theophrastus Publications S.A., Ethens, 241-262.

Key words: Chromite, ophiolite.

A/281. Ahmed, Z., 1986c. Ophiolite related mineral resources of Pakistan. Abstracts, Symposium/Workshop on Plate Tectonics and Crust of Pakistan. Institute of Geology, Punjab University, Lahore, 2-3.

A review of various metallic and non-metallic mineral resources genetically linked to the ophiolitic rocks of Pakistan is presented. Geotectonic and geological features of all the known ophiolitic rocks of Pakistan are summarized. Distribution and characteristics of certain mineral commodities have been outlined and described. Many Pakistani ophiolites lack the upper portions of the ophiolite sequence; others exhibit intimate association of non-ophiolitic and ophiolitic volcanic rocks. Metallic grade chromite is the most widespread of the minerals and forms rich concentrations. Precious gem quality emerald deposits show ophiolitic derivation, probably not observed elsewhere.
Key words: Mineral Resources, ophiolites.

A/282. Ahmed, Z., 1987a. Mineral chemistry of the Sakhakot-Qila ophiolite, Pakistan: Part 1, Monosilicates. Acta Mineralogica Pakistanica 3, 26-41.

This paper is the first of a 4-part serial characterization of the mineral chemistry of the Sakhakot-Qila Ophiolite. Monosilicates from this ophiolite include olivine, sphene and garnets. Olivine with a Fe content of 73% to 97% shows variations in Mg and Fe contents related to the primary rock-types, and to the textural components within rock samples. Olivines with the highest Mg and lowest Fe from inclusions in chromite crystals. Olivine grains embaying into the boundaries of chromite crystals are intermediate between such inclusions and discrete grains. Olivines with the highest Fe and lowest Mg are those from the Fe-websterite dyke. Sphene is a late-stage crystallization product found only in metadolerites and plagiogranite differentiates. Its chemical variation is insignificant. Garnets are all metasomatic and present in various type of rodingitic veins and dykes. Grossular is the most common garnet and often coexists with hydrogrossular, or rarely, andraditic grossular. At interfaces of rodingites with the chromitite wall rocks, uvarovite or Cr-rich titanian grossular may develop. The garnet compositions are commensurate with the mother fluids having a seawater source.
Key words: Mineralogy, Ophiolite, Malakand.

A/283. Ahmed, Z., 1987b. Mineral Chemistry of the Sakhakot-Qila complex, Pakistan: Part 2, polysilicates. Acta Mineralogica Pakistanica 3, 140-158.

Polysilicates contained in the SQO include enstatite, bronzite, diopside, endiopside, salite, augite, magnesio-anthophyllite and a variety of calcic amphiboles. Their compositions vary mainly with the primary rock types, and too much less extent, with the effects of secondary metasomatic activity. Orthopyroxenes exhibit a relatively restricted range in Fe variation, except for more magnesian inclusions in chromite crystals and more Fe-rich crystals in websterite dykes. Primary Mg-Fe variations in clinopyroxenes are superimposed by the metasomatic Ca-enrichment. The primary amphiboles exhibit a less marked Fe-enrichment, Si-depletion trend with increasing SiO_2 in the rock. This is overshadowed by the secondary tremolite-actinolite formation by the interaction of fracture-controlled SiO_2 rich solutions. Minor element variations in polysilicates are not significant.
Key words: Mineralogy, ophiolite, Malakand.

A/284. Ahmed, Z., 1988a. Bulk-rock chemistry and petrography of the Sakhakot-Qila ophiolite, Pakistan. Acta Mineralogica Pakistanica 4, 4-29.

Petrographic observations on the Sakhakot-Qila ophiolitic rocks are supplemented by their characterization in terms of bulk-rock contents of major, trace and rare-earth elements. The thick, mantle-rock sequence exhibits Mg-rich compositions with very small variations. Strong magmatic differentiation is shown by non-cumulate dyke rocks. REE abundance levels progressively increase during the magmatic evolution, maintaining LREE-depleted pattern. The criteria used by Ishiwatari (1985) indicates derivation of this ophiolite after a moderate degree of partial melting of an Iherzolitic mantle.
Key words: petrography, geochemistry, ophiolite, Malakand.

A/285. Ahmed, Z., 1988b. Mineral chemistry of the Sakhakot-Qila ophiolite, Pakistan: Part 3, phyllosilicates. Acta Mineralogica Pakistanica 4, 45-64.

Phyllosilicates of the Sakhakot-Qila ophiolite are products of secondary processes and include rock-forming and vein-serpentine, chlorite and clintonite. Serpentines of rock-forming and vein types appear chemically indistinct, and are rich in Mg. Structure of the asbestos chrysotile is 2Mc1. rarely, within samples, earlier serpentines may contain higher SiO_2, MgO and lower FeO, Al_2O_3. NiO, MnO than the later ones. Chlorite shows diversity in mode of occurrence and composition. Rodingites and chromitites often contain "IIb-even" structure type chlorite with b cell dimension varying from 9.18 to 9.24 Å. Chlorite has variable Al, Fe and Mg; and a trend of Fe-enrichment and Mg-depletion is depicted from earlier towards later magmatic differentiates. Clintonite forms in rodingites by localized Al-metasomatism.
Key words: Mineralogy, Ophiolite, Malakand.

A/286. Ahmed, Z., 1988c. Mineral chemistry of the Sakhakot-Qila ophiolite, Pakistan: Part 4, disillicates, tectosilicates and non-silicates. Acta Mineralogica Pakistanica 4, 65-80.

The rocks of Sakhakot-Qila ophiolite contain disilicate: clinozoisite and vesuvianite; tectosilicate: quartz and albite; and non-silicates: chromian spine, ilmenite, corundum, perovskite, apatite, nantokite, native Cu and a nickeliferous opaque mineral assemblage comprised of awaruite, pentlandite, heazlewoodite, PGE-rich awaruite, and troilite. In clinozoisite, theoretical pistacite content increases from the lower level towards the higher-level within the metagabbros. The accessory chromite in ultramafic rocks is more ferruginous and less magnesian than the associated ore forming chromite. Both types conform to compositions known form ophiolitic rocks, except the Liguria-type ophiolites. Rodingitizing fluids cause increased Al-activity that is reflected by the presence of corundum: the elevated Cu and Cl, concentrations in the fluid are reflected in native Cu, nantokite and chlorapatite; and reaction of rodingitizing fluids with chromite may result in some local perovskite. Serpentinizing fluids form a variety of nickeliferous opaque minerals whose composition depends upon host-rock chemistry.
Key words: Mineralogy, ophiolite, Malakand.

A/287. Ahmed, Z., 1990a. An overview of Pakistani ophiolites. Science Technology and Development 9, 31-48.

Key words: Ophiolite.

A/288. Ahmed, Z., 1990b. Geochemical characterization of Proterozoic upper crustal metamorphic terrain of southern Malakand Agency, Pakistan. Precambrian Research 46, 189-194.

Proterozoic crystalline schists that have extensive outcrops in the southern Malakand Agency and adjacent regions were sampled from localities west of Dargai town to include lithologically different samples. Their major and trace element chemistry and mineralogy indicate a sedimentary origin, protolith variations, and a passive continental margin tectonic setting. The REE contents indicate considerable mixing of various source lithologies during sedimentation. The samples have high TREE and LREE/HREE compared with the post-Archaean upper crustal values. The chemical data indicate their derivation from a typical granodioritic upper crust with a large component of K-rich granitic rocks.
Key words: Geochemistry, metamorphism, Malakand.

A/289. Ahmed, Z., 1991. Comparison of the chemistry of ophiolitic pyroxenites with a strongly fractionated dyke of pyroxenite from the Sakhakot-Qila ophiolite, Pakistan. Chemical Geology 91, 335-355.

Exceptionally strong fractionation has been found amongst the pyroxenite dykes crosscutting the ultramafic rocks of the Sakhakot-Qila ophiolite, Pakistan. One such dyke, an "Fe-websterite", is particularly fractionated and anomalously Fe-enriched and Mg-depleted. This is supported by the data from whole rock analyses of major, trace and rare earth elements, as well as by the mineral chemistry of the constituent chromian spinel, olivine, clinopyroxene, orthopyroxene and magmatic amphibole. Secondary sulphides of the "Fe-websterite" include troilite-

pentlandite instead of the awaruite-hazlewoodite-pentlandite assemblage typical of all the other ultramafic rocks of the host ophiolite. The non-cumulate parent liquid of the magnesian pyroxenites crystallized in an initial episode when the surrounding cumulates were still hot. In a belated second episode, the Fe-websterite may have crystallized in isolated pockets after its differentiation to an extent much greater than that known from most pyroxenite dykes in ophiolites.
Key words: Geochemistry, ophiolite, pyroxene, Malakand.

A/290. Ahmed, Z. & Ahmad, S., 1974. Mineralogy and petrology of spinel lherzolite from Bar Bandai, Swat District, Pakistan. Geological Bulletin, Punjab University 11, 7-14.

Minor ultramafic bodies occur sporadically within the so-called Upper Swat Hornblendic Group (? Precambrian) of northern Pakistan. A spinel lherzolite outcropping near Bandai, Swat, District, Pakistan, has been investigated. It's field relations, textural features and petrography is described. Modal analyses of twelve samples and chemical analysis of one of them are included. Contemporaneous with the crystallization of silicate minerals, a spinel solid solution exhsolved into two phases, a non-titaniferous magnetite and a chromehercynite. Ore microscopic features of the spinel phases and their alteration products are described.
Key words: Mineralogy, petrology, spinels, Swat.

A/291. Ahmed, Z. & Ahmad, S., 1975. Garnets from the upper Swat hornblendic group, Swat District, Pakistan. Part 1: Garnets from gneisses and pegmatites. Mineralogical Magazine 40, 53-58.

Chemical analyses and refractive indexes are reported for eleven garnets. They are dominantly consisting of almandine component.
Key words: Garnets, Swat.

A/292. Ahmed, Z. & Bevan, J.C., 1981. Awaruite, iridianawaruite and a new Ru-Os-Ir-Ni-Fe alloy from the Sakhakot-Qila Complex, Malakand Agency, Pakistan. Mineralogical Magazine 44, 225-230.

The authors report the first occurrence of awaruite in Pakistan, in the Sakhakot-Qila ultramafites. Electron-microprobe analysis reveals a considerable variation in the compositions of awaruites from different parts of the complex. The presence of copper in awaruite, in amounts up to 5 atomic percent, is also reported for the first time. In one chromitite body, an iridian awaruite with up to 27 wt% of iridium occurs in association with 'normal' awaruite and a new Ru-Os-Ir-Ni-Fe alloy. The awaruites are discussed in relation to those from other localities.
Key words: New minerals, ultramafics, Malakand.

A/293. Ahmed, Z. & Chaudhry, M.N., 1976. Geology of Babusar area, Diamir District, Gilgit, Pakistan. Geological Bulletin, University of Punjab 12, 67-78.

A geological map of 67.4-km^2 area near Babusar, Gilgit Agency, Pakistan, has been prepared on a scale of 1:63,360. Detailed petrography of various rock units with 20 selected modal analyses is given. Ten chemical analyses are reported. Regional metamorphites of both ortho- and para- type occur in the Babusar area in addition to a small peridotite body. Pelitic, carbonaceous and calcareous schists of upto almandine grade belonging to the Precambrian Salkhala Series lie in the south. Between these and the Thak Valley Igneous Complex to the north are concordantly present meta-igneous rocks of chlorite to almandine grade and a higher grade banded amphibolite. Minor dykes and sills intruding these metasedimentary and meta-igneous rocks, were subjected to amphibolite facies regional metamorphism. A Tertiary alpine peridotite was intruded into the banded amphibolite as a curved L – shaped lensoid body.
Key words: Geology, Babusar, Gilgit.

A/294. Ahmed, Z. & Hall, A., 1981. Alteration of chromite from Sakhakot-Qila ultramafics complex, Malakand Agency, Pakistan. Chemie der Erde 40, 209-239.

Key words: Chromite, Ultramafics, Malakand.

A/295. Ahmed, Z. & Hall, A., 1982. Nickeliferous opaque minerals associated with chromite alterations in the Sakhakot-Qila complex, Pakistan and their compositional variation. Lithos 15, 39-47.

Chemical compositions of the awaruite-heazlewoodite-pentlandite assemblage from the Sakhakot-Qila ultramafic complex, Pakistan, indicate its genesis in highly reducing conditions with fo2 and fs2 much below those yielding nickel sulphide ores. The compositions from various parts of the complex exhibit larger variations than those reported so far from a single complex, and include unusually high Ni contents. Awaruite compositions extend beyond the previously known limit of Ni content, and are unique in containing Cu and not Co as the third constituent after Ni and Fe; with sympathetic relation between Cu and Ni. Previous reports indicate genesis of such minerals by serpentinization only, but the present example links them to chloritization and the formation of 'ferritchromit' as well. Their petrographic distribution is related to that of chromite grains and segregations and not to that of serpentine.
Key words: Chromite, Ultramafics, Malakand.

A/296. Ahmed, Z. & Hall, A., 1984. Petrology and mineralization of the Sakhakot-Qila ophiolite Pakistan. In: Gass, I.G., Lippard, S.J. & Shelton, A.W. (Eds.), Ophiolites and Oceanic Lithosphere. Geological Society of London, Special Publication 13, 241-252.

The Sakhakot-Qila complex is an incomplete, dominantly ultramafic ophiolite. The geology, rock and mineral compositions, and occurrences of chromite ore deposits are described. The predominant ultramafic rock types are harzburgite, wehrlite and dunite, and dykes of pyroxenite. The mafic components of the complex are a metamorphosed gabbro and dykes of metadolerite. Postmagmatic alteration is common, and several kinds of rodingite are abundant. They formed by addition of Ca, Al, Cl and Cu and removal of Si, Mg, Fe and Ni from pre-existing rocks, and contain corundum, clintonite and Al-depleted ferritchromite in addition to the more usual minerals such as grossular and vesuvianite. The rodingites appear to have developed independently of serpentinization, probably with the participation of seawater. There are numerous small chromite deposits, varying widely in texture and composition. There is a strong reciprocal Cr-Al variation and lesser Mg-Fe^{2+} variation, partly related to the stratigraphic position of the chromite. Nickeliferous opaque mineral assemblages are well developed.
Key words: Chromite, Petrology, Ultramafics, Malakand.

A/297. Ahmed, Z., Hussain, S. & Awan, A., 1977. Petrology of Thelichi area, Gilgit Agency. Geological Bulletin, University of Punjab 14, 27-38.

Near Thelichi, Gilgit Agency, 181 square Kilometer area lying along the newly constructed Karakorum Highway, has been geologically mapped and studied in detail. Detailed petrography including 49 modal analyses of various rocks is presented. Field and microscopic evidences show that there are two major dioritic plutons of Cretaceous-Eocene age, separated by regionally metamorphosed epi- and meso- zonal rocks and a sill of porphyritic diorite. The metamorphics including amphibolites were derived from original sedimentary rocks of different composition. The dioritic rocks lack pyroxenic basic rocks or ultrabasics. They show systematic mineralogical variations due to magmatic differentiation and assimilation. Residual agmatic fractions crystallized the widespread pegmatites and hydrothermal quartz veins. A brief survey of the economic mineral potential of the area is included.
Key words: Petrology, Thalichi, Gilgit.

A/298. Ahmed, Z., Khan, R. & Rauf, A., 1978. Petrology of the Taghma area, Swat District, NWFP, Pakistan. Geological Bulletin University of Punjab 15, 25-31.

A detailed geological map of Taghma area, Swat District, N.W.F.P., Pakistan, based on petrographic rock types, is being presented. The field relations and petrography of various rock units is given. Certain genetic features of various rock types and the china clay deposits are discussed briefly.
Key words: Petrology, Swat.

A/299. Ahmed, Z., Navid, M.A., Siddiqui, M.A., & Mirza, K.J., 1983. Field Report on the Geology of Kitiari Shamozai Area, District Swat, North West Frontier Province, with special emphasis on Mineralogy and petrology of Marble, Garnet–Mica–Schist, Graphitic and Green Schist, Carbonates and Amphibolites. M.Sc. Thesis. Punjab University, Lahore.

Key words: Petrology, Marble, Graphite, schists, Swat.

A/300. Ahsan, N., Ahmad, N., Chaudhry, M.N. & Hameed, A., 1999. Petrology and environment of deposition of Lumshiwal Formation, Jhamiri Village, Haripur-Jabrian Road, Hazara Basin, Pakistan. Pakistan Journal of Geology 10 & 11, 9-19.

Key words: Petrology, Deposition, Lumshiwal Formation, Haripur, Hazara.

A/301. Ahsan, N., Ahmad, N., Chaudhry, M.N., Mahmood, T. & Masood, K.R., 1999. Microfacies analysis and environment of deposition of Hangu Formation at Chahla Bandi, Azad Kashmir, NW Lesser Himalayas. Pakistan Journal of Geology 10 & 11, 34-40.

Key words: Microfacies, Deposition, Hangu Formation, Lesser Himalaya, Azad Kashmir.

A/302. Ahsan, N., Ahmad, N., Nadeem, M. & Chaudhry, M.N., 1998. Sedimentological studies of Chorgali Formation at Chahla Bandi on the western limb of Hazara Kashmir Syntaxial Region in Azad Jammu and Kashmir. Pakistan Journal of Geology 8 & 9, 18-28.

Key words: Sedimentology, Chorgali Formation, Hazara-Kashmir-syntaxis, Azad Jammu and Kashmir.

A/303. Ahsan, N., Ahmad, N., Rehman, Z., Chaudhry, M.N., Ghazanfar, M. & Masood, K.R., 1998. Lithofacies studies of Margala Hill Limestone at Khaira Gali, Murree-Ayubia Road, Hazara Basin, Pakistan. Pakistan Journal of Geology 8 & 9, 7-17.

Key words: Lithofacies, Limestone, Margalla Hills, Hazara.

A/304. Ahsan, N., Baloch, I.H., Chaudhry, M.N., Chaudry, M.M. & Gondal, M.M.I., 2001. Petrography and geotectonic study of Allai River bed aggregate near Banna, NWFP, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, 55-56.

The Allai River is an important tributary of the River Indus. The Allai River confluences the Indus near Besham at Kund Syyadian. A number of dams with a total hydroelectric potential of about 1000 MW are likely to be built on the Allai River and its tributaries. Therefore tens of thousands of cubic metre of fine and coarse aggregate will be required for the dam and related civil structures. The gravel and associated sand deposit occurs on the bed of the Allai River and its tributaries near Banna. These deposits were studied petrographically as well as from engineering point of view. The Allai River derives its sediments both from the Indian plate edge as well as from the Indus suture zone and Kohistan island arc. The Indian plate edge in the area is composed of high grade pelites, psammite, S-type Mansehra granite, Susil Gali granite and metasediments belonging to Hazara Group as well as Tethyan sediments which are composed of thick sequence of dolomite, dolomitic limestone, limestone and slates. The suture zone and Kohistan island arc is composed of ultramafics, norites, diorites and amphibolites. Since the Allai River flows near

the boundary of the Indian plate and the Kohistan island arc, therefore the composition of the sand and gravel along the river varies widely. However, we have chosen Banna because of the large quantity of available sand and gravel. All fractions of the coarse aggregate have been studied petrographically. The range In composition of all the sieves is composed of amphibolites (1.3 to 15.6%), diorite (0-33.8%), granite (8.2% to 19.5%), S-type granite gneiss (0-10.7%), granite mylonite (0-7.1%), marble (12.7% to 25.5%), mylonite (0 to 6.8%), pegmatite (0-2.5%), schist (0-20.5%), vein quartz (0-3.7%), norite (0-12.2%) and dunite (0-28.4%). The fine aggregate is composed of granite/granodiorite (1.1% to 24.6%), diorite/tonalite/ amphibolite (0 to 32.8%), quartzite (8.1% to 21.8%), phyllite/slate* (7.2% to 20.4%), greywacke group* (0-0.4%), chert* (0-0.8%), quartz mica schist/gneiss (4.6% to 8.5%), quartzipolygrain quartz (21.1% to *53.6%),* feldspar (4.4% to 8.3%), biotite (1.3% to 2%), muscovite (1.4% to 2.4%), amphibole (0.9% to 3.7%), epidote (1.5% to 1.8%), magnetite (1.0% to 3.0%), garnet (1.1% to 1.2%), tourmaline (0-0.1%) and zircon (0-0.3%). The physical properties of the coarse and fine aggregate fulfil the parameters set by BS812: 1965 and ASTM part 4.
Key words: Petrography, tectonics, Allai River, Banna, NWFP.

A/305. Ahsan, N., Baloch, I.H., Chaudhry, M.N. & Majid, C.M., 2000. Strength evaluation of motars of Lawrencepur, Chenab and Ravi sands and concrete using Lockhart and Margala Hill limestones. In: Hussain, S.S. & Akbar, H.D. (Eds.), Proceedings, National Symposium on Economic Geology of Pakistan, 1997, Islamabad, 213-239.

Key words: Concrete, limestone, Lawrencepur, Chenab, Ravi, Margalla.

A/306. Ahsan, N. & Chaudhry, M.N., 1998. Facies and microfacies analysis of Kawagarh Formation of Hazara basin, Pakistan. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 5-6.

The Upper Cretaceous in the Hazara Basin is marked by a transgression which deposited Kawagarh Formation (Latif, 1970, Shah, 1977). At the type locality (lat. 33° 45' 30" N; long. 70° 28' 30" E) the Kawagarh Formation is composed of dark marl, cleaved calcareous shale and nodular argillaceous limestone. The section of the Kawagarh Formation at the type locality is incomplete due to folding and faulting. A study of four sections of Kawagarh Formation of Hazara Basin at Jabri, Changla Gali, Giah and Borian is presented and discussed in the following.
The Kawagarh Formation near Jabri (lat. 33° 55' N; long. 73° 1.5" E) is composed of light brown to chocolate, whitish grey to light grey and pinkish grey limestones. The basal portion contains thinly laminated dirty to earthy grey and rusty grey marls interlayered with arenaceous limestone (Ahsan et al., 1993). The formation here is divided into eight facies which are composed of glauconitic arenaceous mudstone facies, mixed arenaceous limestone/marl facies, mud to wackestone facies, mixed grainstone to mudstone facies, wackestone to mudstone facies, mixed grainstone to mudstone facies, mudstone facies and mixed dolomitic limestone facies.
The Kawagarh Formation at Changla Gali (Iat. 33° 55'30" N; long. 73° 22'30" E) consists of medium to dark grey limestone which we attiers to offwhitish grey, yellowish grey and light grey shades. Earthy grey, rusty to yellowish grey and splintery mart (20.52m thick) is present at the top. However, eight marly horizons intercalated within the limestone also occur. The formation is composed of four facies which are dolomitic arenaceous mudstone facies, packstone-, dolomitic packstone-dolospar and mad facies, mixed wackestone packstone-marl facies and marl facies (Ahsan et al. 1994). The Kawagarh Formation at Giah (Iat.34° 6' 30"; long.73° 21'26") is white to light grey, bluish grey and dark grey limestone (Chaudhry et al., 1992). It is composed of four facies which contain mixed dolomitic limestone-dolospar facies, biomicrite facies, sandy biomicrite facies, sandy dolomitic limestone facies, sandy dolospar facies. Towards top it contains coarse grained detrital quartz. The Kawagarh Formation at Boriati (lat. 34° 9' 15" N; long. 73° 17' 15" E) is composed of light to dark grey, light yellowish grey, whitish maroon, reddish maroon to maroonish grey limestone (Ahsan et al. 1993), The formation consists of four facies which contain mixed wackestone-packstone-dolomite facies, mixed mudstone to wackestone facies, mixed mudstone-wackestone facies and mixed mudstone-wackestone-intraclast bearing wackestone-dolostone facies. The sections of the Kawagarh Formation at Jabri 3nd Changla Gali which are located southwards of the Nathiagali Fault contains fair amount of marls and arenaceous limestone. Arenaceous limestone and mars constitute 23.13m of lower part of the Jabh section. The Changla Gali section is composed of alternations of marl and limestone horizons. The sections situated/the north of the Nathia Gali Fault do not contain mads or limestones of significant clastic matter. The sections south of the Nathia Gali Fault which contains fair amount of the marl were deposited at relatively shallower depths of around

80 to 100 m since they lack benthic fauna and contain pelagic foraminifera. However, the sections to north of the Nathia Gali fault which lack marl were deposited towards the very shelf edge at about 200 to 250 m as indicated by presence of Oligostegina. Carbon oxygen isotope studies of selected samples show that it was deposited in warm water conditions. It has been established that Indian Plate established its first contact with Kohistan Arc at about 67±2 Ma (Bard et al., 1979). It resulted in uplift of shelf and lateritization of the Kawagarh Formation in Maastrichtian (Chaudhry et al., 1994). The burial of Kawagarh Formation started with deposition of shelf carbonates and shales in Thanetian and continued upto deposition of Murree Formation, The total thickness of sediments is about 3800m. The deposition of Siwaliks is not certain in the studied area. The maximum temperature was about 125°C and pressure reached about 0.9 kb. Non ferroan microcrystalline calcite is penecontemporaneous to the bioclasts. The Mg^{++} bearing solutions from Chichali Formation deposited authigenic dolomite during burial. The ferroan recalcification of dolomite, groundmass and some bioclasts is associated with final uplift and is due to influx of reducing waters. Microstylolites were developed at pressure of about 0.9 kb.
Key words: Facies, Microfacies, Kawagarh Formation, Hazara Basin.

A/307. Ahsan, N. & Chaudhry, M.N., 1999. Sedimentology of Lumshiwal Formation, Attock Hazara fold and thrust belt, NW Lesser Himalayas, Pakistan. Terra Nostra 99, Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 4-5.

The Middle Cretaceous Lumshiwal Formation (Shah, 1977; Chaudhry et al., 1994, 1997) is a time transgressive unit of the Attock Hazara Fold and Thrust Belt, “AHFTB” (Ghazanfar and Chaudhry, 1990) and Salt - Surghar Ranges of North Western, Pakistan. This unit is composed predominantly of marine glauconitic sandstone in the AHFTB and parts of Salt Range. This unit overlies the Lower Cretaceous marine black shales, which were deposited in an anoxic basin with poor circulation. The deposition of Lumshiwal Formation marks the onset of relatively open marine conditions with better circulation. In the Attock Hazara Fold and Thrust Belt of North Western Pakistan, five sections of this formation were measured and studied in detail for facies, microfacies, provenance, environment of deposition and diagenesis in the north western part of the oil and gas producing Indus Basin. The Lumshiwal Formation is producing gas in the northern part of Punjab Platform.
Facies: It is composed predominantly of glauconitic arenite and quartz wackes. Arenaceous limestones, arenaceous dolomites and oolitic limestones are subordinate to arenites. Shales and sandy shales are rare. They are well to very well sorted, subangular to rounded, compositionally mature and texturally submature to mature. Diastems at places are marked by sub-marine hard grounds. These horizons are cemented with iron oxides and may occasionally contain collophanite or dahalite.
Cement Stratigraphy: Based on detailed textural studies in various sections of the following general cement stratigraphy has been worked out. Glauconite and calcite is present as very early cements. The formation of glauconite itself suggests slow rates of sedimentation (0.96 mm/1000 years, Chaudhry, et al., 1998) and mildly reducing conditions. Other events in younging order includes i) Flint cement, ii) Kaolinite cement, iii) Early calcite cement, iv) Dolomite cement, v) Ferroan calcite cement, vi) Deep burial quartz cement, vii) Late diagenetic kaolinitic cement and viii) Iron oxide cement.
Provenance: Plagioclase, microcline, schorl, indicolite, zircon, epidote and sphene are the accessory minerals. These minerals indicate sialic basement with minor basic component as the ultimate source. The granitoid component was S-type. Thermal aureoles contributed indicolite. The restricted suit of heavy minerals, compositional maturity and shape of grains strongly suggest significant recycling. Lack of high grade metamorphic minerals suggest absence of high grade schists and gneisses. Their fine grain size and palaeocurrent indicators suggests derivation from low relief area on the Indian Shield to the south.
Environment of Deposition: The Lumshiwal Formation of the Attock Hazara Fold and Thrust Belt contains marine fossils like pelecypodes, brachiopods and belemnites. They indicate better circulation conditions during the Tithonian with a depth of less than 80 meters within photoic zone. Slightly reducing conditions, at least below the water sediment interface, are indicated by the ubiquitous presence of organic matter, glauconite and pyrite. Towards the end of Lumshiwal deposition, the shallower subtidal shelf rapidly deepend during the worldwide Cretaceous transgression to receive the Upper Cretaceous pelagic Kawagarh Formation (Ahsan et al., 1993; Ahsan and Chaudhry, 1998) which contains pelagic fauna.
Diagenesis: The textural evidence suggests that glauconite formed from clays during the early stages of burial. The clays were present within the pores of quartz arenites. During these stages, calcite formed which was then replaced by dolomites due to rising of Mg^{++} rich solutions from the underlying clay rich Chichali Formation. Suturing of quartz grains occured during deep burial and provided silica for cementation. The other silica contributing sources

are clays and siliceous Skeletons of organisms. Iron oxides and some manganese oxides appear to have precipitated due to halmyrolysis. Iron oxides also formed during late diagenetic processes involving circulation of oxygenated meteoric waters through Fe-rich glauconitic sandstones during uplift replace all other minerals.
Key words: Sedimentology, Lumshiwal Formation, Attock Hazara, Lesser Himalaya.

A/308. Ahsan, N. & Chaudhry, M.N., 2000. Characterization of Pakistani oil shales. Pakistan Journal of Geology 12 & 13, 13-25.

Key words: Oil shale.

A/309. Ahsan, N., Chaudhry, M.N., Ghazanfar, M. & Sameeni, S.J., 1993. A preliminiary interpretation of microfacies, deposition and diagenesis of Kawagarh Formation at Barian Abbottabad-Nathiagali Road, Hazara, Pakistan. Geological Bulletin, Punjab University 28, 30-40.

Key words: Microfacies, deposition, Diagenesis, Kawagarh Formation, Hazara.

A/310. Ahsan, N., Chaudhry, M.N. & Hameed, A., 2001. Petrology and environments of deposition of Lumshiwal Formation, Jhamiri village, Haripur-Jabrian Road, Hazara basin, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, 53-54.

The section of Lumshiwal Formation (Shah, 1977) exposed at Jhamiri (Fatmi, 1972) on Haripur-Jabrian Road, Hazara Basin (Chaudhry et al., 1998; Ahsan and Chaudhry 1999) is 2l.60m thick. The formation is mainly composed of very fine to coarse-grained sandstone, which is blackish brown, dark greenish grey and mustard brown to reddish grey on surface. At places, fresh surface shows greenish tinge that becomes darker green on wetting. The basal part is coarse grained with large quartz grains. A few maroonish, rusty to brownish thin layers of splintery shale are present.
The formation at Jhameri village contains twelve microfacies. These include: 1) Coarse to medium grained iron oxides and glauconite cemented quartz arenites, 2) Medium grained carbonate and glauconite cemented quartz arenites, *3)* Medium grained iron oxides cemented quartz arenites, 4) Fine grained clay and iron oxides cemented quartz arenites, 5) Fine grained glauconite and clay cemented quartz arenites, 6) Fine to medium grained clay and iron oxides cemented quartz arenites, 7) Fine grained clay cemented quartz arenites, 8) Fine to medium grained glauconite cemented quartz arenites, 9) Fine to medium grained glauconite and iron oxides cemented quartz arenites, 10) Fine-grained glauconite and carbonate cemented quartz arenites and, 12) Fine to medium grained glauconite cemented quartz arenite.
Textural parameters show that the arenites of the formation are generally supper mature and are angular to subrounded. The accessory minerals include tourmaline, zircon, rutile, sphene, epidote, muscovite, microcline, albite, quartz, chert, flint, chlorite and biotite. The suite of heavy minerals indicates derivation of sediments from the south from S-type granitic or gneissic source. The formation was deposited in marine middle subtidal zone (Flugel, 1982). The lower contact with Chichali Formation (Chaudhry et al., 1998) and upper contact with Kawagarh Formation (Ahsan and Chaudhry, 1998) is transitional.
Key words: Petrology, Deposition, Lumshiwal Formation, Hazara Basin.

A/311. Ahsan, N., Chaudhry, M.N., Mahmood, T. & Masood, K.R., 2001a. Facies analysis and environment of deposition of Lockhart limestone, Chahla Bandi, Azad Kashmir, northwest Himalayas. Abstracts, 4th Pakistan Geological Congress, Islamabad, 22-23.

The Lockhart Limestone near Chahla Bandi Azad Kashmir (Ghazanfar et al., 1987) is 72.80m thick. It is dark grey on fresh surface and weathers to light grey, pale grey, bluish grey to blackish grey. Lithologically the limestone is divided into nodular limestone and massive to thick-bedded limestone. The limestone contains abundant corals, mollusks, echinoids and rare algae. Prominent benthic foraminifera include *Ranikothalia sindensis*, *Miscellanea miscella*, *Lockhartia haimei*, *Discocyclina ranikotensis* and *Lockhartia conditi*. The Lockhart limestone at Chahla Bandi is divided into five facies from bottom to top. Mudstone facies (I) contains splintery, very thin bedded, and

clayey limestone with pyrite nodules at the base. In the middle part this facies is composed of argillaceous nodular limestone. Mudstone to wackestone facies (II) composed of thin bedded, nodular (3cm x 3cm) limestone. Wackestone to packstone fades (III) is composed of very well bedded nodular limestone. Most of the nodules (4 cm X 5 cm) are of equal size. It is thin bedded. Mudstone to wackestone facies (IV) contains nodular (20 cm X 10cm) limestone. It is medium bedded. Wackestone to packstone facies (V) is massive and contains rare nodules. The nodules where present are 30 cm x 20 cm in size and there is no clayey/shale partings interbedded in this facies. The upper contact with Patala Formation is transitional, whereas the lower contact with Hangu Formation is unconformable (Shah, 1977; Chaudhry and Ahsan, 1998).
The groundmass of the microfacies is nonferroan calcite. Neomorphism to ferroan calcite is a common phenomenon. Evidences of physical and chemical compaction are present. Dolomite is rare and where present has been recalcified. This lithostratigraphic unit was deposited in subtidal environment probably on a carbonate shelf. The lower most facies is a shallow shelf deposit with some reworked allochems (echinoids). The rest of the formation is a middle subtidal deposit. There is an overall dominance of Acritarchs and Algal spores, with sporadic occurrence of Pteridophytic spores and Angiosperm pollen. Gymnosperm pollens are absent. Mycorrhizal and Fungal spores also exist in all samples.
Key words: Facies, deposition, Lockhart Limestone, Azad Kashmir.

A/312. Ahsan, N., Chaudhry, M.N., Mahmood, T. & Masood, K.R., 2001b. Microfacies and environment of deposition of Hangu Formation at Chahla Bandi, Azad Kashmir, NW Lesser Himalayas. Abstracts, 4th Pakistan Geological Congress, Islamabad, 52-53.

The Hangu Formation at Chahla Bandi, Azad Kashmir, overlies unconformably the Abbottabad Formation, while in the Hazara Basin (Chaudhry et al., 1988; Ahsan and Chaudhry, 1998) it overlies the Kawagarh Formation of Cretaceous age (Shah, 1977; Latif, 1970; Butt, 1989).
The Hangu Formation at Chahla Bandi contains eleven microfacies. These include: I) Black shale with occasional quartz grains of 1-2mm in size. It weathers to orange to rusty grey. Some streaks of siltstone also occur; 2). Clay/sericite cemented coarse-grained quartz arenite that weathers to rusty brown colour, 3). Clay/sericite, iron oxide cemented medium grained quartz arenite that weathers to rusty brown to light grey. 4). Clay/sericite cemented coarse to medium grained quartz arenite that weathers to off-white, grey and orange, *5).* Clay/sericite, iron oxide cemented coarse-grained gritty quartz arenite. Its fresh colour is off-white and it weathers to rusty brown; 6). Clay/sericite cemented coarse-grained quartz arenite that weathers to brownish grey, 7) Clay/sericite cemented medium grained quartz arenite that weathers to orange to black; 8). Clay/sericite and carbonaceous cemented quartz arenite that weathers to maroon colour; 9) Coal with medium grained quartz weathers to dull black; 10) Coal with fine-grained quartz that weathers to dull black; and I I) Bauxitic clay that weathers to rusty orange.
The basal microfacies, black shale/marks the on set of a transgression after a gap of about *505* million years that deposited 227 cm thick black shale (microfacies 1). The microfacies 2 to 7 represent deposition at upper shore face to lower sl4ore face. The microfacies 8 to 10 are coal bearing and represent supratidal marshy depositional regime. The microfacies 11 is residual deposits (70 cm thick) of continental origin that is composed of pisolitic bauxite. It marks an episode of regression at the end of Danian.
Hangu Formation contained poorly preserved palynoflora presenting a case of marginal palynology. Microfossils were fragile, impregnated with high amount of fixed carbon, posing special problems in correct identification. Pollen and spores were equally represented with sporadic occurrence of Dinoflagellates and Acritarchs at certain horizons. Pollen Were of stephanocolpate and polycolpate type whereas spores were predominantly trilete and psilate.
Key words: Facies, Deposition, Hangu Formation, Azad Kashmir.

A/313. Ahsan, N., Chaudhry, M.N. & Majid, C.M., 2000. Mineralogy, engineering properties and alkali aggregate reaction potential of Mira sand, Thakot, Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, 150-152.

The Kawagarh Formation of Jabri area is divided into eight internal units and thirty- six microfacies for the first time. It is basically a transgressive unit deposited during Cretaceous global transgression. The maximum depth of the sea at that time was about 250m. On the basis of planktonic fossils the age of the unit ranges from Upper Coniacian to Lower Campanian.

Key words: Engineering properties, alkali aggregate, sand, Thakot.

A/314. Ahsan, N., Chaudhry, M.N. & Rehman, Z., 2000. Lithofacies and microfacies studies of Margala Hill Limestone at Khaira Gali, Murree-Ayubia road, Hazara, Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.150.

A preliminary sedimentological account of Margala Hill Limestone exposed at Khaira Gali is presented for the first time. This formation is divided into 12 lithofacies units and 63 microfacies. The] 2 lithofacies units are separated by 11 marly horizons. These horizons formed as a result /of influx of clay into the basin of deposition due to fluvial channel shifting. The entire formation is free of oolites and pellets. Sedimentary structures like ripple marks, cross bedding etc. are deposited in open marine conditions on a carbonate ramp under subtidal conditions. The unit is marked by a number of minor changes in sea level resulting in deposition from upper subtidal to lower subtidal environs. The organic content on the average is about 2%. However, some horizons contain as much as 5% organic content. The porosity (other than fracture porosity) is around 2% but varies from traces to 5%. Fracture porosity on the out crop scale is dominant. Both mechanical and chemical compaction have played an important role in volume reduction.
Key words: Facies, microfacies, Margala Hill, limestone, Khaira Gali, Hazara.

A/315. Ahsan, N., Chaudhry, M.N., Sameeni, S.J. & Ghazanfar, M., 1993. Reconnaissance microfacies studies of Kawagarh Formation, Jabri area, Hazara, Pakistan. Pakistan Journal of Geology 1 & 2, 32-49.

Key words: Microfacies, Kawagarh Formation, Hazara.

A/316. Ahsan, N., Iqbal, M.A. & Chaudhry, M.N., 1994. Deposition and diagenesis of Kawagarh Formation, Changla Gali, Murree - Ayubia road, Hazara, Pakistan. Pakistan Journal of Geology 2, 17-23.

A field and petrographic study of Kawagarh Formation from Changla Gali was carried out in order to work out microfacies, environment of deposition and diagenesis. The formation has been divided into 30 microfacies. They include dolomitic arenaceous mudstone, packstone, dolomitic packstone, dolospar and wackestone with occasional intercalated marls. These microfacies are grouped into four units from bottom to top. CU-1 was laid down on top of Lumshiwal Formation in upper subtidal zone probably at a depth of about 50 to 80m. CU-II marks a rapid transgression and was deposited under pelagic shelf conditions below upper subtidal zone. This was followed by a CU-III, sequence of wackestone to packstone with marly intercalations deposited in lower subtidal zone CU-IV marks on-set of regression culminating into subareal exposure. Post depositional changes such as cementation, neomorphism, compaction, dolomitization and dedolomitization are discussed.
Key words: Deposition, diagenesis, Kawagarh Formation, Murree, Ayubia, Hazara.

A/317. Ahsan, N., Majid, C.M. & Chaudhry, M.N., 1997. Strength evaluation of blends of Lawrencepur, Chenab and Ravi sands with Lockhart and Margalla Limestones for use in concrete. Abstracts, National Symposium on Economic Geology of Pakistan, Islamabad, 2p.

Concrete is a composite material consisting of inert coarse and tine aggregates hound by a binding medium. The cement water and air combine to form a paste that hinds the aggregates together. Pakistan is gifted with enormous quantities of coarse and tiny aggregates. The coarse aggregates from the Lockhart Limestone and Margalla Hill Limestone were used with fine aggregates from lawrencepur. Chenab and Ravi to evaluate their strength properties with ordinary Port land cement. The Lockhart Limestone and Margalla Hill Limestone showed excellent physical and mechanical properties: hulk densities 84 lbs/cft and 86 lbs/cft water absorption 0.8% and 0.6%. Los Angeles abrasion values 24% and 26% impact value 13% and 16% crushing value 25% and 27% and soundness by Na_2SO_4 1.71% and 1.60% respectively. The Lawrencepur Chenab and Ravi sands were tested and found that the Lawrencepur sand is the best which generally meets the requirement given in BS 882/1965. However the Chenab

sand showed the desired results when mixed with Lawrencepur sand in the proportion of 25-30: 75-70 while the Ravi sand is not good for use in concrete as it is fine and does not come up to the required standards. The coarse and fine aggregates were blended with ordinary Portland cement keeping in view the desired water-cement ratio for acquiring desired strength. The Lockhart Limestone and Margalla Hill Limestone were found excellent coarse aggregates with pure Lawrencepur sand and a blend of Chenab and Lawrencepur sand. They gave high compressive strength (upto 8000 psi). The Ravi sand with its very fine size was not found satisfactory as an individual tine aggregate. It is not an economic deposit when blended with the Lawrencepur sand. The Chenab sand is however economical when blended with Lawrencepur sand.
Key words: Sand, concrete, limestone, Lawrencepur, Chenab, Ravi, Margala.

A/318. Ahsan, A., Naveed, N., Khawaja, A.A. & Chaudhry, M.N., 2001. A preliminary account of facies and determination of Ca, Mg, Sr, Mn, Fe and Na in Kawagarh Formation, Kala Pani, Abbottabad-Thandiani Road, Hazara, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, 54-55.

Kawagarh Formation (Shah, 1977; Chaudhry, et al., 1998. Ahsan and Chaudhry, 1998) at Kala Pani is composed of light grey to grey limestone. The formation is generally medium to thick bedded but nodular at the base. The lower contact of the formation is transitional with Lumshiwal Formation (Ahsan and Chaudhry, 1998) and upper contact is unconformable with Hangu Formation. Petrographically it is established that faunal constituents of the formation are composed of planktons and oligosteginids. On the basis of the proportion of these allochems, the formation is divided into planktonic facies, planktonic-oligosteginid facies and oligosteginid-planktonic facies. The planktonic facies constitutes 23.34% of the formation and is composed of 34.48% plank-mudstones, 41.37% plank-wackestones and 24.14% plank-packstones. The planktonie-oligosteginid facies constitutes 60.49% of the formation and contains 17.33% plank-oligo- mudstone, 73.33% plank-oligo- wackestones and 9.34% plank-oligo- packstones. The oligosteginid-planktonic facies is 16.17% of the formation and is composed of 10% oligo-plan -mudstone, 70% oligo-plank-wackestones and 10% oligo-plank-packstones. 20 whole rock samples of the formation were analyzed to determine major (Ca, Mg) and minor (Fe, Sr, Mn and Na) trace elements by atomic absorption spectroscopy using air-acetylene flame. The Ca varies from 19.23% to 39.11% with an average of 33.92%, Mg varies from 0.132% to 1.854% with an average of 0.335%, Mn ranges from 0.3 19 ppm to 1.723 ppm with an average of 0.929 ppm, Sr varies from 0.715 ppm to 4.213 ppm with an average of 2.975 ppm, Na ranges from 4.7 ppm to 8.5 ppm with an average of 5.969 ppm and Fe varies from 6.11 ppm to 36.11 ppm with an average of 17.244 ppm. Moreover a comparison was made in the estimation of Ca and Na by using flame photometer and atomic absorption spectrophotometer. The values obtained by the two methods, were almost the same.
Key words: Facies, Kawagarh Formation, Abbottabad, Hazara.

A/319. Ahsan, Z., 1981-83. Lithostructural mapping and biostratigraphic study of Burikhel Bandakha Area (Western Salt Range) District Mianwali. M.Sc. Thesis, Punjab University, Lahore, 93p.

Detailed Lithostructural Mapping and Biostratigraphic study of Barikhel- Bandakha Area (Western Salt Range) District Mianwali, has been done at 1:10,000. Area is exclusively a sedimentary terrain. Stratigraphy along with micropaleontology of certain formations is described. In addition to this macrofauna have been described. Lateral extension of liminic permean coal is noted. Tectonic style of the area is described with the help of structural details i.e. study of folds, faults and joints etc.
Key words: Lithostructure, biostratigraphy, Salt Range, Mianwali.

A/320. Ajmal, M., 1987. A research report on groundwater investigations with special emphasis on hydrochemical study of National Park, Islamabad. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 19p.

Key words: Groundwater, hydrochemistry, national Park, Islamabad.

A/321. Akash, B., 1975. Focal mechanism earthquake of December 28th 1974, North Pakistan. Journal of Earth and Space Physics 4, 15-19.

Key words: Earthquakes.

A/322. Akbar, J., 1977-79. Mineralogy Petrology of Udigram Area, District Swat. M.Sc. Thesis, Punjab University, Lahore.

The project area lies in northwestern extension of Himalayas in Pakistan. It is part of edge of the Indian plate at its subduction zone. The project area is partly meta-sedimentary and meta-igneous. It consists of the Lower Swat-Buner Schistose group.
The four major rock units have the following sequence from top to bottom.
Green Schist; Phyllitic Schist; Schistose marble; Amphibolite;
The meta-sedimentary sequence has the following grade chlorite, biotite, garnet, kyanite. The green schist formation at the extreme of the project area and extends northward 35-km to the Shangla area where blueschists are developed proving the fossil trench position. The meta-sedimentary sequence is of Paleozoic age and therefore older than the plate movements which took place during the Cretaceous period of blueschists. Therefore the original metamorphism was older than subduction episode but retrograde metamorphism had occurred during plate subduction.
The green schist belongs to the edge of subduction zone, as it is well known that subduction zone rocks are composed normally of igneous detritus, oceanic floor basalts and basic intrusions mixed with sediments. Therefore, green schist evolved out of such a mixed lithology, predominantly from the basic igneous rocks. The zonation of pressure/temperature is so placed that towards Shangla high temperature-low pressure lithologies were formed, while towards project low temperature-low pressure rocks were formed such as green schist. Under the same action, meta-sedimentary sequence suffered retrograde metamorphism of low temperature and low-pressure type.
Key words: Petrography, petrology, Udigram, Swat

A/323. Akbar, M., 1980-82. Geology and Petrology of Hasis-Gahkoch-Gupis (Gilgit Agency). M.Sc. Thesis, Punjab University, Lahore, 90p.

The project area (HESIS-GUPIS) lies in the Punial-Gupis Valley, District Gilgit, Latitude 30^0 4’ 32’ - 36^0 24’ 35’ and Longitude 73^0 25’ 0’ - 73^0 47’ 0’ has been mapped tectonically. The area is located in the Centre of Karakoram Mountains and represents a part of a cross section through this mighty range. Area is intensely disturbed tectonically being involved in Himalayan Orogeny, which is evident from the strained, crushed and deformed lamellae of the mineral in the rock
Structure found in area is orthotectonic. Following features are present in the project area, which is characteristics of an orthotectonic region. Cleavage is well developed in the project area i.e. slaty cleavage, schistocity, fracture cleavage and crenulation cleavage. Igneous activity is present and it shows a magmatic phase on the origin. Folding of isoclinal nature because of the prevalence of severe stresses. The basin, in which deposition has been taking place, is completely destroyed so it is too difficult to reconstruct the geological history of the area. This is a typical characteristic of an orthotectonic region. The project area is composed mainly of igneous and metasedimentary rocks. Metasedimentary rocks are originally deposited in eugeosynclinal conditions as argillaceous sediments and afterwards.
Key words: Petrology, Gupis, Gilgit.

A/324. Akbar, M., 1981-83. Geological mapping and site investigations of dam site and reservoir area of Basha Dam (Chilas Diamer). M.Sc. Thesis, Punjab University, Lahore, 101p.

The electric power demand of Pakistan is very high and the present generation capabilities of the country are insufficient to cope with the increasing load created by industry, agriculture and domestic consumers. In order to tide over the situation water and power development of Pakistan initially identify thirteen sites on the Indus River upstream of Tarbela upto Skardu, because the drop along Indus plains show attractive locations for hydro power development. To study the potential/plan the development of 13 identified sites and feasibility of one best site first

Canadian Technical Assistant has been arranged. Basha damsite is the site selected by the Canadian Consultant for the feasibility purposes which is located on the Indus river near the village Basha about 45 km downstream of Chilas in Gilgit Agency.
Key words: Mapping, reservoir, Basha, Chilas.

A/325. Akbar, S., 1962. Geology of Upper Batrasi area Mansehra, Hazara. M.Sc. Thesis, Peshawar University, 30p.

Key words: Geology, Batrasi, Mansehra, Hazara.

A/326. Akhtar, A. & Khan, F.G., 1998. Stratigraphy and structure of Reshun area (Chitral) north Pakistan: Implications for construction of small hydel power project. M.Sc. Thesis, University of Peshawar, 70p.

Key words: Stratigraphy, structure, hydel power, Reshun, Chitral.

A/327. Akhtar, J., 1987. Vertical magnetic survey of the lead-zinc deposit in Lahor-Serai area, Besham, N.W.F.P., Pakistan. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 31p.

Vertical magnetic investigations were carried out (as a part of integrated geophysical survey) to demarcate the lateral subsurface extent of Pb-Zn ore in Lahor-Serai area of Besham. This study shows that strong magnetic anomalies are solely generated by magnetite concentration in carbonate rock units; whereas the magnetic signal over Pb-Zn ore is very weak.
Analyses of magnetic anomalies yielded that, magnetic patterns of low amplitude (i.e. in the range of -500 to +150.0 gammas) can guide ore exploration within a depth range of 10-20 metres at places located along structurally weak zones.
Key words: Magnetism, Lead-Zinc, Lahor, Besham.

A/328. Akhtar, J., & Iqbal, Z., 1979. Geology and petrology of the Udigram Area, District Swat. M.Sc. Thesis. Punjab University. Lahore.

Key words: Geology, Petrology, Udigram, Swat.

A/329. Akhtar, J., & Sakhawat, M., 1991. Magnetic survey around Khabbal area, near Oghi, District Mansehra, NWFP. GSP Information Release 499.

Key words: Magnetism, Khabbal, Oghi, Mansehra.

A/330. Akhtar, M., 1983. Stratigraphy of the Surghar Range. Geological Bulletin, University of Punjab 18, 32-45.

Sedimentary rocks of marine and non-marine origin ranging in age from Permian to Pliocene constitute most of the stratigraphic sequence in the Surghar Range. The sequence comprises 10 lithostratigraphic units with a cumulative thickness of more than 5000 meters. The lithologies consist predominantly of limestone, shale and sandstone with subordinate marl, dolomite and minor interformational conglomerate. Permian-Triassic boundary is marked by a slight lithological break indicating a paraconformity. Cretaceous-Paleocene and Eocene-Miocene sequences are also intervened by unconformities.
Key words: Stratigraphy, Surghar.

A/331. Akhtar, M. 1984-86. The geology and mapping of Muzaffarabad area from Chehla Bandi to Chhattar Kalas with special emphasis on landslide problems along roads. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 64p.

Nature does not supply all the things to man, but merely offers opportunity to secure all things, and a condition where man controls the elements is inestimably superior to a condition where the elements control man.
This field report comprises a complete geological study based on mapping of nearly 100 sq. kms of Muzaffarabad – Chhattar Kalas area. Special emphasis has been put on describing the stratigraphy and landslide problems in the project area. The stratigraphic succession has been established. The rock units present in this area Hazara Formation (Cambrian), Abbottabad Formation (Cambrian), Patala Formation (Paleocene) Margala Hill Limestone (Eocene), Kuldana Formation (Eocene) and Murree Formation (Miocene). The major tectonic features in the proximity are Jhelum fault, Muzaffarabad fault and Muzaffarabad anticline.
The Muzaffarabad-Kohlala road is the main way of transportation and communication between the Pakistan and Azad Kashmir. A number of huge slides occur on this road which blocks it for hours and sometimes for days. Due to the vital importance of the road it is unbearable. So this field report is prepared with the aim to study the area in detai1 and to explore the reasons of sliding on this road.
The samples are taken for laboratory tests. The purpose of laboratory test is to evaluate the strength parameters which are responsible for driving and resisting the moment. In this report an attempt is made to explore the reasons of failures in the area as well as economical and adequate remedial measures were suggested.
Key Words: Geology, mapping, landslides, Muzaffarabad.

A/332. Akhtar, M., 1988a. Preliminary bibliography of lower Tertiary rocks of Pakistan. Geological Survey of Pakistan, Information Release 347.

Key Words: Bibiliography, Lower Tertiary.

A/333. Akhtar, M., 1988b. Lithological description of type and reference section of Triassic-Cretaceous rocks of Surghar Range. Geological survey of Pakistan, Information Release 346.

Key words: Type Section, stratigraphy, Triassic-Cretaceous, Surghar Range, Trans-Indus Salt Range

A/334. Akhtar, M., & Butt, A.A., 1999a. Microfacies and foraminiferal assemblages from the Early Tertiary rocks of the Kala Chitta Range (Northern Pakistan). Geologie Mediterraneenne 26, 185-201.

Key Words: Microfacies, foraminifera, Tertiary, Kala chitta.

A/335. Akhtar, M., & Butt, A.A., 1999b. Lower Tertiary biostratigraphy of the Kala Chitta Range, northern Pakistan, Revue de Paleobiologie, 18(1), 123-146.

Key Words: Biostratigraphy, Tertiary, Kala chitta.

A/336. Akhtar, M., & Masood, T., 1988. Guidebook to the geology of Surghar Range. Geological Survey of Pakistan, Information Release, 341.

The Sur ghar Range is a part of the Trans-Indus Salt Range. This guide book is a useful accompaniment with the paper by Alam (1983) on the range.
Key words: Surghar Range, Trans-Indus Salt Range

A/337. Akhtar, M., & Sarwar, M., 1987. A giant Tetraconodont species from Middle Siwaliks of Dudial, Azad Kashmir, Pakistan. Kashmir Journal of Geology 5, 101-104.

A very large-sized tetraconodont maxilla bearing last two molars, roots of the first molar and root impression of the last premolar has been described from the Middle Siwalik beds exposed along the River Puch near Dudial, Azad Kashmir, Pakistan. It comparison with the known species of the genus has proved it to be a new species. Regarding size, it happened to be the largest of the known tetraconodont. The name, Tetraconodont dudialensis, has been proposed for this new species.
Key Words: Conodont, Siwaliks, Dudial, Azad Kashmir.

A/338. Akhtar, M.G., 1984. Integrated geophysical survey along Karakoram Highway between Taglat and Gunar farm. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 123p.

Key Words: Geophysics, Karakoram Highway, Gunar farm.

A/339. Akhtar, M.K., 1968. A report on the geology of Nawansher Giah area, Hazara. M.Sc. Thesis, Punjab University, 86p.

Key words: Geology, Nawansher, Hazara.

A/340. Akhtar, M.K. & Abbas, S.Q., 1988. Investigation for clay deposit in Dandot area, Chakwal District, Punjab. GSP, Information Release 332.

Key words: Clay, Dandot, Chakwal.

A/341. Akhtar, M.K., Abbas, S.Q. & Khan, A.A., 2001. Geological map of Murree (43 G/5, 1206). Geological Survey of Pakistan.

Key words: Geological map, Murree

A/342. Akhtar, M.K. & Cheema, M.R., 1988/89. Distribution and evaluation of fireclay and bauxite deposits of Chhoi-chak Jabbi area, Attock district, Punjab. Geological Survey of Pakistan, Information Release 331.

Key words: Fireclay, bauxite, Attock, Punjab.

A/343. Akhtar, S., 1982-84. Report on geology and structure of Balakot-Kummi Area. M.Sc. Thesis, Punjab University, Lahore, 101p.

The present work constitutes a comprehensive report on the geology of Balakot -Kummi area and is submitted in partial fulfillment of the requirements for the degree of M.Sc. at the University of the Punjab. The report includes a detailed geological map at 1:6,000 of about 65 km. sq. area along with a number of geologic sections and sketches. The various chapters include geomorphology, stratigraphy, structure and tectonics. Stratigraphically, the Balakot-Kummi area includes a number of diverse sedimentary and metamorphic elements ranging in age from Precambrian to Miocene with a fairly large gap in .the Mesozoic period. Structurally, the area incorporates part of the core and western limb of the Hazara-Kashmir syntaxis and through it pass the major Murree and Panjal Faults. The Balakot-Muzaffarabad anticline is the major fold overturned and overthrust to the southwest. No major economic mineral deposit was found within the project area, although a lot of material is available as rock crush, aggregate components and building stones.
Key words: Mapping, structure, Balakot.

A/344. Akhtar, S., 2001. 2-D seismic reflection data interpretation of Chak-Naurang area line No. 855-CW-03. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 67p.

Key words: Seismicity, Chak Naurang.

A/345. Akhtar, S.M., 1974. Akora Khattak clays of Nowshera Tehsil. Pakistan Journal of Scientific and Industrial Research 17(4 & 5), 160-162.

Key words: Clay, Nowshera.

A/346. Akhtar, S.M., Alauddin, M. & Khan, A.H., 1972. A note on Sirvik Gol pegmatites, Pakistan. Science and Industry 9(1 & 2).

Key words: Pegmatites.

A/347. Akhtar, S.M., Khan, Z.A., & Khan, A.H., 1970. Dolomite of Ghundai Tarako (34^o 13'N, 72^o 25' 15"E), Peshawar Division. Pakistan Journal of Scientific and Industrial Research 12, 488-492.

The small hill of Gundai Tarako at Mardan Swat State boarder is mainly composed of marble. High dolomite content was observed in four localities. Composite sample analyses from localities two and four contain 68-95% dolomite, 0.37-11.47% silica and 0.85-0.88% R_2O_3. Sulphur and phosphorus are either absent or present only in traces. The dolomite from these two localities are of chemical grade and can be used in metallurgical and glass industries.
Key words: Dolomites, Mardan, Swat.

A/348. Akhtar, S.M., & Siddiqi, F.A., 1965. Mineralogy of the alluvial sand of Kabul River near Charsadda. Pakistan Journal of Scientific and Industrial Research 8(4), 245-248.

Key words: Mineralogy, Alluvial Sand, Kabul river, Charsadda.

A/349. Akram, H., 1994. Groundwater contamination study of the Sihala Industrial Triangel area, Kahuta Road with reference to hydrochemical, biochemical and physiochemical analysis. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 56p.

Key words: Groundwater, contamination, Hydrochemical, Biochemical, Sihala, Islamabad.

A/350. Akram, H., Ahmad, M.N. & Yoshida, M., 1996a. Magnetic susceptibility and hysteresis loop properties of Late Quaternary loess-paleosole deposits of Haro River area, Attock, Pakistan. Extended Abstracts, International Seminar on Paleomagnetic Studies in Himalaya-Karakoram Collision Belt and Surrounding Continents, November 20-21, 1996, Islamabad. Geosciences Lab, GSP, Islamabad, 90-93.

Key words: Magnetism, Paleomagnetism, Quaternary Deposits, Haro River, Attock.

A/351. Akram, H., Ahmad, M.N. & Yoshida, M., 1996b. Rock magnetic studies of late Quaternary Loess-paleosol deposits of Haro river area, Attock district, Pakistan. Proceedings of geoscience colloquium, Geoscience labs, GSP, Islamabad, 14, 93-105.

Rock magnetic properties of the loess deposits for 24 samples collected from two different sites of Ham river in the Pakistan area were studied Magnetic methods such as imthermal remanent magnetisation acquisition experiment and the magnetic analysis indicated the presence of mawtc, accompanied by trace amount of maghemite and goethite. Hysteresis loop parameters show that most of the magnetic grains are of multi domain nature and some of them are of pseudo single domain. The hysteresis loop parameters such as coercive force and ratio of remnant magnetisation to saturation magnetisation increase with the increase of finer W o n (< 0.3pm) of the clay percentage, which proves that magnetic methods can be used for gram sue differentiation in these loess deposits. Magnetic susceptibility is not high in the case of paleosols as compared to the other loess beds, which shows a very different behavior from weal loess-paleosol sequences in the Chinese Loess Plateau.
Key words: Magnetism, Paleomagnetism, Quaternary Deposits, Haro River, Attock.

A/352. Akram, H. & Yoshida, M., 1997. Ultra-fine magnetite/maghemite and their magnetic granulometry in the Late Pleistocene loess-paleosol deposits, Haro River area, Attock Basin, Pakistan. In: Khadim, I.M., Zaman, H. & Yoshida, M. (Eds.), Paleomagnetism of Collision Belts. Geoscience Laboratory, GSP, Islamabad, 153-169.

Variation of magnetiogranulometric properties in late Pleistocene (18-130 ka) loess-paleosol sequence of Haro River area, Attock basin, Pakistan were studied. Isothermal remanent magnetization (IRM) acquisition experiment and thermomagnetic analysis indicate that magnetite and maghemite are the major ferromagnetic (fenimagnetic) minerals present in these samples. Hysteresis loop parameters such as coercivity (Hc), remanence coercivity (Hcr), coercivity ratio (HcrMc), and remanence ratio (MrNs) show that the magnetite/maghemite grains are mostly of pseudo-single domain (F'SD) size, while less amount of multi domain (MD) and superparamagnetic (SPM) grains are also present. Anhysteretic remanent magnetization (ARM) and its normalized parameter discloses the relative enrichment of (SD to SPM size) magnetite/maghemite grains in the paleosols as compared to loess deposits, which are considered to be of pedogenic origin. Bilogarithrnic plot of saturation isothermal remanent magnetization (SIRM) and volume magnetic susceptibility also shows relative concentration of ultra-fine ferrimagnetic minerals in the paleosols. This magnetiogranulometric data was correlated with the rnechanicaUsedimentologica1 analysis data. The magnetic granulometry is informative to understand the particle-size distribution of natural sediments like in the case of loess-paleosol deposits, particularly for the SPM.
Key words: Magnetism, Pleistocene, Haro River, Attock.

A/353. Akram, M., 1986-88. Geology and structure of Balakot-Garhi Habibullah-Dalola area Kaghan valley District Mansehra, NWFP, Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 116p.

This report comprises a complete geological study of nearly 320 sq. km; located between and around Balakot-Garhi Habibullah. In the project area micaceous quartzites, quartz mica schists, garnet mica schists, dolomite, limestone, Sandstones and slates are encountered. A stratigraphic sequence has been worked out. The rocks extend in age from Precambrian to Miocene.
Structurally, the rock, are folded into a number of major structures. The area comprises of major structures like Balakot Anticline, Garhi Habibullah syncline, Muzaffarabad fault and Murree Fault. Micro structures of the project area has also been discussed in detail. Hazara Kashmir syntaxis has a great influence on the stratigraphy, structure, and tectonics of the investigated area. In the field of economic geology a number of deposits including clays, graphite, limestone, feldspar, granites and sandstone have been discussed. This report also includes a petrographic description of the rock units as well as numerous sketch section and photographs, illustrating the geology of the area.
Key words: Geology, structure, Kaghan, Mansehra.

A/354. Akram, M., 1988. Crustal studies along a single total intensity magnetic profile between Jhelum and Nowshera. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 46p.

Key words: Magnetic profile, Jhelum, Nowshera.

A/355. Alam, G.S. & Cheema, M.R., 1974. Hunza spinel (ruby spinel) deposits, Hunza state, Gilgit Agency, Pakistan. Geological Survey of Pakistan. Information Release 77.

Key words: Spinel, ruby, Hunza.

A/356. Alam, G.S., Hussain, A. & Asrarullah, 1976. The mapping of Warcha and Kalabagh salt mines and potash investigations, Punjab, Pakistan. Geological Survey of Pakistan, Records 40, 14p.

Key words: Mapping, Salt Mines, Potash, Warcha, Kalabagh, Punjab.

A/357. Alam, G.S., Jaleel, A. & Masood, T., 1989. Report on evaluation of limestone and clay deposits at Wah, Punjab, Pakistan. Geological Survey of Pakistan, Information Release 403.

Key words: Economic geology, limestone, clay, Attock

A/358. Alam, G.S., Kausar, A.B. & Jawed, S., 1986. Heavy mineral analyses and petrography of Chinji and Nagri formation of Salt Range-Potwar areas, Punjab, Pakistan. Acta Mineralogica Pakistanica 2, 83-92.

The paper describes the lithology and mineral contents of Chinji and Nagri Formations of late Tertiary age, from sections located in the Salt Range and Potwar. Minerals in the heavier than bromoform fractions of sandstone include amphibole, chlorite, tourmaline, garnet, epidote, magnetite and pyrite. The sandstone samples are also chemically analyzed for major and certain trace element contents.
Key words: Mineralogy, petrography, heavy minerals, Chinji Formation, Nagri Formation, Salt Range.

A/359. Alam, I., 2000. Structure and stratigraphy of the area south of Kohat, N.W.F.P., Pakistan. M.Phil. Thesis, University of Peshawar, 74p.

Key words: Stratigraphy, structure, Kohat.

A/360. Alam, I., Ghauri, A.A.K. & Ahmad, S., 2001. Structural and tectonic setup of the area south west of Kohat NWFP, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.32.

The study describes the stratigraphy and structural setting of the 250-km^2 areas constituting a part of Kohat foreland basin and located southwest of Kohat city. No rocks older than Eocene are exposed. The outcropping rocks consist of Panoba shale, Sheikhan Formation, Kuldana Formation and Kohat Formation of Eocene age, unconformably overlain by the Murree and Kamlial Formations of the Rawalpindi Group. The imprints of the ongoing Himalayan tectonics are well recorded in the outcropping rocks and represented by a series of south verging anticlines and synclines with a common east-west axial trend. In addition to these folds, several east-west trending and north and south verging thrust faults are also present. The part of the Kohat Plateau has undergone three distinct phases of deformation. The earliest phase DI, was responsible for development of the large overthrust sheet. This thrust sheet was later on folded in second phase of deformation D2. During D2 the entire package of rocks and structures (including autochthonous rocks and overlying allochthonous thrust sheet) was folded. The third phase of deformation D3, represents the collapse of structurally elevated rocks due to gravity.
Key words: Structure, stratigraphy, tectonics, Kohat.

A/361. Alam, K., 1986. Geophysical investigations for groundwater in Qandhari Safi Plain, Mohmand Agency, N.W.F.P. Geological Survey of Pakistan, Information Release 265.

Key words: Geophysics, groundwater, Mohmand

A/362. Alam, K. & Nazirullah, R., 1998. Reconnaissance gravity-magnetic profiles for iron ore exploration in Nizampur area, NWFP, Pakistan. GSP, Information Release 681.

Key words: Gravity, Magnetism, Ore, Nizampur.

A/363. Alam, K. & Salam, A., 2001. Electrical resistivity survey for groundwater exploration in Shakar Dara area, Kohat District, N.W.F.P. Geological Survey of Pakistan, Information Release 736.

Key words: Geophysics, electric resistivity, groundwater, Shakar dara, Kohat

A/364. Alam, M.M., 1964. Geology of Tanawal, Hazara. M.Sc. Thesis, Punjab University, 40p.

Key words: Geology, Tanawal, Hazara.

A/365. Alam, M.Z., 1987. Composite fault plane solution study of the events occurring in the vicinity of Tarbela Dam, Pakistan. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 63p.

Key words: Faults, Tarbela dam.

A/366. Alam, S., 1995-96. Structure, stratigraphy, micropaleontology and petrography of Shahdara and Pirsohawa areas, Margala Hills, Islamabad, Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 107p.

The Shahdara pirsohawa area lies in the Attock-Hazara fold and thrust belt of the northwest Himalaya of Pakistan. The Mesozoic to Cenozoic rocks in the area are entirely sedimentary in nature. The rocks are strongly folded and imbricated during Tertiary Himalayan collision. The study deals with the structure, stratigraphy, micropaleontology and petrography of the area.

The early Paleocene Hangu Formation unconformably overlies the late Cretaceous Kawagarh Formation. The late Cretaceous subduction of the Indian plate below the Kohistan Island arc caused the deepening of the Tethyan shelf in the subduction zone and initiated the deep marine deposition of the Kawagarh Formation. The abrupt change from Late Cretaceous deep marine environment of the Kawagarh Formation to terrestrial deposition of Hangu Formation indicates the initial Early Paleocene collision of the Indian plate and Kohistan island arc. The Lower Tertiary sequence of Early to late Paleocene Lockhart Limestone, Late Paleocene Patala Formation, Early Eocene Margalla Hill Limestone and Late Eocene Kuldana Formation mark the complete cycle of transgression and regression of the Tethyan Ocean. The presence of Early Paleocene to Late Eocene foraminiferal assemblage like globorotalia, globigerina, lockhartia, assilina, nummulitess and fasciolites in the limestone and shales of the Lower Tertiary sequence show the tropical to sub-tropical open sea upper slope to outer shelf environments. The Kuldana Formation includes marine limestone, continental clays and shales and evaporatic gypsiferous beds. The rock assemblage shows transgression of Tethyan Ocean and initiation of continental deposition of the Kuldana Formation due to Himalayan uplift.

The Paleocene- Eocene boundary can not be marked on the basis of microfossils in the area because the Patala Formation lacks microfossils. However, the tentative Paleocene-Eocene boundary between Patala Formation and Margala Hill Limestone can be marked at the base of Margala Hill Limestone on the basis of first appearance of Early Eocene microfossils.

The two phases of D1 and D2 deformations related to Himalayan collision are recorded in the Mesozoic to Cenozoic shelf and platform sediments of the Attock-Hazara fold-and-thrust belt of Shahdara-Pirsohawa area. D_{1a} is the main phase of southeast-directed thrusting and the southeast vergent F1 folding. D_{1b} is related with the folding of MBT due to backsteepening. The backsteepening is documented by southeast dipping thrust faults and at places northwest

vergent Makhnial and Pirsohawa synclines. The D2 deformation phase is related with the folding of earlier northeast-southwest trending Dl structures along northwest plunging F2 fold axes. The F2 cross folds are mainly antiforms and synforms. The F2 cross folds are related with the development of Hazara-Kashmir syntaxes.
Key words: Structure, stratigraphy, micropaleontology, petrography, Margala, Islamabad.

A/367. Alauddin, A., Khan, A., Masood, H., Begum, F., Khattak, M.A. & Khan, M.A., 1994. Studies of potash bearing evaporate basins of Kohat Karak Salt Range, NWFP, Pakistan. Pakistan Journal of Scientific and Industrial Research 37(11), 491-00.

Potash-bearing minerals occur in nature with common salt and usually deposited in the evaporite basin on evaporation of brine water. In view of the huge deposits of common salt in Pakistan, particularly in Kohat-Karak evaporite basin, NWFP; investigations to locate the potash deposits in the common salt of the area were undertaken. The geology of the potash bearing deposits reveal their occurrence in the form of lenticular beds associated with rock salts. The present study has successfully brought into focus areas of potash concentration in the above area, which after refining may be exploited to meet the requirement of potash for fertilizer.
Key words: Potash, Evaporate, Kohat, Karak, Salt Range.

A/368. Alauddin, M., 1969. Preliminary petrography of Sarok Gal pegmatite, Chitral. Geological Abstracts, 11th Annual Conference, Scientific Society of Pakistan, Multan, p.18 (In Urdu).

This report is in Urdu and gives the mineral composition of this granitic pegmatite in Chitral area.
Key Words: Pegmatite, Chitral.

A/369. Alauddin, M., Hussain, V. & Jan, N., 1992. Characteristics of glass making sands of Munda Kuchha, District Mansehra and their beneficiation and utilization for the production of colorless container glass. Pakistan Journal of Scientific and Industrial Research 35(4), 151-00.

Large deposits of silica sand occur at a distance of 50-km to the northeast from Mansehra town, near Munda-Kuchha village along the Siran river. Estimated reserves up to a workable depth of 300 feet are 57 million tons. Twelve representative samples were collected from the area for studying their suitability for glass industry. The chemical composition and grain size distribution of these samples were determined. Beneficiation studies by physical and chemical methods were undertaken to remove color-imparting impurities, which are a factor for producing the glass of inferior quality. The objective of this study was to upgrade the quality of silica sand to the acceptable limits for the production of colorless container glass. Using physical methods a maximum of 41.66% of the iron, the most undesirable impurity, was removed; by chemical treatment seven of the twelve samples can be brought into the specification for colorless container glass, five can be brought into, or very near, the specification for optical glass.
Key Words: Silica sand, glass, beneficiation, Munda Kuchha, Mansehra,

A/370. Aleem, S., 1989-91. Geology and Geochemistry of Battal Village and its surrounding area with special emphasis on the Geochemistry of altered products near Ahl Village, and water & Soil chemistry along the Karakoram High way (KKH), District Mansehra, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 113p.

The present study has been basically focused on the geology and geochemistry of a part of the lesser Himalayas. The study has been divided into four parts. The first part deals with the geological mapping and tectonic setup of the area which reveals that the studied area lies between the syntaxial loop and Oghi shear zone of the lesser Himalayas, comprising of mainly metamorphic rocks, granitic rocks and granite gneiss of Precambrian, Cretaceous/Tertiary and Cambrian age respectively. Tectonically, the area represents a sandwich between the two major thrusts, i.e., Main Central Thrust (MCT) in the north and Main Boundary Thrust (MBT) in the south, also, there runs a NS Oghi shear zone in the west and syntaxial loop of NW Himalayas in the east. The second part deals with the detailed geochemical and mineralogical investigation of the area. Three types of rocks are characterized in the studied area; a) metamorphic rocks of garnet mica schist grade comprising mainly of quartz, garnet, muscovite, biotite and chlorite. b) granite gneiss mainly composed of quartz, K-feldspar, plagioclase feldspar, muscovite, biotite and

sphene; c) minor basic intrusions as amphibolites; mainly consist of amphiboles (hornblende) along with quartz, sphene and muscovite. The third part deals with the geochemistry of the altered products near Ahl Village. The variation of major oxides in the altered products as: SiO_2 > Al_2O_3 > Na_2O > K_2O, with FeO, and CaO & MgO as minor constituents. It suggested that this aluminum-silicate rich material could be used for ceramic purpose. The fourth part deals with the water and soil chemistry of the studied area to explore the weathering style and water and soil characteristic in the area. The chemistry of water samples show that they are rich in Ca^{+2} and HCO_3 indicating the decomposition of plagioclase feldspar; the X-ray diffraction patterns of the soil samples show the presence of quartz, albite, muscovite and anorthite which are the unaltered constituents of the same parent rocks while the presence of illite and phlogopite in all the soil samples, and saponite and sepiolite in some samples represents the intensity of the weathering in term of bauxitization. The water quality of the studied area is well within the permissible limits of drinking standards. The soil samples of the studied area classify into the category of normal soils with pH ranges from 6.4 to 7.7 and other parameters like EC, ESP & RSC are also within the permissible limits for cultivation purpose. The cultivation of tea at various localities where pH of the soil is relatively lower is recommended for the uplift of socioeconomic condition of the area.
Key words: Geochemistry, mapping, Himalaya, Hazara.

A/371. Alessadri & Ginori, V., 1931. Meteorologia, geofisca, aerologia e pirelometria. In: Spedizione Italiana de Filippi nell'Himalaia, Caracorum e Turchestan Cinese (1913-1914), 3. Zainchelli, Bologna, 570p.

Key words: Meteorology, geophysics, Karakoram, Chinese Turkestan.

A/372. Ali, A., 1976-78. Geology of Jogabunj-Sadiqa Banda Area Dir District. M.Sc. Thesis, Punjab University, Lahore, 115p.

The project area lies in central Punial area, adjoining to Yasin Valley, Gilgit Agency. The area is located in Karakoram Mountains. Area is intensely disturbed tectonically being involved in Himalayan Orogeny. Evidence is provided by crushing and strained effect on minerals. Project area is composed mainly of igneous rocks and metasedimentary rocks.
These different rock units are shown on map, which was previously prepared by enlargement of toposheet. The major units in the project area are granite, diorite, amphibolite and paragneiss. Special emphasis was given to the mineralogy description and petrographic analysis of the rock units and is reported in detail. The petrogenesis of these rocks units has been discussed as well.
Granite is considered to be a part of Karakoram axial granite, which is emplaced as a partially fused and mobile mass rich in alkali feldspar during synthetic phase of orogeny. Diorite is probably tholeiitic basaltic magma injection. Granodiorite produced during differentiation with decrease of calcic contents.
Key words: Geology, granites, Dir.

A/373. Ali, A., 1992. Shallow seismic velocities of rock units in Islamabad and Rawalpindi. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 31p.

Key words: Seismicity, Islamabad, Rawalpindi.

A/374. Ali, A., 1997-98. Geological mapping and hydrogeological studies of Rawlakot area (District Poonch) A.K. with special emphasis on pollution studies and waste disposal. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 52p.

The spring water and stream water has been investigated from Rawlakot Azad Kashmir to the quality of water for drinking and other uses. The area lies under the influence of lesser Himalayas. The total of 74 samples were collected from spring and stream waters in two phases. 40 samples were collected in wet season and 34 samples were collected in dry season. Chemical constituents such as Ca, Mg, Si, carbonate and bicarbonate were determined. Physical properties colour, taste, odour and temperature were noted in the field. Turbidity, TDS and conductivity were determined in the laboratory.

The effects of solid and liquid wastes and sewage water effected the quality of ground and surface water. The concentration of Pb, Zn, Cu and Ni increases due to waste disposed off into streams and nala water. The waste water from households seepage of water through sewage system, waste water from CMH and the suspended load of finer particles from Murree formation are main pollutants. The waste disposed by shopkeepers and municipal wastes also pollutes the surface and ground water. The experimental data show that the waste dispose sites should be selected by Municipal Corporation and the treatment plant is essential for supplying good quality drinking water in Rawlakot area. The water available from Hussain Kot springs can be developed and supplied to the inhabitants of Rawlakot. Pure water can also be developed by drilling tube wells in Rawlakot valley. Kanapara, Baikh, Chotagala, Khaigala, CMH Rawlakot, Rawlakot city, Tirar, Banjosa and Dhamni localities. It is concluded that the ground and surface water resources are available and need development on scientific grounds.
Key words: Mapping, hydrogeology, pollution, Rawlakot, Azad Kashmir,

A/375. Ali, A., 1997. Structure and Stratigraphy of a part of Kohat basin between Lachi and Banda Daud Shah, N.W.F.P., Pakistan. M.Phil. Thesis, University of Peshawar, 58p.

The detailed mapping of the study area have resulted in establishing nine lithostratigraphic units which range in age from Eocene to Pliocene. These units fall within three groups which are from bottom to top as Chharat, Rawalpindi and Siwalik Groups. The Chharat group is represented by five formations in the area including Panoba shale at the base, overlain by Jatta Gypsum along with its lateral equivalent Sheikhan Limestone, Kuldana and Kohat Formations. The Chharat group is unconformably overlain by the Murree and Kamlial Formations of the Rawalpindi group. The representative units of the Siwalik group in the area are Chinji and Nagri Formations. The structural geometry of the area comprise large scale, east-west trending folds and thrust faults. The fold structures include narrow anticlines and anticlinoria mostly cored by thrust faults. The synclinal folds are open, with both their limbs overturned and reflect fan-geometry. The faults include fore and back thrusts. The back thrusts are mostly overturned at their surface exposures and have changed their vergence from north to south.
The proposed structural model based on surface and subsurface seismic data shows a series of large scale hinterland dipping listric thrust faults emerging from the basal decollement. All these faults are steeply dipping at surface and becomes gentle with depth. Other prominent features are associated pop-ups and triangle zones which are the result of north verging splays from the listric thrust faults. The presence of triangle zones bounded by thrust faults of opposing vergence have resulted in the tectonic overprinting and delamination of different horizons at various levels. All the above mentioned features are characteristivs of the foreland fold and thrust belts in different parts of the world. The basal detachment is located at the base of salt range formation at a depth of around 8 km and 8.4 km in the southern and northern parts of the study area respectively. The restored version of the deformed state cross-section shows about 19.5 km shortening for the mapped area with maximum structural relief of about 4000 meters above the regional level.
Key words: Structure, stratigraphy, Kohat basin.

A/376. Ali, A., 1998-99. Engineering geological mapping from Naushera to Barsala (District Muzaffarabad) with special emphasis on joint orientation of the Miocene rocks of Kohala Hydro Electric Project Area (A.K.), Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 135p.

Key words: Structure, engineering geology, Miocene, Azad Kashmir,

A/377. Ali, A.M. & Afridi, M.K., 1999. Seismic reflection interpretation of Chak-Naurange area, Pakistan. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 47p.

Key words: Seismicity, Chak Naurang.

A/378. Ali, C.M., 1962. The stratigraphy of the southwestern Tanol area. Hazara, West Pakistan. Geological Bulletin, University of Punjab 2, 31-38.

The stratigraphy of the pre-quaternary rocks of the southwest Tanol Area, Hazara, based on preliminary mapping is described. The rocks are compared with those found in the Abbottabad and Swabi areas, previously referred to as the Infra-Trias, in the former, and now redesignated the Abbottabad Formation. Three major rock units could be distinguished – the Hazara Slate Formation, the Tanol Formation, and the Abbottabad Formation.
Key words: Stratigraphy, Hazara Slate, Abbottabad Formation, Tanol Formation, Hazara.

A/379. Ali, F., 1992-93. Geological mapping and sedimentology of the Dhok Pathan Formation, Siwalik Group in Surghar Range-Shinghar Range, Bannu Basin, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 198p.

Key words: Sedimentology, Dhok Pathan Formation, Siwaliks, Bannu basin.

A/380. Ali, F., 1994. Structure and tectonic set-up of area north and north-west of Karak, N.W.F.P., Pakistan. M.Phil. Thesis, University of Peshawar, 83p.

The Karak area which constitute southern edge of Kohat plateau exposes a suite of evaporite deposits, shelf sediments and a thick molasses sequence of Cenozoic age. The oldest rocks in the area are of Eocene age and constitute Bahaderkhel Salt and Jatta Gypsum followed by shelf sediments which comprise Kuldana and Kohat Formations. These units are overlain by molasse sediments of Miocene to Pliocene age which include rocks of Rawalpindi Group (Kamlial Formation) and Siwalik Group (Chinji Formation, Nagri Formation, Dhok Pathan Formation and Soan Formation).
Structurally the area is interpreted as an east-west trending positive flower structure which is exposed for 20 Km along strike and is about 5 Km wide. It is bounded by the north dipping Karak Fault in the south and the south dipping Nari Panos Fault in the north and internally subdivided by the south dipping Banda Kunghara Fault. All these faults trend eastwest and have moderate surface dips.
A right lateral component of deformation along the Karak structure is indicated by (a) the east-north-east directed trends of the Daggar syncline in the foot wall of the Nari Panos backthrust, (b) by small scale thrusts in the core of this syncline and (c) by east-north-east trending enechelon folds south and south east of Banda Charpara. The idea is supported by interpretation of seismic data (906-NSK-47) which indicates rapid steepening of the Karak, Nan Panos and Banda Kunghara Faults to near vertical with depth and east-west trending slikenlines present on different fault surfaces of the area. This work emphasizes the importance of transpression within the NW Himalaya on a regional scale. Recent work by Beck et al. (in prep.) has suggested transpressive deformation along the Main Boundary Zone (MHZ) to the west of the Kohat Plateau.
Key words: Structure, Tectonics, Karak.

A/381. Ali, F., Ahmad, S. & Abbasi, I.A., 2000. Imprints of transpressional deformation on the southern Kohat Plateau, Karak area, NW Himalayas, NWFP, Pakistan. Late Abstracts, Third South Asia Geological Congress, Lahore, p.1.

Consult the following account for further information.
Key words: Deformation, Kohat Plateau, Karak, Himalaya.

A/382. Ali, F., Ahmad, S., Ahmad, I. & Hamidullah, S., 2000. Imprints of transpressional deformation on the southern Kohat Plateau, Karak area, NW Himalayas, NWFP, Pakistan. Geological Bulletin, University of Peshawar 33, 87-95.

A suite of evaporite deposits, shelf sediments and molasse sequence of Early Cenozoic age from Karak area marks a part of southern Ghat Plateau. Structurally the area is interpreted as east-west trending positive flower structure, which is exposed for about 20 km along strike with widths varying from 3-5 laterally. It is bounded by the north dipping Karak Fault in the south and south dipping Nan Panos Fault in the north and internally subdivided by the south dipping Banda Kunghara Fault. All these faults trend east-west and have moderate suvace dips. A right lateral component of deformation along the Karak-Nari Panos structure is indicated by: 1) the north-east directed trend of

the Daggar Syncline in the footwall of the Nari Panos Fault, 2) the local scale thrusts in the core of this syncline and 3) east-north east trending right stepping folds located south-east of Banda Charpara in the footwall of Banda Kunghara Fault. The idea of transpressional deformation is also supported by the seismic data, which shows that all the major fault structures become steep, converging at deeper level and the presence of horizontal to sub-horizontal slicks on different fault surfaces. The region has experienced an early phase of compressional deformation overprinted by later phase of transpressional deformation of Plio-Pleistocene age.
Key words: Deformation, Kohat Plateau, Karak, Himalaya

A/383. Ali, F., Khan, I. & Ahmad, D., 1996. Significance of mesoscopic shear zones in the Precambrian limestone belt around Gandghar and Attock-Cherat Ranges, NW Himalayas, Pakistan. Abstract volume, 11th Himalaya- Karakoram- Tibet Workshop, Flagstaff, Arizona (USA), p.17.

The south and southeastern boundary of the Pakistan basin exposes a belt of Precambrian limestone (Shekhai, Utch Khattak and Shahkot formations). This limestone belt has well preserved mesoscopic scale, brittle-ductile shear zones, which are related to the movements along the Panjal Fault in the Gandghar Range and Khairabad Fault in the Attock-Cherat Ranges.
The detailed geometric analysis of these steeply dipping conjugate shear zones in the Gandghar Range shows that sinistral shear zones strike NNW and dextral shear zones strike WNW. The conjugate shear zones mapped in the Attock-Cherat Range are moderately dipping with sinistral shear zones, striking NE and dextral shear zones striking NW. The slip linear and the acute bisectors of these conjugate shear zones indicate that the Gandghar Range has developed in response to NW oriented compressional stresses and the Panjal Fault which lies south of it, is an oblique ramp with left lateral strike-slip adjustments in addition to major thrust-slip movements.
The Attock-Cherat Range has experienced NS directed compressional stresses and the Khairabad Fault which is the northern most tectonic boundary of the Attock-Cherat Range is south verging frontal ramp.
Key words: Shear zone, Limestone, Gandghar, Attock-Cherat, Precambrian.

A/384. Ali, Ch.M., 1962. The stratigraphy of the southwestern Tanol area, Hazara, West Pakistan. Geological Bulletin, Punjab University 2, 31-38.

The stratigraphy of the pre-Quaternary rocks of the southwest Tanol area, Hazara, based on preliminary mapping, is described. The rocks are compared with those found in the Abbottabad and Swabi areas, previously referred to as the infra-Trias, in the former, and now redesignated the Abbottabad formation. Three major rock units could be distinguished--the Hazara slate formation, the Tanol formation, and the Abbottabad formation.
Key words: Stratigraphy, Tanol, Hazara.

A/385. Ali, I., Shah, M.T. & Jan, M.R., 1992. Geochemical techniques for the analyses of rocks and their application to the rocks of granitic composition from Kala Dhaka area, Mansehra. 1st National Symposium on Analytical and Environmental Chemistry, Baragali.

Key words: Geochemistry, Granitic, Kala Dhaka, Mansehra.

A/386. Ali I., Shah, M.T. & Jan, M.R., 1994. Geochemical analysis of granitic rocks of Kala Dhaka area, Hazara Division. 2nd National Symposium on Analytical and Environmental Chemistry, University of Sindh.

Key words: Geochemistry, Granitic, Kala Dhaka, Mansehra.

A/387. Ali, I., Shah, M.T., Jan, M.R., & Khan, S., 1998. Trace elements determination by Atomic Absorption Spectrophotometer in the Rocks of Kala Dhakka area, Mansehra. GSP Information Release 671, 16p.

Key words: Trace Elements, Atomic Absorption, Kala Dhaka, Mansehra.

A/388. Ali, K., 1992. Geology and Tectonic setup of a part of Dara Adam Khel Kotal Pass Transect (Kohat Hill Range), Kohat Division, N.W.F.P., Pakistan. M.Phil. Thesis, University of Peshawar, 61p.

This study describes the geology and structural set-up of a 168 km2 area along the Darra Adam Khel-Kotal pass transect in the Kohat Hill Range. The area comprises, from bottom to top, the Jurassic Samana suk, the Cretaceous Chichali, the Lumshiwal, the Kawagarh, the Palaeocene Lockhart and Patala, (Palaeocene), the Eocene Kohat and the Miocene Murree Formations. The area is deformed into complex structures. The principal structure is a "pop-up". It comprises a south verging thrust (Main Boundary Thrust) at the southern flank against the Kohat plateau and a pair of north verging back thrusts at the northern flank against the Peshawar plain. Between these divergent thrusts, there are large scale fold structures (some with half-wave lenght > 7 kms) which have a fan shaped geometry, conforming to the pop-up style of deformation exhibited by the thrusts.
Overall four phases of deformation are recognized in the studied part of the Kohat Hill Range. D1 phase of deformation resulted in local duplex structure, just to the south of the Kotal pass. At least two horses have been recognized each with a stratigraphic range between the Samana suk and Kawagarh Formations, stacked below a roof thrust in the Kawagarh Formation. D2 is the principal phase of deformation related with the development of Main Boundary Thrust (MBT), the back thrusts and fan-shaped folding and pop-up shape of the Hill range thrust sheet. D3 is post folding and is represented by out-of-the-syncline thrusts in the southern limb of the wahabian valley syncline, D4 is marked by low angle normal faults, which represent gravity collapse of the abnormally uplifted Hill range in the latest stages of deformation. The deformation in the Kohat Hill Range started after the deposition of the Miocene Murree Formation and probably continued until recently.
Key words: Tectonics, Kotal Pass, Kohat.

A/389. Ali, K., Abdullah, A.M. & Ahmad, A., 1987. Geology and structure of area south and southeast of the village Pir, Abbottabad. M.Sc. Thesis, University of Peshawar, 44p.

Key words: Geology, structure, Abbottabad.

A/390. Ali, K.A. & Anwar, J., 1969a. Stratigraphic studies of Nowshera Reef Complex, Nowshera Tehsil, N.W.F.P., M.Sc. Thesis, University of Peshawar, 48p.

Consult the following account for further information.
Key words: Stratigraphy, Reef Complex, Nowshera.

A/391. Ali, K.A. & Anwar, J., 1969b. Stratigraphic studies of the, Nowshera Tehsil, West Pakistan. Geological Bulletin, Peshawar University 4, 33-43.

A belt of Siluro-Devonian limestone and quartzite, pink or yellowish-pink in colour, is exposed on either side of the Nowshera-Risalpur road. This belt was identified as a 'Reef Complex' in 1965, and is the first of its kind to be discovered in the lndo-Pak sub-continent. Prior to this discovery, the limestone belt had been erroneously assigned a Precambrian age and regarded as part of the Attock Slates.
The entire belt unconformably overlies the Kandar Phyllite and is divisible into four definite units: 1. Carbonate Rocks, 2. Reef Core, 3. Reef Breccia, and 4. the Misri Banda Quartzite. The first three collectively are known as the Nowshera Formation. With the exception of the last, these units represent the characteristic structural layers of a reef.
The age of the reef complex on the basis of its fossil assemblage ranges between Upper Silurian and Devonian. However, there is no fossil present which may pinpoint an exact age. The uncertainity about the precise age of the reefs largely due to the destruction of many organisms by the process of dolomitization.
In the opinion of the writers, the Nowshera Formation and the Misri Banda Quartzite were deposited in the southernmost extremities of the basin in which the Muth Quartzite, of Siluro-Devonian age, was formed.

In their opinion, the Nowshera Formation and the Misri Banda Quartzite can be correlated with the middle and upper parts of the Muth Quartzite. .

Key words: Stratigraphy, Reef Complex, Nowshera.

A/392. Ali, K.S.S., Ahmad, M. & Khan, B., 1969. Geology of the northern part of Warsak area. M.Sc. Thesis, University of Peshawar, 62p.

The northern part of the previously unmapped Warsak area, bounded by 34° 10' and 34° 14' North Latitudes, 71° 20' and 71^0 26' east longitude has been mapped on a 1 inch to 0.314 mile scale and the petrography and structure of the rocks is described in detail.

The rocks of the thesis area are typical of the Paleozoic metasediments of the Mohmand Agency that have been intruded by ultramafic (near Tangi etc) basic and acidic rocks, including pegmatites and quartz veins.

The oldest rocks of the area are metasediments represented by quartz-biotite schists, hornblende schists, phyllitic schists, garnet-chlorite schists and calcareous schists. These were intruded by a series of basic intrusions represented by metagabbros and metadolerites, and acid intrusions represented by porphyritic microgranites and alkali granites. The alkali granites possibly represents a differentiated fraction of the porphyritic granite. The intrusions are probably late Mesozoic to early Tertiary, and many are concordant. Quartz veins are commonly associated with all of these rocks. During recent tomes, the eastern low hills of the area were covered by alluvium.

The structure in the investigated area is simple, most of the rocks strike north-west and dip north-east. However, the rocks to the south-west (in Khyber agency) are folded and faulted, and the relationship of the rocks of the area with those of Khyber Agency are not well understood. Economic minerals were looked for but the results were not encouraging. However, marbles, granites and some other rocks can be exploited profitably for building and decorative purposes.

Key words: Metasediments, Warsak.

A/393. Ali, L.M. & Nadar, H., 1984. Geology of portion of Kohat quadrangle, Darra Adam Khel, Kohat, North West Frontier Province, Pakistan. M.Sc. Thesis, Peshawar University, 97p.

Key words: Darra Adam Khel, Kohat, NWFP.

A/394. Ali, M., 1995-96. Structure, stratigraphy, micropaleontology and petrography of Darthian, Narota & Karwali areas District Haripur Hazara (NWFP), Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 95p.

The Darthian, Narota and Karwali area are part of Attock-Hazara fold-and-thrust belt of the northwest Himalaya of Pakistan. The lithographic units exposed in the area are mainly sedimentary in nature and range in age from Mesozoic to Cenozoic. The area is deformed by folding and faulting during the Tertiary-Himalayan collision.

The Early Cretaceous Lumshiwal Formation has disconformable contact with the overlying Late Cretaceous Kawagarh Formation. The presence of glauconite in the Lumshiwal Formation reveals that the formation was deposited in marine condition during regressive as well as transgressive phases. The Late Cretaceous subduction of the Indian plate below the Kohistan Island arc caused the deepening of the Tethyan shelf in the subduction zone and initiated the deep marine deposition of the Kawagarh Formation. The contact between Kawagarh Formation and Early Paleocene Hangu Formation is marked by break in deposition which is evidenced by the presence of laterite/haematite and sandstone. The abrupt change in facies from deep water marine environment of Kawagarh Formation to terrestrial deposition of Hangu Formation indicates the initial Early Paleocene collision of the Indian Plate and Kohistan Island arc.

The Lower Tertiary sequence exposed in the area is Early to Late Paleocene Lockhart limestone, Late Paleocene Patala Formation, Early Eocene Margala Hill Limestone, Early Eocene Chorgali Formation and Early to Middle Eocene Kuldana Formation. The Lower Tertiary sequence marks the complete cycle of transgression and regression of the Tethyan Sea. The presence of early Paleocene to Late Eocene foraminiferal assemblage like globorotalia, globogorina, lockharia, assilina and nummulites in the limestones and shales of the Lower Tertiary sequence show

the tropical sub-tropical open sea upper slope to outer shelf environments. The Kuldana Formation is composed of marine limestone, continental variegated clay, shales and evaporitic gypsiferrous bands.
Key words: Structure, stratigraphy, paleontology, petrography, Haripur, Hazara.

A/395. Ali, M. & Ahmed, S., 1978. Interpretation of Bouguer anomalies over Gilgit valley, northern area, Pakistan. Geological Bulletin, University of Punjab 15, 40-51.

The Bouguer anomalies and up to third degree trend surface gravity analyses of the Gilgit valley, reveal that under the alluvial cover, the metasediments of Permo-Carboniferous age extend towards East and steeply dip under the thick basic igneous complex in the southeast. These basic rocks in the northeastern segment are overlain by intrusions of granodioritic rocks of Cretaceous to Eocene age, which continue up to the eastern boundary. The Permo-Carboniferous rocks in the West, contain a dyke intrusion of a granitic complex of Oligocene to Miocene age.
Key words: Geophysics, Bouguer anomaly, Gilgit.

A/396. Ali, M. & Das, A., 1997. Gravity modeling across Peshawar Basin. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.8.

Peshawar basin studied extensively by several workers is manifested by high angle vertical faulting in association with magnetic activity. Our gravity interpretation from Peshawar to Dargai suggests that the basin is a rifted-graben structure which is bounded by east-west trending Charsadda basement fault in the south and the Vale rift zone in the north. Charsadda fault is a consequence of the gravity modelling of steep gravity gradient in that zone. Large to small scale dykes appear intruding in rifting and Malakand granite is the major intrusion in weaker zone. Gravity traverse across the eastern section of Dargai complex supports the idea that it is a smaller ultramafic body that migrated from Dir ultramafic complex.
Key words: Gravity, Magnetism, Peshawar.

A/397. Ali, M., Khawaja, A.A., Ahmad, Z., Akhtar, J., Mazharulhaq, Kh. & Fraz, E., 1987. Geophysical study of Lead-Zinc deposit of Besham area. Acta mineralogical Pakistanica, 3, p.65.

Key words: Geophysics, lead-zinc, Besham.

A/398. Ali, M., Latif, Y. & Nazeer, M., 1997. Bed rock studies in Behrain with the use of seismic refraction. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.9.

The application of seismic methods in civil engineering and construction work has increased rapidly because of the recognition of the importance of shallow geological structures in all phases of site selection and foundation studies. Seismic refraction experiment conducted in igneous/metamorphic terrain of Behrain for the delineation of bedrock configuration indicates that the bedrock represented by seismic velocity more than 3000 m/sec is faulted/fractured on places and lies under overburden that varies in thickness from 10 to 40 meters.
Key words: Seismology, geotechnical.

A/399. Ali, M. & Mujtaba, G., 1992. Gravity and magnetic studies in the region of Main Boundary Thrust, west of Himalayan syntaxis. Geological Bulletin, University of Peshawar 25, 51-58.

Interpretation of gravity measurements in the west of Hazara Kashmir syntaxis, particularly around Main Boundary Thrust region suggests that the crustal thickness in the region is around 47 km, and the Moho dips at an angle around 1.0 degree towards northeast against the calculated dip of about 4.0 degrees just south of Margala ranges. The residual gravity, which corresponds reasonably to a generalized litho-structural model of the area, predicts also some anomalous situation which get support from magnetic results. The density modeling along Islamabad-Haripur

sections gives the possibility of existence of basement or ultra-basic slices near Islamabad at a depth of 5 km. Further, the MBT and langrial faults to be changing dips downwards to 25º or more.
Key words: Gravity, Magnetism, MBT, Himalayan Syntaxis.

A/400. Ali, M., Yoshida, M., Khadim, I.M. & Ahmad, M.N., 1994. Total gamma-ray observation along the Karakoram Highway, northern Pakistan: An attempt of geological interpretation by radioactivity of rocks. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad 8, 81-93.

The purpose of this survey was to see the possibilities of lithogeological application of radioactivity of rocks and radiometric pollution of air and soil across major rock units exposed along the KKH between Hassanabdal and Khunjerab river. The following conclusions were arrived at:
(1) The change of total intensity of the natural gamma-ray radiation along the
KKH is closely related to surface geology as well as lithology. It means total gamma- ray survey is applicable for geologic mapping, especially for regional reconnaissance survey.
(2) Most anomalies in total gamma-ray radiation are probably derived from potassium (K^{40}) in rocks. Granitic rocks and micaceous metasediments shows relatively high intensities of total gamma-ray radiation.
(3) The hot-spring area around the Nanga Perbat gneiss body shows the highest value of radiation in the surveyed route. It may due to radioactive radon-gas associated with the hot-spring water. It also suggested that the hot-spring is supplied from subsurface fracture-type reservoirs in the country rocks.
(4) Further spectral gamma ray-survey is recommended for detailed geological and mineralogical interpretations.
Key words: Geophysics, KKH.

A/401. Ali, M., Yoshida, M., Khadim, I.M., Ahmad, M.N. & Fujiwara, Y., 1993. An isotropy of magnetic susceptibility measurement of some igneous-metamorphics rocks in northern Pakistan. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad 6, 66-81.

An isotropy of magnetic susceptibility (AMS) of the Jijal and Chilas complexes and Mansehra granite were performed for the purpose of structural analyses. It is tentatively concluded that the directions of AMS of the Chilas and Jijal complexes closely correspond to their internal structure, such as foliation. The paper also emphasizes that AMS measurement is not only useful in solving the micro-structural problems, but informative on magnetomineralogical viewpoints such as SD grain ratio.
Key words: Palaeomagnetism, igneous, metamorphic.

A/402. Ali, M.A., Ahmad, M.A. & Khan, A., 1986. Ground water conditions Nikpikhel area, Mingora, Swat, N.W.F.P., Pakistan. M.Sc. Thesis, University of Peshawar, 42p.

Key words: Groundwater, Mingora, Swat.

A/403. Ali, M.M., 2000. Application of geoelectrical and hydrological parameter for roundwater investigation studies in the area of G-14/4 Islamabad. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 67p.

Key words: Groundwater, Islamabad.

A/404. Ali, R., Ahsan, N., Chaudhry, M.N. & Masood, K.R., 2000. Lithofacis, microfacies, diagensis, environment of deposition and palynology of Lumshiwal Formation at Kundla, Hazara basin, Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.155.

The Lumshiwal Formation from Kundla is divided into XII Lithofacies on the basis of field observations. These include lower grey sandstone facies, fossiliferous limestone facies, phosphatic glauconitic, lower grey sandstone facies, silty sandstone facies, green sandstone facies, light grey sandstone facies, carbonaceous sandstone facies, hard ground facies; upper grey sandstone facies, and grey arenaceous carbonates facies. These facies contain 19 microfacies that repeat at random. The formation was deposited in intertidal to subtidal environment but not below 80 m. Diagenetically, glauconite was the first cement to deposit in the sands from the alteration of mixed layer clays, then quartz, carbonates, flint and iron oxides were precipitated. The sandstone are compositionally mature. Texturally these are submature to super-mature. They are very fine grained to coarse grained. Tourmaline, .zircon, epidote and sphene indicate derivation from sialic metamorphic-igneous basement. However some basic sources also contributed during the deposition of the formation. Palynomorphs were represented by Dinoflagellates (Baltisphaeridium sp. And Micrhystribium sp. Pollen and spores (Densoisporites, Leptolepidites, Punctatisporites and Acropolis) and some Acritarchs.

Key words: Lithofacies, Microfacies, Deposition, Palynology, Lamshiwal Formation, Hazara.

A/405. Ali, R. & Halim, A., 1962. Geology of the lower Batrasi area, Hazara. M.Sc. Thesis, Punjab University, 30p.

Key words: Geology, Batrasi, Hazara.

A/406. Ali, S., 1991-93. Slope stability problem along Murree Kohala Road. M.Sc. Thesis, Punjab University, Lahore, 123p.

Key words: Natural Hazards, Slope Stability, Murree.

A/407. Ali, S., 1996. Seismic refraction studies to map bed-rock in Sai area (Gilgit) for Sai Hydel Power Project. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 55p.

Key words: Seismology, Hydel Power, Gilgit.

A/408. Ali, S., 1997-98. Geological mapping of Rawlakot area with special emphasis on engineering characteristics of geo-material as aggregates. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 43p.

Geological mapping of Raw and has been conducted at the scale 1:50,000 and the total area of research is about 100 sq. km. The aggregates available in the area are Murree Sand stones. These natural sandstone aggregates from Rawlakot are being used for manufacture of concrete for building construction and other Civil engineering projects. The durability of the aggregate has not yet been evaluated by any organization or through any research work. Theses work summarizes the main characteristics for consideration of aggregated to be used as concrete which is still little understood, specially those leading to cracking and deterioration. It considers the specifications of aggregates through experiments and local experience and emphasis the need of testing to be used more specifically in different climatic and geological settings, the strong influence on aggregates performance is mineralogical composition and the changing environmental conditions. Presently work related to mineralogical composition, Losangles, Abrasion Value, Crushing Value, Impact Value, Specific Gravity, Water Absorption, Flakiness Index & Elongation Index are performed and related to mineralogical composition according to ASTM standards. The percent value of chert, clays, silt, plagioclase chlorite, muscovite and hematite effect the aggregates when in contact with water. Reserves of minerals sandstone estimated from Dharamsal and Dhamni are 10.2 x 10^5 million tons and Damsite and Dhoke Kohian are 5.8 x 10^6 million tons.

Key words: Mapping, engineering, Muzaffarabad.

A/409. Ali, S., Din, A. & Faruqi, F.A., 1983. Geology, exploration and evaluation of the commercially feasible glass sand deposits of Surghar Range (Trans Indus Salt Range), District Mianwali. Second National Seminar on Development of Mineral Resources, Peshawar, 1, 17p.

Key words: Exploration, Glass, Surghar Range, Mianwali.

A/410. Ali, S.T., 1959. Mineral deposits and showings in the northern part of West Pakistan GSP, Information Release 2, 36p.

Please refer to Ahmad, Z. 1969.
Key words: Mineral deposits, West Pakistan.

A/411. Ali, S.T., 1962. Bentonites. Natural Resources 1(4 & 5), 13-18.

Key words: Bentonite.

A/412. Ali, S.T., 1967. Iron ore resources of Pakistan. In CENTO Symposium on Iron Ore, Isphahan, Turkey, 55-60.

Key words: Iron Ore.

A/413. Ali, S.T., 1978a. Mineral resources of Pakistan. GSP, Information Release 105, 33p.

Key words: Mineral Resources.

A/414. Ali, S.T., 1978b. Mineral deposits of Pakistan. National Seminar on Development of Mineral Resources, Lahore March 6-9, 1978, 32-35.

Key words: Mineral Deposits.

A/415. Ali, S.T., 1984. Mineral deposits of Azad Jammu and Kashmir. Abstracts, First Pakistan Geological Congress, Lahore, p.70.

Areas comprising the territory of Azad Jammu and Kashmir are occupied by a suite of igneous, metamorphic and sedimentary rocks ranging in age from Pleistocene to Precambrian. These rock units have been briefly discussed in this paper. The mineral deposits found in various environments are described, their commercial viability or otherwise, has been elaborated.

Key words: Minerals Deposits, Azad Jammu and Kashmir.

A/416. Ali, S.T., Abdullah, S.K.M., & Rashid, M.A., 1965. Bentonite deposits of Azad Kashmir: Geological Survey of Pakistan. Information Release 31, 20pp. 2 maps.

The bentonite deposits of Bhimber and Mirpur areas are found in 3 to 8 inches thick beds associated with volcanic ash extending for about 40 miles, laterally. Bentonite is of white, bluish grey, black and brownish varieties, is mostly a calcium bentonite and is categorised as a non-swelling type. The reserve estimates indicate that about 4800 tonnes, per foot of depth of white and bluish grey varieties of bentonite. Very large reserves of brownish-black variety of bentonite are available in both the areas.
Key words: Minerals Deposits, Bentonite, Azad Jammu and Kashmir.

A/417. Ali, S.T., Ahmad, M. & Siddiqui, R.A., 1978. Mineral Map of Pakistan. GSP, Geological Map Series, Scale 1:2,000,000.

This map shows locations of minerals of economic interest in Pakistan together with other brief information.

Key words: Mineral deposits, maps.

A/418. Ali, S.T., Ashraf, M. & Malik, R.H., 1983. Mineral deposits of Azad Jammu Kashmir-a review. Kashmir Journal of Geology 1, 119p.

The territory of Azad Jammu and Kashmir lies between Pakistan (on its west) and Indian occupied main land mass of the disputed State of Jammu and Kashmir (on its east). The total area of Azad Jammu and Kashmir is about 12,000 km^2. It has a fairly rugged mountainous topography.
Geology is simple and well exposed. Almost all the rock units are of sedimentary origin, ranging in age from Precambrian to Recent. Acidic and occasional small basic intrusive bodies are present in the Neelum Valley. Large scale regional metamorphism is encountered in the northern half of the State. The major tectonics are controlled by the collision of the Indo-Pak Plate with the Eurasian Plate north of the Nanga Parbat, the fourth highest mountain peak in the world. One of the most important tectonic features in this area is the Syntaxial bend of the Himalayas as just around Muzaffarabad, the capital town of the States of Azad Jammu and Kashmir.
Major metallic mineralization has not been met with up till now, however, workable deposits of bauxite, bentonite, coal, dolomite, fireclay, graphite, gypsum, limestone, marble, mica, quartzite, silica sand, slates, soapstone, and volcanic ashes are well established as a result of numerous exploratory surveys carried out by various concerned agencies. Reported occurrences and showings include phosphate, gemstones, feldspar, iron ores, lead, oil, gas. Pozzulana materials, gold barite and rare earths. The possibilities of discovering minerals like scheelite, ilmenite, monazite and zircon exist.
Key words: Minerals Deposits, Azad Jammu and Kashmir.

A/419. Ali, S.T., Calkins, J.A. & Offield, T.W., 1964. Mineral deposits of the southern part of the Hazara District, West Pakistan. Geological Survey of Pakistan, Record 13(1), 38p.

Key words: Mineral Deposits, Hazara.

A/420. Ali, S.T., Offield, T.W., & Calkins, J.A., 1967. Soapstone deposits of the Sherwan area, Hazara district, West Pakistan. GSP and U.S.G.S. Project Report, PK (IR) 25, 13p.

Key words: Soapstone, Hazara.

A/421. Ali, S.T., Offield, T.W., & Calkins, J.A., 1968. Reconnaissance geology of the Tarbela quadrangle, Hazara district, West Pakistan. GSP and U.S.G.S. PK (IR) 37, 37p.

Key words: Reconnaissance, Tarbela, Hazara.

A/422. Ali, S.T., Calkins, J.A., & Offield, T.W., 1969. Geology and mineral resources of the southern Hazara district, West Pakistan and part of Western Kashmir. GSP and U.S.G.S. Project Report, PK (IR) 43.

Key words: Mineral resources, Hazara.

A/423. Ali, S.I., 1964. What geology says of Kohat. Geological Bulletin, Peshawar University 1, 26-28.

This report gives an account of the area between Kohat and Hangu. The details are based on the field trips conducted by the students. This is a very preliminary study and gives some information about the topography and stratigraphy of the area.
Key words: Topography, stratigraphy, Kohat.

A/424. Ali, S.M., 1975a. A concise review on marbles, pegmatites, graphitic schists and garnetiferous rocks exposed along roadside between Chakdara and Dargai areas of Dir and Swat, North West Frontier Province. Pakistan Mineral Development Corporation, Report, 30p.

Key words: Marbles, pegmatite, graphite, Dir, Swat, NWFP.

A/425. Ali, S.M., 1975b. A brief note on geology and proposals for future drilling and additing operation on Chakdara fluorite deposits, District Dir, North West Frontier Province. Pakistan Mineral Development Corporation, Report, 25p.

Key words: Fluorite, drilling, Dir, NWFP.

A/426. Ali, S.M. & Amin, M., 1963. Chemical composition of chromite from Peshawar region. Pakistan Journal of Scientific and Industrial Research 6, 227-232.

Seventeen (complete and partial) analyses suggest that most chromites are aluminian, some are ferrian. The deposits containing Cr/Fe >3 are of metallurgical grade. The number of divalent (Fe^{+2}, Mg) and trivalent (Cr^{+3}, Al, Fe^{+3}) cations per unit cell are calculated and discussed in relation to the units cell structure.
Key words: Geochemistry, chromite, Peshawar.

A/427. Ali, S.M. & Amin, M., 1968. Beneficiation of low-grade laterites for the production of alumina. Pakistan Journal of Scientific and Industrial Research 11(1), 31-34.

Key words: Beneficiation, laterite.

A/428. Ali, S.S., 1992. Shallow seismic refraction study in Darbokach (Kohat). M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 50p.

Seismic data of a line is obtained for interpretation collected in DARBOKACH area near KOHAT. The survey was done by OGDC and the objective was to establish velocity lithology relationship and to detect any subsurface structures present in the area. The seismic line is shot at 100 meters interval. Splitspread shooting scheme with 96 channels recording system was used. The offset distance on either side of the shot is 75 meters and the intergeophone spacing is 25 meters. The reverse profiles were prepared at 50 meters interval using the splitspread data.
Parameters such as depth Z_0 and velocities V_0 and V_1 are determined and their distribution along the seismic line is established. Depth under each geophone for reversed profiles using delay time and Plus Minus methods is determined. From the obtained results it is concluded that weathering layer thickness ranges from 18.5 m to 25.5 m with refractor being almost horizontal. Weathered layer velocity ranges from 1320 m/sec to 1820 m/sec and consists of sandstone with interbeds of shale. The refracting surface is faulted towards southeast end with downthrown side towards northwest. The average displacement in the bed is 42.6 m.
Key words: Seismicity, Kohat.

A/429. Ali, T.A. & Akbar, S., 1962. Geology of upper Batrasi area, Hazara. M.Sc. Thesis, Punjab University, 23p.

Key words: Mineral deposits, Hazara.

A/430. Ali, U., 1997. Geomorphological hazards and their impact in Swat valley, northern Pakistan. Abstracts, 9th All Pakistan Geographic Conference, Peshawar, 8-9.

Key words: Geomorphology, Hazard, Swat.

A/431. Ali, Z., 1991-93. Geology of Dubran Area District Haripur with microfacies study of Langrial Algal limestone. M.Sc. Thesis, Punjab University, Lahore, 127p.

Geological mapping of some 64-km2 area around Dubran in District Haripur has been carried out at the scale 1: 12500. The geomorphology, soils, stratigraphy and structure have been described. Stratigraphically a Mesozoic-Tertiary sedimentary cover is overlying a Precambrian to Eo-Cambrian basement of Hazara Group now metamorphosed in the lower greenschist facies. Numerous faults, high angle north dipping Nathiagali Thrust is the main fault that passes through the area and has thrusted the Precambrian Hazara Slates over the younger sedimentary sequence. Dubran syncline lying on top of a major anticlinorium makes an interesting structure.
Key words: Sedimentology, Microfacies, Limestone, Haripur.

A/432. Ali, Z. & Raza, S., 1999. Engineering geology of Ghazi Barrage Site (Ghazi Barotha Hydropower Project, Terbela), Pakistan. M.Sc. Thesis, University of Peshawar, 63p.

Key words: Engineering geology, Hydel power, Ghazi Barotha, Tarbela dam.

A/433. Alizai, S.A.K. & Ali, J., 1988. Comparison of Landsat and SIR-A data for geological applications in Pakistan: Current status and future programme. International Journal of Remote Sensing, 7, 1147-1151.

Key words: Remote sensing.

A/434. Alizai, S.A.K. & Khan, G.M., 1990. Remote sensing applications to geologic/mineral studies. In: Siddiqi, F., Husain, V., Kaifi, Z. & Ghani, A. (Eds.), Proceedings, First SEGMITE Conference on Industrial Minerals, March 1990, Peshawar, 68-73.

The application and interpretation of RS is described with respect to geological work. With the help of Landsat images, brief comments are made on the structure of five selected ranges of Pakistan: the Balochistan arc, Western Salt Range and Khisore Range, Eastern Salt Range and Potwar Plateau, Southern Sulaiman Range, and Coastal Makran Range. The author lays emphasis on combining field studies with RS. The western Salt Range and Khisore Range have complex structure, with considerable impact of salt tectonics. The Siwaliks of the Himalayan foreland are viewed as vertical sequence of individual stream channels overlain by related flood plain facies (shales and certain sandstones).
Key words: Remote sensing, salt range, Potwar, Sulaiman Range, Makran Range

A/435. Alizai, S.A.K. & Mirza, M.I., 1986. Remote sensing applications in Pakistan. International Journal of Remote Sensing, 9, 85-94.

Key words: Remote sensing.

A/436. Allauddin, M., 1969. Preliminary Petrography of Sirvik Gol Pegmatite, Chitral. Abstracts, 11th Annual Conference Science Society, Pakistan, p.18.

Key words: Petrography, Pegmatite, Chitral.

A/437. Allen, C.R., 1974. Preliminary report on visit to Tarbela dam and vicinity. Prepared for TAMS, Tarbela Dam Report, 23p.

Key words: Dams, Tarbela.

A/438. Allen, J.E., 1964. Quaternary stratigraphic sequences in the Potwar Basin and adjacent Northwest Pakistan. Geological Bulletin, Peshawar University 1, 2-5.

Prof. Ahmad Hassan Dani and Farzand Ali Durrani of the Department of Archaelogy; Univ. of Peshawar kindly permitted the writer to accompany them upon a number of their trips to the remarkable Archaelogy "digs" near Charsadda, Senghao and Thana which were under investigation during 1963-64.
The problem faced by them in the dating of the formations within which artifacts occur at once aroused the writer's interest since they are in large parts geological problems in Quaternary stratigraphy. Nothing has been published on this aspect of the area, the nearest work has been in Kashmir (De Terra. 1939) many miles to the north-west, and in Gujrat (Zeuner 1950-63) over farther to the south. Both are indifferent drainage systems, which might not correlate with Potwar System.
After a number of trips to various parts of the region, a pattern emerged in March of 1964, and tentative correlations appeared possible between similar sequences of unit found near the Swat River a mile south-east of Thana, along the Sher Garh nullah 17 miles north of Mardan and north of Katlang near Sanghao, Because of the absence of the previous publications, it seemed worthwhile to present the available data and some conclusions reached as a guide to further investigation, inspite their highly tentative and incomplete nature.
Key words: Quaternary, stratigraphy, Potwar Basin.

A/439. Allen, T. & Chamberlain, C.P., 1989a. Thermal consequences of mantle gneiss dome implacement. Earth and Science Planetary Letters 93, 392-404.

Key words: Mantle gneiss dome.

A/440. Allen, T. & Chamberlain, C.P, 1989b. Petrologic constraints on the tectonic history of the northern Shyok suture and the main Karakorum Thrust, Baltistan, Northern Pakistan. Geological Society of America Abstracts with Programs, 21(6), p.A181.

The Northern-Shyok Suture and the Main Karakorum Thrust (MKT) separate rocks in the Asian plate from rocks in the Kohistan-Ladakh Island Arc. We determined the P-T history of the metamorphic rocks both north and south of this suture in effort to place constraints on the suturing process. The terranes north and south of the MKT have different, unrelated metamorphic histories. Our data is consistent with a tectonic model that involves metamorphism of the Kohistan-Ladakh Arc due to plutonic activity and metamorphism of the Karakorum Metamorphic Complex as a result of subduction related processes. After metamorphism the two terranes were juxtaposed by the late south directed MKT, which obscures the original Northern-Shyok Suture.
Key words: Petrology, tectonics, Shyok Suture, MKT, Baltistan.

A/441. Allen, T. & Chamberlain, C.P., 1991. Metamorphic evidence for an inverted crustal section, with constraints on the Main Karakorum Thrust, Baltistan, northern Pakistan. Journal of Metamorphic Geology 9, 403-418.

The Shyok Suture Zone separates rocks in the Asian plate from rocks in the Kohistan-Ladakh island arc. In Baltistan, this suture has been reactivated by the late 'break-back'Main Karakorum Thrust (MKT). The *P-T* histories of metamorphic rocks both north and south of the MKT have been determined in an effort to place constraints on the tectonic history of this zone. The terranes north and south of the MKT have different, unrelated metamorphic histories. Rocks from the Kohistan-Ladakh island arc south of the MKT have undergone a static low-*P* (2–4 kbar, *c.* 500° C) thermal metamorphism. The *P-T* paths and metamorphic textures of these rocks are consistent with metamorphism due to emplacement of plutonic rocks into the island arc. This metamorphism pre-dates folding and deformation of these rocks. Rocks in the Karakorum Metamorphic Complex, north of the MKT, have experienced a complex deformational and metamorphic history. Prograde metamorphic isograds have been deformed by subsequent south-verging folding and by gneiss dome emplacement. However, decompression metamorphic reactions occurred during nappe emplacement. Higher pressure rocks are associated with higher level nappes,

creating an inverted pressure metamorphic sequence (8–9-kbar rocks over 5–6-kbar rocks). There is little variation in temperature with structural level (550–625° C). These two different terranes have been juxtaposed after metamorphism by the late south-directed MKT.
Key words: Petrology, Tectonics, Shyok Suture, MKT, Baltistan.

A/442. Al-Nawab, L.M.A., 1983. Geology of a portion of Kohat quadrangle Darra Adam Khel, Kohat, North West Frontier Province, Pakistan. M.Sc. Thesis, Peshawar University, 97p.

Key words: Darra Adam Khel, Kohat

A/443. Aloisi, P., 1933. Le rocce. Relazioni scientifiche della Spedizione Italiana “De Filippi” nell’ Himalaya, Caracorum e Turchestan Cinese (1913-14). Series 2[a], Risultati Geologci e Georafici 7; Le Rocce. Zanichelli, Bologna.

This is a compilation of the scientific work of the Italian expedition to the Himalaya, Karakoram and Chinese Turkestan, now referred to as Sinkiang. This covers the work done during the period 1913 – 14 and concerns the lithology and rocks of the region studied.
Key words: Lithology, Italian Expedition, Himalaya, Karakoram, Chinese Turkestan.

A/444. Aloisi, P. & Dainelli, G., 1934. (Exact title not known). Series 2[a], Risultati Geologci e Georafici 7; Le Rocce. Zanichelli, Bologna.

The authors distinguish in the Karakoram and the neighbouring regions three types of granites of different ages on stratigraphic ages: 1. Precambrian, 2. Biotite granites and two mica granites, the most frequent and pre-cretaceous in age (Himalayan granite), 3. Mica-amohibole granites with associated diorites and basic rocks of Senonian age (trans-Himalayan granite).
Key words: Granites, Karakoram, Himalaya.

A/445. Alvi, D.H., 1985-87. The mineralogical/geochemical studies of rocks, soils and water from Khanaspur Dewal Area. M.Sc. Thesis, Punjab University, Lahore, 102p.

This report gives an account of Mineralogical and geochemical studies carried out in Khanspur and Dewal area. The prescribed area lies to the north of Murree, in extreme east of Abbottabad and southwest of Muzaffarabad. Except an area of about 6 sq. km. which belongs to District Rawalpindi, the area lies in Abbottabad District, N.W.F.P. It is a mountainous region with fairly high relief.
Geological mapping of approximately 56 sq. km. on lithostratigraphic basis, at the scale 1:10,000 was carried out. The stratigraphic succession ranges from Datta Formation (Jurassic) to Murree Formation (Miocene).The lithology is mainly limestone, shales and sandstone. Extensive sampling of rocks, soils and water was carried out and these samples were studied in laboratory and data regarding these studies are given in this report.
A brief systematic description of various rock units in hand specimen and thin section is included. A brief description of chemical staining techniques applied to the limestones and that of performed limestone analysis is also given. A chapter regarding the detai1 geochemica1 studies of soils of the project area is also included. This chapter gives an account of all the parameters necessary for soil study and according to these parameters, the soils of the area are categorized as non-sodic, non-saline.
Geochemistry of two main streams of the area has also been studied in detail and the data regarding the chemical analysis of the water are reported and interpreted by various graphica1 techniques. According to these data, the minera1 components and other parameters lie within the safe limits, established for water to be used for domestic and agriculture purposes. Chemical characteristics of waters of various springs of the area, originated in different rock units have also been studied and interpreted in detail. Spring waters are also fit for irrigation and drinking purposes. Finally, there is a general discussion about the waters of the area and the effect of various encountered rock units on the chemistry of water passing through them.
Key words: Mineralogy, geochemistry, hydrogeochemistry, soil, water, Abbottabad.

A/446. Ambraseys, N., Lensen, G. & Moinfar, A., 1975. The Pattan earthquake of 28th Dec. 1974. UNESCO, Paris (RP 1975–76/2, 222, 3), (Serial No. FMR/SC/GEO/134), 41p.

Consult the following account.
Key words: Earthquake, Pattan.

A/447. Ambraseys, N., Lesen, G., Moinfar, A. & Pennington, W., 1981. The Pattan (Pakistan) Earthquake of 28 December, 1974: Field Observations. In: Quarterly Journal of Engineering Geology 14, 1-16, Edinburgh.

In the early evening of 28 December 1974, a magnitude 6.0 (*mb* USGS) earthquake occurred in a remote and mountainous region of northern Pakistan, resulting in loss of life and damage to property. The Pakistani Army Engineers involved in construction and maintenance of the Karakorum Highway, a one-to two-lane gravel road along the Indus River valley, quickly established an efficient relief operation. Since the highway was damaged and unusable during most of the relief operation, helicopters were used to carry supplies from Besham, at the end of the usable highway, to Pattan, where a hospital camp was set up.
Two seismic reconnaissance teams visited the affected area: the first arrived from Tarbela Dam on 1 January 1975, and included one of the authors (Pennington); the second team, with the other three authors (Ambraseys, Lensen and Moinfar) arrived later in January. The following report is based largely on their field studies (Ambraseys *et al*. 1975; Pennington 1975).
The earliest known earthquakes of the Northwest Frontier Provinces (NWFP)
As early as the 4th century BC, the region north of the Jhelum was reputed for its destructive earthquakes. Historians who accompanied Alexander the Great on his expedition in Swat allude to such events; they briefly state that as a result of earthquakes in this track of country even the beds of rivers are changed. Alexander must have reached Aornos (modern Pir-sar about 20 km from Besham) late in 327 BC (Stein 1927, 1929;
Key words: Earthquake 1974, Pattan.

A/448. Amerise, C., Quintavalle, M. & Tropepi, R., 1998. Palynological dating (Arenig) of the sedimentary rocks overlying the North Karakoram crystalline basement near Vidiakot, Chitral, Pakistan. CIMP Symposium and Workshop, Programme and Abstracts, University of Pisa, p.35.

Key words: Palynology, sedimentary rocks, Chitral.

A/449. Amin, K.M., 1999. Hydrogeophysical studies for groundwater exploration in the vicinity of Quaid-i-Azam University, Islamabad. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 81p.

Key words: Geophysics, groundwater exploration, Islamabad.

A/450. Amin, M., 1982-84. Geology and Petrotectonic Study of Shino-Kaghan-Batal Area, District Mansehra Pakistan. M.Sc. Thesis, Punjab University, Lahore, 189p.

This field report comprises a complete geological study based on a first time mapping of nearly 328 km2 of Central Kaghan Valley. Special emphasis has been put on, describing the stratigraphy and deciphering petrotectonic relationships of the rocks. A tentative stratigraphic correlation of the rock units has also been attempted. Between Shino and Batal a large number of rock unit including volcanics, tillites, metaconglomerates, schists, quartzites, marble, granites and migmatites are encountered. A stratigraphic sequence has been worked out. The rocks extend in age from Permo-Trias to Precambrian, have been correlated with Panjal Volcanics, Agglomeratic Slates, Tanols, Slates (Hazara/Dogra) and Salkhalas/Sharda Group.
Structurally, the rocks are folded into a number of major structures, which are now separated from each other by mostly north dipping high angle thrust faults. The area thus comprises a large number of thrust sheets over riding

each other. A study of the petrotectonic relationships of the various rock units brings out the very interesting discovery of a third suture in NW Himalayas. This suture is much older than the two already described (MKT & MMT) and coincides with the position of MBT. In the field of economic geology a number of new potential economic deposits including quartzites, marble graphite and gypsum being reported. This report also includes a petrographic description of the rock units as well as numerous sketch sections and photographs, illustrating the geology of the area.
Key words: Petrology, Tectonics, Kaghan, Mansehra.

A/451. Amin, M., 1988. Shallow seismic refraction survey in Fateh Jhang area District Attock. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 121p.

Key words: Seismic refraction, Fateh Jhang, Attock.

A/452. Amin, M., 2000. Fault solution of a part of Northern Pakistan during period, 1993-96. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 43p.

Key words: Structure, seismology, Faults.

A/453. Amin, M.T., 1981-83. Geology of Paras-Bela-Jared Area, central Kaghan valley. M.Sc. Thesis, Punjab University, Lahore, 148p.

This report gives an account of lithostratigraphic mapping and, Tectonic and structural observation of the area between Paras and Jared in Kaghan valley. Some details of the geomorphology of the area is also given.
Key words: Lithostratigraphy, Mapping, Kaghan.

A/454. Amin, R.S., 1998. To understand the unconformity in seismic reflection section. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 27p.

Key words: Seismic reflection, structural geology.

A/455. Amir, M., 1987. The electrical resistivity survey for groundwater exploration. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 34p.

Key words: Geophysics, electrical resistivity, groundwater.

A/456. Anczkiewicz, R., 1998. Structural and geochronological study of the Indian-Kohistan arc collision, lower Swat region of Pakistan, NW Himalaya. Ph.D. thesis, Swiss Federal Institute of Technology, Zurich.

The NW Himalayan collisional system comprises three distinct crustal domains. From south to north they are: the Indian plate, the Indus Suture Zone (Main Mantle Thrust) and the Kohistan paleo-island arc (KIA). The studied area is located in the Mingora-Alpurai region, Lower Swat district of Pakistan, where the Indus Suture Zone (ISZ) forms one of the largest exposures. Structural mapping of the Indus Suture Zone lithologies and neighbouring parts of the northern Indian margin and of the basal part of the Kohistan arc were carried out. Geochronological studies were conducted in order to provide time constraints on pre- syn- and post-collisional magmatic, metamorphic and deformational evolution in the three domains. In addition, geochronological studies were carried out on the garnet granulites of the KIA in the Jijal-Patan area were conducted.
The Indian plate
The lowest crustal level in the Indian plate domain is represented by the Swat and the Choga granite gneisses. The Choga granite gneiss consists of peraluminous granites, whose U-Pb zircon dating yielded a 468±5 Ma magmatic emplacement age. The alkaline Swat granite, which intruded overlying Alpurai metapelite, yielded a 268 +7/-3 Ma

U-Pb zircon age interpreted as the time of intrusion. The granitoids together with the overlying Alpurai and Saidu schists underwent amphibolite and greenschist fades metamorphism during collisional time. The earliest, collision related, deformational phase is associated with southward-directed thrusting and formation of large-scale recumbent folds. This period was followed by the reactivation of the ISZ as a normal fault. As a result of normal faulting the greenschist fades Saidu schists were juxtaposed against amphibolite fades Alpurai schists. Strike-slip faulting, most likely, occurred at this stage. The extension related structures are folded by N-S trending folds, whose formation is probably contemporaneous with building of the Besham syntaxis.
Sm-Nd dating of garnet from the Alpurai schists and ^Ar/^Ar dating of hornblende and muscovite indicate that the Lower Swat region remained under lower amphibolite fades conditions (or higher) until ca. 35 Ma. The main period of exhumation is most likely related to the extensional period. Its maximum age was constrained by dating late kinematic alkali granite dykes, which post-date the main metamorphism and are deformed by the extension related N-vergent folds. U-Pb zircon dating yielded 29.3±0.2 Ma magmatic emplacement age, which was also confirmed by a 28.6±1.4 Ma Ar/Ar muscovite age.
Indus Suture Zone
A new subdivision of the Indus Suture Zone lithologies is proposed. The main mapped units represented by Sheared Olistostromic Unit, Interlayered Blueschists and Greenschists, Volcaniclastic metaturbidites and serpentinised ultramafics. They are separated by fault contacts and form a zone of imbricated blocks, which underwent multiphase deformational history. Due to different rheological properties and strong brittle overprint structural comparison between the units is ambiguous. Very well preserved extensional structures within the 'Sheared Olistostromic Unit', similar to those observed in the Indian plate, suggest that Indian plate and the ISZ lithologies have shared a similar deformational history since this stage or earlier.
Rb-Sr dating of blueschist facies assemblages yielded ages of 77.0±0.4 and 79.7±0.4 Ma. This was confirmed by a 80.4+0.7 Ma Ar-Ar muscovite age. These dates are interpreted as reflecting peak blueschist facies conditions. Lack of collision-related metamorphic overprint is probably due to underplating of the blueschists to the hanging wall of the MMT prior to collision or earlier obduction onto the Indian plate.
Kohistan arc
Sm-Nd and Rb-Sr garnet dating of the Kamila amphibolites in Kwazakhela area yielded concordant ages of 94.6±5.3 and 99.5±15.7 Ma, respectively. Similar ages were obtained for the amphibolitised garnet granulite, from the Jijal-Patan complex, which yielded 95.7+2.7 and 101.3±10.4 Ma by Sm-Nd and Rb-Sr techniques, respectively. Petrological observations and comparison with other studies indicate that garnet is a relic of the earlier, granulite facies metamorphism. These dates are interpreted as reflecting, or shortly postdating the granulite facies metamorphic peak. Rb-Sr and Ar-Ar dating of the amphibolitisation process leads to more
Key words: Structure, geochronology, collision, Kohistan arc, Swat.

A/457. Anczkiewicz, R., Burg, J.P., Hussain, S.S., Dawood, H., Ghazanfar, M. & Chaudhry, M.N., 1998. Stratigraphy and structure of the Indus Suture in the lower Swat, Pakistan, NW Himalaya. Journal of Asian Earth Sciences 16, 225-238.

We present a geological map, detailed structural description and new subdivisions of the Indus Suture Zone lithologies in northeast Pakistan (Lower Swat region). The Indus Suture Zone is a dominantly fore-arc related assemblage obducted onto the Indian Plate. Initial southward thrusting was followed by the reactivation of the Indus Suture as a ductile-brittle normal fault. Significant strike-slip faulting may have taken place at this stage. Later brittle reverse faults demonstrate that shortening outlasted normal faulting. The comparison of the structural evolution of the Indus Suture Zone and the Indian Plate shows that both remains were sharing the deformational history, possibly since the earliest stage of collision. The Lower Swat area records a full orogenic cycle from early rifting through continent-arc collision to orogenic collapse. We present a geodynamic model that integrates all these elements.
Key words: Stratigraphy, structure, Indus Suture, Swat.

A/458. Anczkiewicz, R., Burg, J.P., Meier, M., Oberli, F., Vance, D., Dawood, H., Hussain, S., Ghazanfar, M. & Chaudhry, M.N., 1997. Tectonometamorphic evolution of the Indus Suture viewed by structural and isotopic data, lower Swat, Pakistan NW Himalaya. Abstract volume, 12^{th} Himalaya- Karakorum-Tibet International Workshop, Rome, Italy, 2-4.

In NW Himalaya the Indus Suture separates the Kohistan paleo-Island Arc (KIA) from the Indian continent. The Indus Suture in the Mingora-Alpurai region of Lower Swat (NE Pakistan represents a complex exposure of greenschist and blueschsit faces mafic, ultramafic and metasedimentary rocks wedged in-between ortho-amphibolites of KIA to the north and metapelites of the Indian plate to the south (map).
In the studied area Indian plate lithologies comprise the Manglaur schists, associated Swat granite gneiss, and overlying metapelites. These rocks were subsequently metamorphosed during the Kohistan-India collision. Preliminary U-Pb zircon dating of the Swat granite-gneiss (map, samp. 95/198) yielded an upper intercept age 276 + 40/-9 Ma which represents the time of magmatic emplacement. Amphibolite facies metamorphism dated by Sm-Nd techniques on metapelitic schists of the Alpurai group (map, samp. 94/1) at 36±2 Ma. This event was followed by a second magmatic episode expressed by syn- to post-kinematic pegmatitic dikes, which intrude the Swat granite gneiss.
The dominant style of deformation within the Alpurai para-amphibolites and overlying Saidu schists is characterized by asymmetric, north-vergent folds with gently to moderately south dipping axial planes. Similar style of folding is also observed in the basal unit of the Indus Suture Zone where extension is indicated by numerous shear band and normal faulting (cross-section). Comparable north-vergent folds from the neighboring Naran region were shown to be synconvergent collapse features related to the backsliding of the Kohistan arc.
The lithologies of the Indus Suture Zone represent a sequence of imbricated blocks that bear evidence of metamorphism and deformation prior to collision. This early phase is indicated by the age of blueschist facies metamorphism and conjugate box type folds preserved in metacherts, which underwent first phase of deformation probably in the forearc environment. All units were juxtapose, metamorphosed and deformed when collision occurred. The Kohistan amphibolites show features mainly related to southward directed shearing which resulted in anastomosing shear zones and south verging folds. Rare asymmetric quartz clasts mark a late stage of northward-directed movement. The latest stage of ductile deformation is expressed by NE-SW trending strike-slip faults with unconstrained amounts of vertical and horizontal displacement.
Key words: Tectonics, Metamorphism, Isotopes, Structure, Indus Suture, Swat.

A/459. Anczkiewicz, R., Oberli, F., Burg, J.P., Meier, M., Dawood, H. & Hussain, S.S., 1998. Magmatism south of the Indus Suture, lower Swat, Pakistan. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 7-9.

The lower Swat magmatism is dominated by the so-called Swat granite, which intruded the Manglaur Formation and is unconformably overlain by the Alpurai schists (Fig.1). Its age of emplacement has been assumed to be similar to that of the Mansehra granite, which gave a Rb-Sr total-rock isochron of 516±16 Ma age (Le Fort et al., 1980). We present results of petrological, geochemical and geochronological studies of the Swat granitoids in the northern part of the Loe Sar dome and Alpurai regions (Fig. 1).
At the northern edge of the Loe Sar dome the granitoids occur as two sill-like bodies. We investigated the upper sill at the northern edge of the dome. It exhibits dominantly augen and flaser type textures, which show alkaline composition. U-Pb single zircon dating of sample 95-198 (Fig. 1) yielded 268+7/-3 Ma. Preliminary dating of sample 95-196 confirms the Permian age, which we interpret as the time of magmatic emplacement. The body is intruded by alkaline syn- to post kinematic pegmatitic dykes, which are truncated and sheared at the contact with the overlying Alpurai schists (Fig. 2a). U-Pb zircon dating gave an age of 29.2±0.2 Ma interpreted to represent an intrusion age. This date establishes also the maximum age for shearing. Scarce kinematic indicators suggest a thrust sense of movement. Thus, the Tertiary alkaline volcanism appears to be associated with regional thrusting (see also Le Bas et al., 1987) rather than rifting as proposed by Kempe and Jan, 1980.
Taking into account field observations and age data we suggest an intrusive rather than an unconformable nature for the contact between the Swat granite gneiss and the Alpurai schist. This interpretation is based on i) the existence of a fine-grained fabric at the border of the granite gneiss, ii) the occurrence of xenoliths of garnet-amphibolite that may have been derived from the Alpurai schists and iii) the Permian age of the granite, which has intruded Middle Carboniferous to Permian beds at the base of Alpurai schists (Marghazar Formation of DiPietro et al., 1997). Regional shearing at ca. 30 Ma is responsible for the truncation of the pegmatitic dykes at the Swat granite gneiss / Alpurai schists interface and have obscured the original intrusive character of this contact.
Based on similar stratigraphic position with respect to the Alpurai schists, the Choga granite gneiss (Fig. 1, 2a,b) of the Alpurai region has been commonly assigned to the Swat granitoids. Microprobe analyses of major mineral phases in sample 95-21 1, however, are different from those of samples 95-198 and 95-196, which originate from the northern part of the Loe Sar dome (Fig. 1). This observation is corroborated by a U-Pb zircon age of 468±5 Ma

obtained for Choga granite, which we interpret as an intrusion age. Based on similarities in major mineral geochemistry, we consider the Choga granite to be related to the granitoids in the core of the Loe Sar dome (lower sill).
Because our investigations have been focussed on a rather limited part of the Swat granitoids, it is still uncertain, whether the Permian age determined for their northern margin is representative for the entire upper unit or whether the Permian magmatites form smaller intrusions within Cambro/Ordovician granitoids. The results extend the spatial distribution of alkaline magmatism, previously restricted to the Peshawar Plane igneous province, to the Swat area. Furthermore, they give clear proof that this magmatism was generated in at least two cycles unrelated in age.
Key words: Magmatism, Indus Suture, Swat.

A/460. Anczkiewicz, R., Spencer, D.A., Hussain, S.S., Dawood, H., Chaudhry, M.N. & Ghazanfar, M., 1995. Emplacement and subsequent tectonic history of the Indus Suture in the Mingora-Shangla-Malam Jabba area (NW Himalaya, Pakistan). Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

A complex exposure of the Indus Suture in the Northwestern Himalayan area is situated on the western side of the Besham Syntaxis (northeastern Pakistan). Between Mingora and Lilauni, the Indus Suture bifurcates into a wedge-shaped complex, which comprises of predominantly mafic rocks of blueschist and greenschist facies grade. It is separated by the tectonic contacts from the amphibolites of the Kohistan Island Arc to the north and from the metasediments of the Indian Plate to the south. The enclosed Indus Suture Mélange Group was previously subdivided into three units: the Mingora Ophiolitic Mélange, the Charbagh Greenschist Mélange and the Blueschist Mélange. These were suggested to have been separated by major thrusts that were active when the continental collision occurred. The mélange units are thought to represent oceanic crust material, which is of either Island Arc, Mid Oceanic Ridge or subduction zone origin.
Preliminary results of fieldwork in the Mingora, Shang La and Malam Jabba areas indicate that the interpretation of a mélange-type subdivision can no longer be sustained. We were not able to confirm the existing divisions of the three units separated by the thrust contacts. Only the lower and upper contact of the suture zone are marked by the presence of distinctive shear zones which show a thrust sense of movement, although occasionally evidence for extensional movement is found.
Initial petrological studies of the Alpurai schists revealed distinct variation in the metamorphic and deformational history within this unit. Schists from the vicinity of the village Kashora show two stages of the growth of garnet which postdate the formation of the main foliation while schists from Makad show one stage of growth and are cut by the main foliation.
Key words: Tectonics, Indus Suture, Mingora, Shangla, Malam Jabba, Himalaya.

A/461. Anczkiewicz, R. & Vance, D., 2000. Isotopic constraints on the evolution of metamorphic conditions in the Jijal-Patan complex and Kamila belt of the Kohistan arc, Pakistan Himalaya. In: Khan, M.A., Treloar, P.J., Searle, M.P. & Jan, M.Q. (Eds.), Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya. Geological Society, London, Special Publication 170, 321-331.

Pressure-temperature data and Sm-Nd and Rb-Sr garnet ages presented for retrogressed granulitic rocks of the Jijal-Patan complex and the Kamila Amphibolite Belt. Despite the retrogression and hydration, the two samples contain garnet and hydrous minerals that yield pressures and temperatures similar to previous estimates for pristine granulite facies rocks from the same area. The Sm-Nd and Rb-Sr garnet ages are concordant at 95-100 Ma for the two samples and for both isotopic systems, these ages are interpreted as dating cooling through 700-800ºC following magmatic crystallization and granulite facies metamorphism. In the case of the garnet amphibolites from the Kamila Belt, the garnets system is very close to the recorded temperatures. For these reasons, the age of 100 Ma must represent a time close to that when the pressure and temperature preserved in the mineralogy and its chemistry was recorded. The isotopic equilibrium between garnet and paragonite at 90-100 Ma suggest that the regional hydration event that affected the lower crust of the Kohistan arc also occurred at this time. Cooling rates calculated from the Rb-Sr and Sm-Nd ages for the partially retrogressed granulite give a minimum of 3-6ºC Ma-1and imply a different

tectonic mechanism for the exhumation of the lower crust than is typical for granulites. This process may be related to early regional decompression following the collision of the Kohistan arc with Eurasia.
Key words: Isotopes, metamorphism, Jijal, Pattan, Kamila, Kohistan arc, Himalaya.

A/462. Anczkiewicz, R., Villa, I.M., Miller, W., Burg, J.P., Meier, M., Dawood, H. & Hussain, S.S., 1998. Rb/Sr and $^{39}Ar/^{40}Ar$ dating of blueschist facies metamorphism in Shangla region, Pakistan, NW Himalaya. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 9-10.

Geochronological studies of high-pressure rocks in many metamorphic terrains show that Ar-Ar dating often yield ages inconsistent with other dating techniques (e.g. Li et al., 1994). Therefore an independent control by other isotopic geochronometers is needed. We present preliminary results of coupled Rb-Sr and 39Ar/40Ar dating of the Shangla blueschists.
The Shangla blueschists are squeezed within the Indus Suture Zone, on the western limb of the Besham (Indus) syntaxis (Lower Swat region of Pakistan). As such, they outcrop within the so called 'm61ange zone' between the Indian plate and the Kohistan. The blueschist facies event has been previously dated at ca. 80 Ma by 39Ar/40Ar phengite dating (Maluski and Schaeffer, 1982; Maluski and Matte, 1984). Glaucophanes yielded 39Ar/40Ar data scattered between > 450 and 50 Ma (Schams 1980; Maluski and Schaeffer, 1982; Maluski and Matte, 1984).
Prior to dating, we carried out detail microprobe analyses in order to eliminate samples exhibiting retrograde features (invisible on the micro-scale) and detect possible mixing between various phases. Back-scattered electron imaging and quantitative microprobe analyses of the blue amphiboles showed no or very weak zoning. Compositions are all within the range of glaucophane-riebeckite series. Similarly, phengites do not display any significant zoning. Blue amphiboles eventually contain sub-microscopic inclusions of phengites.
Two metasedimentary and three metavolcanic types of blueschists were selected for the geochronological studies. Both show crossite/ glaucophane+epidote paragenesis, which is diagnostic for the transitional blueschist-greenschist facies, typical for the Shangla region. Five glaucophanes and three phengite high-purity mineral concentrates derived from five rock samples were subjected to 39Ar/40Ar dating by stepwise heating technique. In addition, two of them were dated by the Rb-Sr method.
Rb-Sr isochrons of blue amphibole-phengite pairs allow to better ascertain the age of blueschist facies metamorphism. Low 87Rb/86Sr ratios for blue amphiboles together with high ratios for phengite (see table 1) allow precise age determination at 77.0-+0.4 and 79.7±0.4 Ma (errors with 95% c.l.). The estimated thermal peak for the Shangla blueschist (300-380oC) (Jan 1981; Guiraud, 1982) is significantly lower than the commonly accepted closure temperature for Rb-Sr system in phengite and amphibole. Therefore, we interpret our age determination as representing time of metamorphic crystallisation under transitional blueschist-greenschist facies conditions at ca. 80 Ma. 40Ar/39Ar dating was performed on 5 glaucophane samples. Extensive handpicking and preliminary K concentration measurements (K<500 ppm) let us hope to have eliminated 'contamination' by phengites. However Ca/K vs. Cl/K trajectories coupled to mass balance calculations show that true blue amphibole has K<23 ppm, and about 0.4% modal phengites intergrowths by far dominate the K-Ar budget. All ages group around 80 Ma and agree with Rb/Sr dating, Three out of 5 glaucophanes preserved pre-blueschist facies amphibole (?) relics, which give reproducible step ages around 400 Ma in the last 5% of the gas release. This corresponds to about 1 modal % 'relict amphibole', which appears to preserve a signature of the Ordovician volcanism.
Key words: Blueschist facies, metamorphism, geochronology, Shangla, Himalaya

A/463. Anderson, B.W., 1966. Transparent green grossular-a new gem variety; together with observation on translucent grossular and idocrase. Journal of Gemmology 10, 113-119.

Transparent green grossularite from Pakistan has been identified as a new gem variety, similar to previously described chrome-rich grossularite and having an x-ray pattern typical for nearly pure grossularite. Difficulties in distinguishing between grossularite and idocrase can be resolved through density determinations and study of absorption patterns.
Key words: Grossular, gemstones.

A/464. Anderson, R.V.V., 1928. Tertiary stratigraphy and orogeny of the Northern Punjab. Geological Society of America, Bulletin 38, 665-672.

The Tertiary of the Punjab is divided into two principal parts, the marine and estuarine Eocene (Nummulitic) system below, and, unconformably overlying this, a great succession of nonmarine beds representing continental sedimentation from the Oligocene to the late Pliocene or early Quaternary. This nonmarine succession, here named the “Ni-madric System,” includes the Murree and Siwalik series. It comprises over 20,000 feet of fairly well stratified, alternating sandy and silty beds, mainly fine-grained, but coarsely conglomeratic in its uppermost division. It is interpreted as the product of mainly fluviatile, but in part eolian, deposition over fairly flat plains, under a semitropical climate of medium rainfall. The plains extended into the region now occupied by the Himalaya. Evidence of the validity of thickness measurements is afforded by the comparative constancy of individual fine-grained formations, the great thicknesses superimposed in single sections, and by the record here presented of a well 6,000.

Key words: Stratigraphy, orogeny, Tertiary, Punjab.

A/465. Andrews, S.C.P. & Brookfield, M.E., 1982. Middle Paleozoic to Cenozoic geology and tectonic evolution of the Northwestern Himalaya. Tectonophysics 82, 253-275.

Previously published data and data collected by the authors from the northwestern Himalaya are summarized and assessed. The account focuses on Kohistan and the Karakorum Range in Pakistan, and on Ladakh and the Zanskar Range in India.

Five palaeotectonic units are recognized. From south to north these are:

(1) Palaeozoic-Eocene continental shelf sequence on the northern margin of the Indian continent;

(2) a Triassic-Jurassic continental slope sequence: the Lamayuru unit of the Indus zone and of the Spongtang klippe;

(3) the Cretaceous-Tertiary Kohistan-Ladakh magmatic arc, which includes the Kohistan sequence, the Ladakh batholith, the Dras unit, the Spongtang klippe, the Indus molasse unit and the Shyok zone;

(4) the Karakorum batholith: a late Tertiary zone of granitoid magmatism and metamorphism;

(5) a Palaeozoic-Mesozoic continental shelf and slope sequence deposited on the southern margin of an Asian continent.

The following sequence of events is tentatively proposed:

(1) Permian-Carboniferous continental rifting;

(2) Triassic-Jurassic collapse of continental shelf, and formation of deep (oceanic?) basin;

(3) Cretaceous formation of Kohistan-Ladakh magmatic arc, in response to subduction from the south as ocean closed;

(4) Late Cretaceous-Eocene emplacement of Kohistan arc and of thrust sheets of Indus zone (magmatic arc units and Lamayuru unit) southwards onto Indian continental margin, as India approached and collided with magmatic arc;

(5) silicic phases of Ladakh batholith (Palaeocene-Eocene) and Karakorum batholith (Miocene) may be related to subduction of oceanic basin between magmatic arc and Asian margin. Alternatively, they are late- and post-collisional products;

(6) the Shyok zone, between the Ladakh and Karakorum batholiths, was emplaced to the south in Oligocene or Miocene time;

(7) final collision between India, the magmatic arc and Asia in Oligocene-Miocene time was followed by continued crustal shortening which disrupted thrust units.

Key words: Tectonics, geochronology, NW Himalaya.

A/466. Andrieux, J. & Brunel, L., 1977. L’evolution des chaines occidentales du Pakistan. Geological Society of France, Memoir 8, 189-207.

Key words: Structural geology, tectonics.

A/467. Angiolini, L., 1994. 1 brachiopodi del Permiano del Karakorum. Studio tassonomico e biostratigrafico. Ph.D. Thesis. Dipartimento di Scienze della Terra. Univ. Studi di Milano, Italy, 202p.

Key words: Permian, paleontology, brachiopods, biostratigraphy, Karakoram.

A/468. Angiolini, L., 1995a. Permian Brachiopods from Karakorum. Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

Large collections of Permian brachiopods were assembled during four Italian expeditions (1986, 1991, 1992) on the Pakistan side of Karakorum. The first three expeditions visited the Upper Hunza valley and its laterals, Chapursan valley, Abgarch valley and Shimshal valley. The last expedition was led in the western termination of the Karakorum, in the Chitral-Baroghil-Karambar sector.
Permian brachiopods from western Karakorum (Baroghil pass) were first collected by Hayden (1915) and described by Reed (1925). A small collection of Permian brachiopods from Upper Hunza valley, collected by Desio (1962), was described by Fantini Sestini (1965).
Five brachiopod assemblages have been recognized, from the Asselian-Sakmariafl to the Murgabian-Midian .The first association, named Trigonotreta Iyonsensis-Punctospirifer afghanus assemblage, has been collected in the Asselian-Early Sakmarian Gircha Fm. of Upper Hunza Valley. The second assemblage, Hunzina electa-Cleiothyridina ailakensis association, characterizes the Sakmariafl Lupghar Formation, Mb. 1 of Upper Hunza valley and the Sakmarian Lashkargaz Fm., Mb. 1 of Baroghil-Lashkargaz area (Chitral). The third assemblage, with Orthothetina convergens-Aldina hexilis as index-species, is Bolorian in age and it has been collected at the top of Lashkargaz Formation, Mb. 2 of Lashkargaz (Chitral). The fourth association, Waagenochoncha (Gruntochoncha) macrotubercolata-Callytharrella sinensis assemblage, is Kubergaridian in age and characterizes the Panjshah Formation, Mb. 1 of Upper Hunza Valley and the Lashkargaz Fm., Mb. 4 of Baroghil-Lashkargaz area. Finally the youngest association, named Stenoscisma armenica-Chapursania tatianae assemblage, has been collected in the Panjshah Formation, Mb. 2 of Upper Hunza Valley and it is Late Murgabian-Midian in age.
The evolution of the assemblages testifies for a warming of the climate conditions, due to the northward drifting of the Karakorum block during the Permian. Furthermore the youngest assemblages show a greater number of endemic taxa than the oldest ones which have species in common with W Australia, SE Pamir, Afghanistan and NW Tibet faunas.
Key words: Permian, Brachiopods, Karakoram.

A/469. Angiolini, L., 1995b. Permian Brachiopods from Karakorum (Pakistan), Part I (with Appendix). Rivista Italiana de Paleontologia e Stratigrafia 101, 165-214.

Consult the preceding account for further details.
Key words: Permian, Brachiopods, Karakoram.

A/470. Angiolini, L., 1996a. Permian brachiopods from Karakorum (Pakistan). In: Brachiopods. Copper, P., and Jin, J. (Eds.), Balkema, Rotterdam, 13-17.

Key words: Permian, Brachiopods, Karakoram.

A/471. Angiolini, L., 1996b. Permian brachiopods from Karakorum (Pakistan). Part II. Rivista Italiana di Paleontologia e Stratigraphia, 102, 3-26.

Key words: Permian, Brachiopods, Karakoram.

A/472. Angiolini, L., 2001. Permian brachiopods from Karakorum (Pakistan) part. III. Rivista Italiana de Paleontologia e Stratigrafia 107(3), 307-344.

Late Wordian (Guadalupian) brachiopods from Member 2 of the Panjshah Formation in the Karakorum (N Pakistan) are described. The brachiopod assemblage, dated by the associated fusulinids and conodonts, consists of 29 genera (3 of which are questionable and 1 unidentifiable) of the orders Productida, Orthida, Rhynchonellida, Athyridida,

Spiriferida and Terebratulida. Hunzininae, a new subfamily of the Spiriferellidae is proposed; it includes Darbandia n. gen., with type species D. vagabunda n. sp. and Elivina chapursani n. sp. A third new species is assigned to the genus Anchorhynchia of the family Wellerellidae: A. cimmerica n. sp.
A quantitative biostratigraphic analysis demonstrates two major faunal changes in the Elivina chapursani- Chapursania tatianae Assemblage Zone of the upper part of Member 2, which are not strictly linked to lithological changes. This biozone is correlated with the brachiopod faunas of the Gnishik Formation of Armenia and those of the basal Takhtabulak Formation of SE Pamir.
The faunal elements of the Elivina chapursani- Chapursania tatianae Assemblage Zone are an admixture of wide-ranging, Tethyan (particularly abundant), Gondwanan and endemic (Cimmerian) genera, representing a transitional fauna and a biostratigraphic tool for intercontinental correlation, which are particularly problematic in this time interval. The Panjshah transitional fauna demonstrates the persistence of the Transhimalayan Province of the Cimmerian Region into the late Guadalupian, which originated at the end of the Cisuralian and occupied Armenia, Central Afghanistan, Karakorum and SE Pamir. It provides also some insights into the biodiversity pattern before the mass extinction at the end of the Guadalupian, and suggests that this event was as rapid as the end- Permian mass extinction, at least in Central Asia.
Key words: Permian, Brachiopods, biostratigraphy, Karakoram.

A/473. Angiolini, L., Brunton, H., Gaetani, M. & Andra, Z., 1997. The once and future quest: The carboniferous in Karakorum. Abstract volume, 12th Himalaya-Karakorum-Tibet International Workshop, Rome, Italy, 5.

The quest for the Carboniferous in the sedimentary cover of N Karakorum has been one of the main goals of the Italian expeditions from 1986-96. However, it takes us 10 years to discover and its relationships with the Permian and Devonian successions are still unclear. So the term quests and the adjectives once and future are really appropriate.
In the Upper Hunza Valley, and its side valleys, the sedimentary succession starts with the terrigenous Gircha Formation, which contains Lower Permian brachiopods in its middle part. No Carboniferous fossils have been found in this formation but its base is possibly Late Carboniferous.
Westward in the Upper Yarkhun Valley (Baroghil area), crinoidal limestones with shaly intercalations have been tentatively attributed to the Early Carboniferous (Gaetani et al., 1996), due to their stratigraphic position between the Late Devonian Shogram Formation and the Gircha Formation in the Baroghil Unit. But again no well-preserved fossils have been found to prove this age assignment.
The 1996 Italian expedition investigating the region from the Chapursan Valley (Upper Hunza Valley) to Chitral was finally successful in finding Carboniferous fossils near the Karambar Pass and in the Showar Shur area (Upper Yarkhun Valley).
The newly discovered fossiliferous Carboniferous succession belongs to a tectonic unit locate northward of the Baroghil Unit and stacked above it along a SW vergent thrust. Westward of the Karambar Pass, the Carboniferous succession is deformed by intensive folding and thrust stacking. Eastward, the Carboniferous succession passes to a monotonous sequence of black slates and arenites probably ranging up into the Permian. To the north, thus unit is tectonically bounded by the Tash Kupruk Unit. The base of the Carboniferous succession is still unclear: In the Showar Shur gulley it is truncated by a SW vergent thrust, whereas in the Karambar Pass area it is not exposed. However, west of the Karambar Pass, on the left (southern) side of the valley, a thick terrigenous succession, probably including the Carboniferous, overlies the Devonian Shogram Formation.
From the base to the top, the Carboniferous succession consists of at least 200 m of black marly limestones with thick intercalation of massive bioclastic limestones, passing upward to 100 m of black marly limestones, calcareous siltites, calcareous sandstones and hybrid limestone containing Late Carboniferous brachiopods such as Pustula sp., Rhipidomella sp., Choristites sp., Martiniopsis sp., Spirfer sp., Gypospirifer sp., and Composita sp. At the top, about 30-50 m of massive, cross bedded sandstones and conglomerates crop out, followed by 20-40 m of varicolored calcareous siltites, arenites and hybrid limestones containing Moscovian to Kasimovian brachiopods such as Densepustula Sp., Brachythyris sp., Rhipidomella sp., Septacamera dowhatensis, and Alispirfer middlemissi. This mixed sedimentary succession is topped by 30-100 m of massive bioclastic limestones containing crinoids and recrystallized brachiopods and corals. A very thick (500 m?) terrigenous unit follows, chiefly consisting of dark slates and fine arenites with coarse sandstones and conglomerates which may corresponds to the Gircha Formation of the Baroghil, Sost and Gujal Units. In fact on the path leading from Suinji to the Karambar Pass brachiopods similar to those of the lower Permian Gircha Formation (Trigonotreta sp., Spirelytha sp.) have been collected in the

scree. The Carboniferous brachiopods of N Karakorum are very similar to those collected in the Late Carboniferous of the Himalaya (Manang, Spiti, Tibet).
Key words: Carboniferous, Karakoram.

A/474. Angiolini, L., Brunton, H., & Zanchi, A., 1999. Late Carboniferous brachiopods from Karakorum, Pakistan. Rivista Italiana di Paleontologia e Stratigrafia, 105, 3-22.

Carboniferous rocks from North Karakorum display sharp lateral variations in lithology and thickness suggesting accumulation in half-grabens during continental rifting between the Karakorum block and northern Gondwana. Different Carboniferous successions, belonging to distinct tectonic units, have been detected. Thin, poorly fossiliferous successions of arenites and crinoidal limestones contrast with very thick terrigenous-carbonate successions comprising two distinct fossiliferous horizons. The lower fossiliferous horizon yielded brachiopods (Pustula sp., Rhipidomella sp., Choristites sp., Martiniopsis sp., Afghanospirifer sp., Gypospirifer sp., Composita sp.) of Bashkirian age. The upper fossiliferous horizon, lying about 90 m above the former, contains corals, crinoids and brachiopods (Densepustula cf. losarensis, Dowhatania sulcata n. sp., Brachythyris sp., Rhipidomella sp., Septacamera dowhatensis, Alispirifer middlemissi) of Moscovian to Kasimovian age. The Carboniferous brachiopods of North Karakorum are similar to those collected in the Late Carboniferous of Central Afghanistan, Himalaya (Manang, Spiti, Tibet), and Lhasa Block (Xainza area).
Key words: Carboniferous, Brachiopods, Karakoram.

A/475. Angiolini, L., Gaetani, M. & Nicora, A., 1993. The Permian succession of the Baroghil area (E Hindu Kush). Abstract Volume, 8th Himalaya-Karakoram-Tibet Workshop, Vienna, 57-58.

During the 1992 Pakistani-Italian expedition from Chitral to Karambar a complete Paleozoic succession was discovered and analyzed. In particular the Permian part of the succession is extensively exposed in the Baroghil-ShoWar Shur area. There was the great opportunity to visit the Baroghil section, which was studied by Hayden in 1914 and then only shortly visited by Talent and Tahirkheli in 1973. The area was then strictly closed because of the Afghan war.
Three stratigraphic sections for about 2000 in of development have been measured along the Permian part of the Paleozoic succession, with at least 250 samples collected.
The Lower Permian overlies Lower Carboniferous crinoidal packstones and it is represented by a quartzarenitic to litharenitic unit, at least 600 m-thick. This unit has been named Gircha Formation because of its correlatability with the Gircha Formation of the Hunza region.
Then a mixed carbonate-terrigenous succession, several hundreds m-thick follows, named Lashkargaz Fm. It consists of four members; the first, mostly terrigenous, contains Sakinarian conodonts (Adetogna thus paralautus) and brachiopods (Globiella cf. G. rossiae, Elivina tibetana, Spirigerella sp., cleiothyridina ailakensis) at the top. The second member consists of fusulinids packstones and limestones locally crowded with oncolites, corals and gastropods. The third member is only 40-50 m-thick and consists of siltites and arenites. The fourth member chiefly consists of limestones with chert rich in fusulinids, conodonts (Sweetognathus whitei, Gondolella bisselli, Gondolella Cf. G. idahoensis, G. intermedia, Anchignathodus sp., Iranognathus sp.), brachiopods (Costiferina sp., Marginif era sp.), corals and bryozoans. Marly lixnestones may be present. The age of the fourth member is Artinskian to Bolorian on the basis of conodonts.
At the top of the Lashkargaz Fin., above an erosional surface, the Gharil Fm. crops out. It consists of red microconglomerates and arenites with phosphate nodules. Then a huge peritidal dolomitic formation, 700 in-thick follows. In the lower and middle part of this formation Upper Permian small foraminifers (Daçtmarita chanackiensis, Paraglobivalvulina sp., Globivalvulina sp., Lanqella sp., Climacammina sp.) have been detected, whereas in the upper part foraminifers and algae are present and may suggest an Early Jurassic age. The Paleozoic succession is repeated at least three times within three thrust sheets, with slightly different fades in the Baroghil area. On the contrary we have poor informations about most of the Mesozoic.
In contrast to the Upper Hunza and Shimshal valleys (Karakoram), where deep-water sediments are present from the Midian upwards, in the upper Yarkhun-Karambar area the shallow water environments seems to persist throughout the Permian. Correlations may be inferred with the Helmand Block in Central Afghanistan.
Key words: Stratigraphy, Permian, Baroghal, Hindukush.

A/476. Angiolini, L., Gaetani, M., Olivini, G. & Zanchi, A., 2001. Geology and Stratigraphy of the Carboniferous of Western-Central Karakoram. Journal of Asian Earth Sciences 19, p.2.

Key words: Stratigraphy, carboniferous, Karakoram.

A/477. Angiolini, L. & Rettori, R., 1995. Chitralina undulata gen. n. sp. n. (foraminferida) from the Late Permian of Karakorum (Pakistan). Rivista Italiana de Paleontologia e Stratigrafia 100, 477-492.

Chitralina undulata gen. n. sp. n. (Foraminiferida) has been found for the first time in the Permian successions of Karakorum (Pakistan). Biostratigraphic analysis based on fusulinids, brachiopods, conodonts and small foraminifers pointed out that Chitralina undulata gen. n. sp. n. occurs from the Kubergandian to the Late Murgabian-Midian. Morphologically, Chitralina undulata gen. n. sp. n., is comparable to Rectostipulina quadrata Jenny-Deshusses, 1985, differing from it by means of the thickness and composition of the test and for the presence of marked longitudinal costae. The stratigraphic range of Rectostipulina quadrata spans the Midian-Dorashamian time-interval. The new genus Chitralina is a very similar to the Permian genus Giraliarella Crespin, differing from it by means of the absence of transverse growth constrictions. The new family Chitralinidae fam. n., is also described herein.
Key words: Palaeontology, biostratigraphy, Permian, Chitral, Karakoram.

A/478. Anjum, K.M., 1981-83. Lithostructural mapping of Mansehra Susal and Matial Area District Mansehra, with special reference to structural studies. M.Sc. Thesis, Punjab University, Lahore, 109p.

Lithostructural mapping with preliminary structural studies have been made of Mansehra, Khaki, Rihar area district Mansehra at a scale, of 1:1000. An attempt has been made to delineate the boundaries of igneous and metamorphic rocks precisely. Physiographic/Stratigraphic studies and various structural contour diagrams have been drawn to determine axis of minor folds. Orientation of joints has been determined with the help of Rose diagram. Thin sections have been studied to determine different phases of deformation. Attempt has been made to analyse the strain with Flinn's and Ram say's plots.
On the basis of microscopic and mesoscopic analysis it has been tried to interpret the structure and macroscopic scale. On the basis of Kinematic Studies, structure of the area is interpreted.
Key words: Structure, lithostratigraphy, Mansehra.

A/479. Anton, B., 1964. The pink pearls of Pakistan. Gems and Gemology 11, 175-179 & 191. Thirteen photos.

Key words: Pearls, Gems.

A/480. Antonio, G., 1991. Stratigraphy, Metamorphism and Tectonic of the Hazara-Kashmir Syntaxis Area. Kashmir Journal of Geology 8 & 9, 39-65.

The stratigraphical and metamorphic features of the rocks belonging to the Hazara-Kashmir Syntaxis are described. A large-scale subdivision of the area in the classical Sub, Lesser and Higher Himalayan tectonic elements is proposed. A model for the tectonic evolution of the area, based on a coherent and continuous development of the observed small-and large-scale structural and metamorphic features, is suggested.
Key words: Stratigraphy, metamorphism, tectonic, Hazara.

A/481. Anwar, I., 1964. Soapstone deposits of Sherwan, District Hazara. Pakistan Journal of Scientific and Industrial Research 2(3), 19-24.

Key words: Soapstone, economic geology, Sherwan, Abbottabad.

A/482. Anwar, J., Khan, R.D. & Mehdi, S.S., 1977. Geological report on Chromite deposits, Malakand division, N.W.F.P: Internal report of Pakistan Mineral Development Corporation, 86p.

This report describes the geological investigations which indicate that chromite is occurring as disseminated, massive, layered and nodular ore in the rocks of Dargai Ultramafic Complex. The complex is constituted by dunite, harzburgite, peridotite, serpentinite and gabbro. Significant and economically important occurrences of chromite are restricted to dunite bodies in the form of intermittent layers. The layers are generally concordant to sub-horizontal and vertical layering in the host rocks. Chromite is graded as low to medium quality refractory ore containing 7.8% to 41.4% Cr203; 10.0% to 32.17% FeO, 4.2% to 31.2% &03 and 6.2% to 33.6% SiO2. Traces of Nickle and Cobalt have been confirmed in the chromite ore samples. Since these elements and other trace elements like Platinum etc. are usually associated with ultramafic rocks, therefore, there is a possibility of finding these minerals in Dargai Ultramafic Complex. Other minerals like asbestos in ultramafic rocks and quartz in schistose group are also present in the area and could be considered for exploitation. A total tonnage of all grade chromite ore has been estimated to be 580,098 tonnes which includes 290,548 tonnes of probable and 289,550 tonnes of possible reserves.
Key words: Chromite, economic geology, Malakand.

A/483. Anwar, M., 1962-63. Geology of Rawalpindi Area, Hazara (Baghpur). M.Sc. Thesis, Punjab University, Lahore.

Key words: Geology, Rawalpindi, Hazara.

A/484. Anwar, M., 1976. Thesis on Lithostructural mapping and geology of Chalt Hini area, Hunza valley (Gilgit Agency) with special emphasis on the tectonics. M.Sc. Thesis, Punjab University, Lahore, 150p.

Key words: Lithology, Structure, Chalt, Hunza.

A/485. Anwar, M., 2000. Mineral statistics of Pakistan. GSP, Special Issue, 42p.

Key words: Mineral deposits, statistics.

A/486. Anwar, M., Beech, M. & Dennellel, R., 1992. Preliminary study of carnivore accumulation in the Upper Siwalik of the Pabbi Hills, Punjab, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.51.

The fossil specimens for this study come from a locality (362) in the Soan Formation in the Pabbi Hills, situated about 4 km southwest of the village Sohawa and 10 km west of Kharian, District Gujrat. The formation consists of varicoloured sandstone, silts and minor beds of conglomerate. The age of the formation ranges from 2.5 MaBP to about 1 MaBP, but the locality's age is thought to be about 1.6 MaBP. Preliminary study of the fossils recovered through surface collection and excavation of the site indicates the presence of Accipitridae, Hyaenidae, Giraffidae, Proboscidae, bidae, Rhinocerotidae and perhaps Suidae at the locality. Seventeen axial elements including six skull fragments, thirty-eight appendicular elements, and fifty five indeterminate fossil fragments constitute the surface collection while the excavated bone accumulation is represented by seventy three axial elements including six skull fragments and five teeth, seventy two appendicular elements, and thirty three indeterminate fragments. Comparison of the surface and excavated specimens indicates that surface assemblage gives a reasonable indication of the wealth of a fossil site but the surface collection is unlikely to show the full faunal variety. Several taphonomic features of the assemblage recovered from the locality suggest a biological mode of selection with negligible influence of fluvial transportation and sorting. Such features that favour the biological accumulation are the presence of punctures and striations on a few herbivore specimens, larger number of individuals but only of six to eight families, domination of limb bones over other skeletal elements, and the presence of several skeletal parts of hyaena in the

mblage. The Influence of fluvial sorting was minimal' as the mblage contains a few articulated/semi-articulated very delicate skeletal elements (e.g. Ospenis), co-occurrence of denser and lighter bones and the virtual absence of any polished/rounded bones in the assemblage. All these features are Indicative of the assemblage being accumulated in a carnivore den, probably the Crocuta den whose remains are embedded along with the hunted bones due to sudden collapse of the den.
Key words: Paleontology, fossils, Soan Formation, Siwalik Molasse.

A/487. Anwar, M., Fatmi, A.N. & Hyderi, I.H., 1992. Revised nomenclature and stratigraphy of Musakhel and Baroch Groups, Surghar Range, Pakistan. Pakistan Journal of Geology 1, 15-28.

Key words: Stratigraphy, Musakhel, Surghar Range.

A/488. Anwar, M.S., Kazmi, K.R., Gohar, R.A. & Sheikh, N., 1992. Processing of Besham lead-zinc ore for the production of lead-zinc based chemicals. Pakistan Journal of Scientific and Industrial Research 35(1-2), 58-00.

Lead and zinc concentrates from Besham lead-zinc ore were produced by forth flotation method. A number of alternative frother/collectors and depressant were tested and flotation parameter including pH, conditioning time, frother/collector concentration and pulp density were optimized. A series of flotation test were carried out on bench scale as well as on pilot plant scale to produce the lead and zinc concentrates. The grade of each one of the concentrated was about 50% metal content. These concentrates were used as a raw material to produce lead and zinc based chemicals.
Key words: Mineral resources, lead-zinc, ore-processing, Besham.

A/489. Anwar, S. & Khan, N.R., 1997. Aspects of mud logging and well site geology with special reference to Chanda Oil Well, Potwar Plateau, N.W.F.P. M.Sc. Thesis, University of Peshawar, 120p.

Key words: Mud-logging, hydrocarbon, Chanda, Potwar.

A/490. Appel, E., Schill, E., Gautarn, P., Zeh, O., Singh, V.K. & Waldhdr, M., 1998. Block rotations along the India-Asia collision zone - Their significance on different scales detected by Magnetic Remanences. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 13-15.

The India-Eurasia collision has caused crustal deformations of enormous magnitude. Patzelt et al. (1996) presented direct palaeomagnetic evidence for a "Greater India" prior to collision (about 1500 km extent of the northern margin at 89oE, compared to the present outline). Palaeodeclinations (PD) were used to estimate the magnitude of rotational underthrusting (Klootwijk et al. 1985, Appel et al., 1991, Patzelt et al., 1996). Angles between expected and observed PDs allow the quantification of oroclinal bending. Fig. 1 shows the principle of restoring the former margin of the Indian Plate by incremental rotations. The expected PD is calculated from the apparent polar wander path assuming no relative movements at the northern margin of India. Observed PDs are brought into coincidence with the expected PD by stepwise rotations starting in the western syntaxis (pivot PI) and progressing to the east. In Fig. 1, this is demonstrated for the simple case of two segments. The extent of 'Greater 'India' is finally determined by a parallel displacement of both segments to the north until the palaeolatitude matches the result of Patzelt et al. (1996) at a longitude of 89oE.
The reconstruction is disturbed by local and mesoscale block rotations superposed on the regional movements. Data from NW Zanskar (Appel et al. 1995) demonstrate that systematic differences even occur within a few tens of kilometres. In the Pamir and along the Indus Yarlung suture zone (Otofuji et al. 1995) PDs are strongly dependent on major faults. In order to get a reliable data base for the incremental rotation model of Fig. 1, systematic palaeomagnetic sampling is conducted to recognise and to isolate block rotations on different scales. In a first step, about 140 sites have been sampled from the Tethyan Himalaya (TH) of Spiti (NW India), Larkya and Shiar areas

(Central Nepal). The TH rarely contains primary remanences, but is well known to record a stable secondary components carried by pyrrhotite. The remanence acquisition of pyrrhotite can be related to exhumation and cooling of the Central Crystalline and represents a thermoremanence with blocking temperatures around 300ºC.
A nearly one-component behaviour (pyrrhotite only) is observed in the Larkya area. A systematic local scatter appears with a mean in situ remanence of Larkya area, D=010, I=54 (12 sites, k=9.5, α95=13.6). In the Shiar area, the pyrrhotite to magnetite ratio is decreasing towards the east. As a preliminary result from 4 sites, the pyrrhotite component yields an in situ direction of D=205, 1=-12 (k=82.6, α95=82.6). In Spiti, magnetite dominates the magnetic remanence. The varying content of pyrrhotite can be related to a different grade of metamorphism. The magnetite component carries a syntectonic remanence direction (k=14.4, 26 sites, Lower Pin Valley), whereas for the pyrrhotite component of the Upper Pin Valley a consistent in situ remanence direction of D=006 l=32 (12 sites, k=16.9, α95=10) is obtained. In Fig. 2, the rotations in respect to 'stable' India are shown together with earlier results.
In our further study, several other areas will be sampled, and rotations on different scales will be analysed quantitatively to evaluate a more sophisticated model of oroclinal bending and rotational underthrusting.
Key words: Palaeomagnetism, crustal deformation, plate movement, tectonics, India-Asia.

A/491. Arbab, M.S.H., 1967. Geology of parts of Balakot and Dadar areas. M.Sc. Thesis, Punjab University, 81p.

Key words: Geology, Balakot, Dadar, Mansehra.

A/492. Arbab, M.S.H., 1970. Some rocks and mineral showings of the Mohmand Agency. Proceedings National Seminar on Mineral Development. 20-23rd April 1970, Lahore, Abstract, 4p.

Key words: Minerals, Mohmand Agency.

A/493. Arbab, M.S.H., 1972a. Emerald of the Mohmand, Agency. Proceedings National Science Conference, Peshawar, 4p.

Key words: Emerald, Mohmand Agency.

A/494. Arbab, M.S.H., 1972b. A note on the emerald of Mohmand Agency (N.W.F.P). Geological Survey of Pakistan, Geonews II, No. 2, 56-58.

Key words: Emerald, Mohmand Agency.

A/495. Arbab, M.S.H., 1973. A discovery of topaz in Katlang, Mardan. Scientific Society of Pakistan Annual Science Conference (in Urdu), Lahore, 3p.

The reported discovery of Topaz in village Katlang, Mardan district found its way to news media and hence drew a large scale attention from different quarters. The present report is the result of a very short visit to the site for the purpose of collecting first hand preliminary information regarding the deposit. Topaz is found in a small solitary hillock, locally known as Ghundao, about 3 miles from Katlang on the eastern side of the Katlang.
Key words: Topaz, Katlang, Mardan.

A/496. Arbab, M.S.H., 1984. Monitoring use behavior of the land resources of the Peshawar Basin with the help of the landsat data. Seminar on Remote Sensing Application for Land Resources Management. 19-22nd November. 1984. Kuala Lumpur, Malaysia, ESCAP/ MARD/ BANGKOK, Appendix XX, 145-152.

Key words: Land Resources, remote sensing, Peshawar Basin.

A/497. Arbab, M.S.H., 1987. A short note on the Bagrian Pegmatite, Mansehra district, NWFP, Pakistan. Geological Survey of Pakistan Information Release 308, 8p.

Key words: Pegmatite, Bagrian, Mansehra.

A/498. Arbab, M.S.H., 1988. Reporting of the occurrences of Sinoroldic and Columbite in Begrian pegmatite, Mansehra. Geological Survey of Pakistan Information Release 308a.

Key words: Pegmatite, Begrian, Mansehra.

A/499. Arbab, M.S.H., (Ed.), 2000. Geological Map of Chitral district, NWFP, Pakistan. Geological Survey of Pakistan, District Map Series, NWFP. Map No. 1.

Key words: Geological map, Chitral.

A/500. Arbab, M.S.H. & Khan, R.N., 1972. Geology of Dir and Northern part of Timurgara quadrangle, North West Frontier Province, Pakistan. Geological Survey of Pakistan, Information Release 49, 36p.

Key words: Geology, Dir, Timurgara.

A/501. Arbab, M.S.H., & Khan, R.N., 1973. Ruby Corundum in Timurgara, District Dir, NWFP, Pakistan. Geological Survey of Pakistan, Information Release 56, 5p.

During the course of regional mapping of Timurgara and Dir quadrangles, the corundum bearing rocks of Timurgara were briefly examined. The general rock type of this area is amphibolite intruded at random by igneous rocks of granodiorite, diorite and ultramafic (Peridotite, serpentinite and hornblendite) nature. Quartz veins and aplite and pegmatite dykes are also common. Sparsely dispersed corundum crystals are found in amphibolite rock south-east of Timurgara (34 49 lat. 71 53 long). The corundum is opaque and fractured and hence cannot be used as a gemstone. The crystals moreover, are much too few and thus the possibility of its use as an abrasive is also ruled out.
Key words: Ruby, Corundum, Timurgara, Dir.

A/502. Arbab, M.S.H. & Qureshi, I.H., 1972. Topaz mineralization in Ghundo hillock, Katlang village, Mardan District, North West Frontier Province, Pakistan. Geological Survey of Pakistan, Information Release 50, 4p.

The reported discovery of Topaz in village Katlang, Mardan district found its way to news media and hence drew a large scale attention from different quarters. The present report is the result of a very short visit to the site for the purpose of collecting first hand preliminary information regarding the deposit.
Topaz is found in a small solitary hillock, locally known as Ghundao, about 3 miles from Katlang on the eastern side of the Katlang.
Key words: Gemstones, Topaz, Katlang, Mardan.

A/503. Arbab, M.S.H. & Shah, M.R., 1995. Geological map of Kohat ((38 O/7). Geological Survey of Pakistan.

Key words: Geological map, Kohat

A/504. Arbab, M.S.H. & Shah, S.H., 1996. Geological Map of Azad Jammu and Kashmir. (Scale 1:500,000). Geological Survey of Pakistan, Geological Map Series.

Key words: Mapping, Azad Jammu Kashmir.

A/505. Arbab, M.S.H. & Shah, S.H., 1997. Mineral Map of Azad Jammu and Kashmir (Scale 1:500,000). Geological Survey of Pakistan, Mineral Map Series.

This map shows the localities of all minerals of economic interest reported in Azad Jammu and Kashmir.
Key words: Minerals, mapping, Azad Jammu Kashmir.

A/506. Arbab, M.S.H. & Siddiqi, R.A., 1972. Reconnaissance geology of the southern half of the Mohmand Agency and Tangi area of Peshawar District, N.W.F.P., Pakistan. Geological Survey of Pakistan, Information Release 47, 16p.

Key words: Reconnaissance geology, Mohmand Agency, Tangi, Peshawar.

A/507. Arbaret, L., Burg, J.P., Chaudhry, M.N., Dawood, H., Hussain, S.S. & Zeilinger, G., 1998. Different sets of anastomosing shear zones in the "Kamila Belt", Kohistan. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 15-17.

The Kohistan Complex (NW Pakistan) is squeezed between the Indian and Asian continental plates [1]. Among the different units identified in the Kohistan Complex, the Kamila amphibolitic belt separates the Chilas calc-alkaline gabbronoritic complex to the north from the deeper ultramafic Jijal Complex to the south [2]. The southern part of the "Kamila Belt" is mainly composed of retrograde metagabbro and norite with locally preserved igneous layering intruded by hornblendite bodies and plagioclase-quartz±amphibole rich veins. The latter comprise synmagmatic differentiation veins that display the same mineralogical components as the bulk rock. The metagabbro and norite are deformed by numerous anastomosing shear zones with variable spacing and size [2]. In this poster we describe three sets recognized during fieldwork:
Set 1 is composed of conjugate; centimetre scale discontinuous shear zones (Fig. 1) that curve the homogeneous foliation and layering without important change in grain size. The conjugate directions are both striking 130º. One plunges 40º±10º to the NE and corresponds to southwestward thrusts. Conjugate shear zones plunge 20º±10º to the SW and lay along Riedel orientations consistent with a general southwestward sense of shear along a bulk plane dipping 40º to the NE. Limited grain size reduction and measurements of the curved foliations indicate shear strain $\gamma<5$.
Set 2 is characterised by an anastomosing pattern of mylonitic shear zones (Fig. 2) with an average thickness of 10 cm and a marked grain size reduction. They result from the lengthwise connection of set I shear zones, the conjugate directions wrapping around lenses of less deformed gabbro. These centimetres to decametre big lenses have an average shape ratio of 2.5 with their long axis plunging to the Northeast. Set 1 shear zones may occur within the lenses. The anastomosing shear zones contain leucocratic, garnet-bearing veins due to partial melting of the mylonites which, therefore, are high temperature shear zones. The anastomosing shear zones occur also in the northeastern part of the garnet granulites of the Jijal Complex (Southwest of Patan). Grain size reduction points to shear strain higher than 5 within these shear zones.
Set 3 corresponds to 10 cm up to 5 m thick shear zones which are continuous and undulate with large wavelength over 50 m (Fig. 3). Shear took place along horizontal to 30º Northeast dipping planes striking 130º. Strong grain size reduction and presence of centimetre size rotated porphyroclasts of plagioclase derived from stretched pegmatitic veins indicate shear strain of more than 10.
Intersections observed in the field show that these 3 sets were formed successively. Nucleation and growth of set 1 and set 2 shear zones along the same conjugate directions are interpreted as progressive localisation of shear deformation at various scales during southwestward thrusting. Relationships between veins and shear zones indicate

that deformation began during the waning magmatic stage of the gabbronoritic body. Set 3 shear zones occurred later and are post-dated by east-west striking, c.45º north dipping amphibolitic sheared rocks located in the Northeast part the study area [3]. They represent the ductile continuous shearing developed during the upper to lower amphibolitic facies retrogression.

Key words: Shear zone, Kamila, Kohistan.

A/508. Arbaret, L., Burg, J.P., Chaudhry, M.N., Dawood, H., Hussain, S.S., & Zeilinger, G., 1998. Different sets of anastomosing shear zones in the Kamila Belt, Kohistan. In: Khan, M.A., Treloar, P.J., Searle, M.P. and Jan, M.Q. (Eds.). Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya. Geological Society London, Special Publication No. 170, 15–17.

Consult the preceding account for further details.

Key words: Shear zone, Kamila, Kohistan.

A/509. Arbaret, L., Burg, J.P., Zeilinger, G., Chaudhry, M.N., Hussain, S.S. & Dawood, H., 1999. Pre-collisional deformation in the Kohistan complex (NW Pakistan). Terra Nostra 99, Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 5.

The Kohistan Complex (NW Pakistan) is a paleo-island arc obducted onto India after closure of the Tethyan Ocean at ca 55 Ma (Coward *et* at., 1986). The plutonic rocks of the lower southern part of the Kohistan Complex are comprised of calc-alkaline meta-gabbro, hornblende-gabbro and diorite laccoliths that were emplaced during the arc activity (Khan et at., 1993). In the Patan area, the coarse grained Sarangar gabbro lies to the north of, and above the deeper granulitic gabbro laccolith commonly attributed to the upper part of the Jijal Complex (Figure 1). The Sarangar gabbro is intruded, to the north, by homblende-gabbro and diorite laccoliths. We describe the structures and textures related to primary composite strain overprinted by anastomosing shear zones due to sub-horizontal continuous SW-ward shearing from sub-solidus to amphibolite facies conditions. The deformation history is dated between 101 and 83 Ma, which is, therefore, older than the arc collision.

Two anisotropy intensities of the regional strain, defined by heterogeneously distributed foliations with associated mineral lineations, were recognized. The weak one (<20%) is recorded in the core of both the granulitic and the Sarangar gabbros. In the granulitic gabbro, it is associated with NW-dipping foliations bearing a NW-plunging lineation. In the Sarangar gabbro it is associated with an E-W trending sub-vertical foliations bearing a W-plunging lineation. These fabrics correspond to the shape preferred orientation if the magmatic assemblages characterized by cumulate textures. Their difference in orientation reflects differences of magmatic flow in separate plutons.

The higher anisotropy intensities (> 20%) progressively replaces towards the laccolith boundaries the low intensity magmatic fabric by plastic deformation of plagioclase and rigid rotation of pyroxene and other mineral phases. Local S-C structures and the angular relationship between the mineral fabric and magmatic layering indicate a bulk SW-ward shear recorded in the crystallised margins of the plutons. Therefore, these low and high anisotropy fabrics are related to the magmatic emplacement of the gabbros dated between 96 and 101 Ma (Anczkiewicz and Vance, 1997).

Further shear strain localization is responsible for three successive sets of shear zones that formed in a continuum from magmatic emplacement to solid state deformation during cooling of the plutons. Set 1 is composed of two populations of discrete, 1 m long and a few centimetres wide shear zones forming a Riedel association. One consists of normal SW-ward shear zones, which represent Riedel shears R. The second is composed of NE-dipping thrust P shear zones. Stable magmatic parageneses in the most deformed centre zones, cut by millimetre-thick feldspar-rich magmatic joints, point to sub-solidus conditions.

Set 2 is the most spectacular anastomosing pattern of mylonitic, N-dipping, SW-verging reverse shear zones branching into horizontal to W-dipping, SW-verging normal shear zones. The change in attitude accommodates the asymmetric shape at all scales of rock lenses whose their long axes plunge to the Northeast. The asymmetric shape and the strongly dominant SW-vergence indicate that set 2 shear zones developed during distributed, non-coaxial deformation. Partial melting in set 2 mylonites generated quartz-plagioclase-garnet bearing segregation veins pointing to temperatures exceeding 650°C under pressures of >0.8 GPa. The minimum age for set 2 shear zones is inferred from the 87 Ma old amphibole-epidote-paragonite assemblage that has partially overprinted the granulitic assemblage in the granulitic gabbro (Treloar et at., 1990).

The lower amphibolite facies set 3 shear zones ate differentiated by larger strain recorded in the thicket mylonitic zones and widening of the spacing between shear zones during cooling.
These three sets formed by growth and coalescence of set 1 shear zones leading to set 2 shear zones, which in turn have evolved into set 3 shear zones.
Laccoliths forming the lowest part of the Kohistan Complex have recorded the dynamic evolution during their magmatic emplacement from sub-solidus to solid state deformation. Regionally distributed magmatic-related fabrics and subsequent sets of anastomosing shear zones occurred successively between 101 and 83 Ma during SW-ward shearing, probably imposed by subduction of the Tethys lithosphere below the Kohistan arc Complex because the collision, around 55 Ma, is significantly younger.
Key words: Deformation, Kohistan complex.

A/510. Arbaret, L., Burg, J.P., Zeilinger, G., Chaudhry, M.N., Hussain, S.S. & Dawood, H., 2000. Pre-collisional anastomosing shear zones in the Kohistan arc, NW Pakistan. In: Khan, M.A., Treloar, P.J., Searle, M.P. & Jan, M.Q. (Eds.), Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya. Geological Society, London, Special Publication 170, 295-311.

Ductile strain localization commonly forms a pattern of shear zones anastomosing around lenses of less deformed rock. Initiation and development of anastomosing shear zones are studied through description of the structures and deformation history of plutonic rocks that from the lower crust of the Kohistan arc. Structures and textures developed in these rocks result from primary magmatic to solid-state regional strain, overprinted by anastomosing shear zones. The primary strain was mainly acquired during magmatic emplacement at 100-90 Ma. Strain localization took place continuously from magmatic emplacement to solid-state deformation cooling of the plutons and formed their successive sets of shear zones. Set 1 is composed of associated discrete Riedel and thrust shear zones developed above solidus conditions during southwestward thrusting. Continuous deformation from solidus to amphibolite facies conditions between 100 and 83 Ma formed the second set of shear zones. The lower amphibolite facies set 3 shear zones are differentiated by larger strains recorded in the thicker mylonitic zones and enlargement of the spacing probably represents arc-related deformation during subduction of the Tethys oceanic lithosphere below the Kohistan arc.
Key words: Shear zone, Kohistan arc.

A/511. Arcangeli, A., 1934. Isopodi terrestri raccolti nel Karakorum dalla Spedizione di S.A.R. il Duca di Spoleto. Ann. Reg. 1st Sup. Agrario di Milano 1, 1-23, Parma.

Key words: Terrestrial isopods, Karakoram.

A/512. Argles, T., Edwards, M. & Foster, G., 1999. Structural and metamorphic constraints on the evolution of the Main Mantle Thrust, eastern margin of the Nanga Parbat-Haramosh Massif, N. Pakistan. Terra Nostra 99 Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 6-7.

Organic research is increasingly concerned with the early stages of mountain-building, as well as the pre-collisional configuration of orogenic regions. Recent advances in geochemical, particularly isotopic, techniques have allowed together constraints to be placed on orogenic processes, and at the same time techniques have become more discriminating. Theoretically this could result in the determination of more detailed orogenic histories. To complement these geochemical methods, however, similarly detailed and rigorous fieldwork is required.
Investigations on the evolution of the Nanga Parbat Haramosh Massif (NPHM) provide a case in point. While isotopic studies emphasized the rapid recent exhumation of the massif (e.g. Zeitler et al. 1982, 1993) other studies (e.g. Wheeler et al. 1995) recognized the importance of the polymetamorphic nature of the Indian plate rocks in particular. Neogene events in the NPHM have obscured much of its earlier evolution, but the degree of overprinting varies within the massif Structural and metamorphic overprinting are not always concentrated in the same parts of the massif, and the different properties of basement and cover rocks results in both strain partitioning and various degrees of metamorphic reworking. The western margin is dominated by Neogene processes (e.g. the Liachar thrust, Butler and Prior 1988), whereas the eastern margin preserves many earlier Himalayan structures. Structural mapping

of the eastern margin reveals a ductile contact zone preserving many features of the original Main Mantle Thrust (MMT) which emplaced the Ladakh Island Arc (LIA) over the Indian margin in the late Cretaceous. The sequence of ductile deformation was controlled both by the contrasting rheologies of the LIA and the MMT footwall, and the changing thermal regime during subduction, collision and burial, which may have included dissipative shear heating. Preliminary P-T estimates indicate conditions during southward thrusting on the MMT of Ca. 650°C and 9.5 kbar; this thermobarometry is directly correlated with MMT thrust fabrics showing top-to-the-south shear sense (after unfolding of the syntaxial antiform).

An episode of later deformation (post-dating garnet growth) in some cover units took place at Ca. 500°C and 7.4 kbar. These estimates are from rheologically weak, staurolite-grade metasediments just west of the MMT mylonites on the eastern margin. The kinematics cf these rocks are complex, with conflicting shear senses in adjacent layers. We interpret this as indicating partial overprinting of the metamorphic assemblages (and modification of the tectonic fabrics) during an episode of extensional (N-directed) shear in the footwall of the MMT. The extensional strain was partitioned into this narrow zone due to the comparative strength of adjacent units (overlying mafic MMT mylonites and underlying coarse orthogneiss, or basement paragneiss). No direct dating of this event has yet been attempted, but if there was significant exhumation of the region at this time, it could correspond to a period of cooling at around 25-16 Ma previously recognized in N. Pakistan (Treloar et al., 1989; Chamberlain et al,. 1991).

The concordant fabrics and lithological boundaries on either side of the contact are only disrupted by a NW vergent, brittle thrust south of the village of Subsar (Indus Gorge) which cross-cuts the steepened MMT zone. This thrust appears to be related to the neotectonic Raikhot fault on the western margin of the massif and is interpreted as an expression of the regional tectonics at the western termination of the Himalayan arc (Seeber and Pêcher 1998). This late thrusting followed formation ci the syntaxial antiform in Neogene times, and is the sole major evidence for Neotectonic activity on this segment of the eastern margin.

Key words: Evolution, structure, metamorphism, MMT, Nanga Parbat-Haramosh.

A/513. Argles, T., Edwards, M. & Foster, G., 2000. Synconvergent, Ductile N-Directed Shearing on the Western Margin of the Nanga Parbat Syntaxis, N. Pakistan. Abstract Volume, 15th Himalaya-Karakoram-Tibet Workshop, Chengdu (China), 128-129.

A key issue in orogenic research today is the recognition and explanation of normal faulting in the heart of collisional mountain belts. The active Himalayan system remains an ideal locality for studying this phenomenon, both as E-W synconvergent extension of the Tibetan plateau and normal motion on the South Tibetan Detachment System (STDS). However, these processes are difficult to correlate with the evolution of the northwest Himalaya, particularly the Nanga Parbat syntaxis where a Neogene tectono-thermal overprint partially obscures the early collisional history. An integrated programme of structural mapping, petrography, thermobarometry and isotopic dating is presented that places important constraints on both the early and pre-Himalayan evolution of the syntaxis. These data include evidence for synconvergent, ductile extension predating syntaxis development, and improved isotopic correlation of the tectonic units with the familiar central Himalayan thrust sheets, building on the work of Whittington et al. (1999).

Recent studies have focused on the rapid exhumation of the Nanga Parbat-Haramosh Massif (NPHM) during the last 10 Ma and the related Neogene thermal effects dominating the core of the massif (e.g. Zeitler et al. 1982, 1983). However, the degree of both structural and metamorphic Neogene overprinting varies within the massif, becoming weaker away from the summit region. In addition, the considerable variation in rock-type outside the gneissic core results in both strain partitioning and various degrees of metamorphic reworking. Thus several workers (e.g. Wheeler et al. 1995) could reconstruct elements of the early and pre-Himalayan history from field relations and mineral assemblages virtually untouched by Neogene processes. The eastern margin of the massif, in contrast to the active western margin, has remained largely unchanged during the Neogene, except for essentially passive rotation on the limb of the major syntaxial antiform. The original, ductile Main Mantle Thrust (MMT), which emplaced the Ladakh Island Arc (LIA) over the Indian margin in the Late Cretaceous, is preserved in a steepened orientation. Dextral shear sense indicators in this steep fabric can be clearly related to southward thrusting on the MMT at peak metamorphic conditions during the early Himalayan stage (600~700oC and 900~1200 Mpa) once the N-S trending syntaxial antiform is unfolded.

Detailed structural mapping and petrography has revealed distinct horizons of sinistral shear in the first few kilometers of Indian Plate rocks below the MMT (i.e. the upper most MMT footwall). Localities characterized by sinistral shear are generally in rheologically weak lithologies (e.g. mica schist), but there are some localities where an unambiguous timing relationship between sinistral and dextral shear sense indicators exists. Sinistral shear

overprints dextral in all cases, most commonly in the form of discrete, mylonite, sinistral shear zones cross-cutting dextral shear fabrics. In some cases, these sinistral shear zones are associated with leucogranite material. The sinistral shearing post-dated prograde garnet growth but is characterized by ductile behaviour and microstructures indicating temperatures above 300oC. Thermobarometry on schists re-worked during this event suggest deformation occurred at 500~500oC and 600~900 Mpa. We interpret this deformational event as an episode of N-directed, extensional shear in the footwall of the MMT (prior to the syntaxial folding).
The amphibolite grade of deformation suggest (a) that this event occurred soon after the metamorphic peak before substantial cooling or decompression, and (b) that the extension ceased before the rocks entered the greenschist field. This suggests that exhumation during this event occurred at a deeper level than previously documented, mostly greenschist-grade extension in northern Pakistan (Burg et al., 1996; Vince and Treloar 1996). Dating of the extensional fabrics is fabrics is planned; at present the extensional event is bracketed by garnet growth (40-45 Ma, Foster et al. 1998) and Ar-Ar mica and hornblende cooling ages on the eastern margin (ranging from ca. 10~40 Ma, Zeitler and Chamberlain, 1991; Winslow, 1996; Whittington, 1997). Thus the extension could correlate with a period of cooling at around 25~16 Ma previously recognized in N Pakistan (Treloar et al., 1989; Chamberlain et al., 1991), tentatively related to orogen-wide extensional tectonics on the STDS; or it could have occurred at an earlier stage, and/or on a different fault, suggested in the recent model by Chemenda et al., (2000).
Key words: Structural geology, Nanga Parbat.

A/514. Argles, T.W., 2000. The evolution of the Main Mantle Thrust in the western syntaxis, Northern Pakistan. In: Khan, M.A., Treloar, P.J., Searle, M.P. & Jan, M.Q. (Eds.), Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya. Geological Society, London, Special Publication 170, 101-122.

Neogene events in the Nanga Parbat-Haramosh massif have obscured much of its earlier evolution. However, structural mapping of the eastern margin reveals a ductile contact zone preserving many features of the original Main Mantle Thrust that emplaced the Ladakh island arc over the Indian margin in the late Cretaceous. The sequence of ductile deformation was controlled both by contrasting rheologies of the Ladakh island arc and the Main Mantle Thrust footwall, and the changing thermal regimes during subduction, collision and burial. Preliminary P-T estimates indicate conditions during southward thrusting on the Main Mantle Thrust of c. 650 °C and 9.5 kbar, with later deformation (post-dating garnet growth) in some units at c. 500°C and 7.4 kbar. The concordant fabrics and lithological boundaries on either side of the contact are only d8isrupted by a NW-vergent, brittle thrust south of the village of Subsar (Indus gorge) which crosscuts the steepened Main Mantle Thrust Zone. This thrust is related to the neotectonic Liachar Thrust on the western margin of the massif, and is an expression of the regional tectonics at the western termination of the Himalayan arc. This late thrusting followed formation of the syntaxial antiform in Neogene times.
Key words: Structural geology, MMT.

A/515. Arif, A.H. & Khan, M.A., 1970. Groundwater investigations on the right bank of Kabul River, Peshawar Valley with emphasis on water logging problems. Bulletin 17, Water and Soil Investigation Department (WSID) Publication 84.

Key words: Ground water, Kabul River, Peshawar.

A/516. Arif, M., 1970-71. Thesis on geology and mineralogy of Swat Hornblende complex in the Charbagh-Khwazakhela Area, Swat. M.Sc. Thesis, Punjab University, Lahore, 91p.

The Charbagh –Khwazakhela area is dominant1y occupied by the Hornblendic complex, the composition of which ranges from peridotite to diorite. In the south amphibolite is exposed while the eastern side is prevai1ed by sedimentary and metamorphic rocks. This big complex runs to Kalam in the north, to Gilgit in the north-east and to Dir State in the west.
Key words: Geology, Charbagh, Swat.

A/517. Arif, M., 1985. Stratigraphy and chronology of vertebrate fossils localities in Mirpur area, Azad Kashmir. Geological Survey of Pakistan, Information Release 264.

Key words: Stratigraphy, vertebrate paleontology, Mirpur, Azad Kashmir.

A/518. Arif, M., 1987. Fauna and age of a vertebrate fossils locality a near Mirpur, Azad Kashmir. Geological survey of Pakistan, Information Release 323.

Key words: Vertebrate paleontology, Mirpur, Azad Kashmir.

A/519. Arif, M., 1990. Mineral chemistry of the chromite occurrences from Shangla (Swat), N.W.F.P. and Bela, Baluchistan. M.Phil. Thesis, University of Peshawar, 166p.

The partly to wholly serpentinized ultramafic rocks of the Shangla and Bela areas contain disseminated grains and massive bodies of segregated chromite. Field, petrographic, and chemical characteristics of the segregated chromite from both the areas resemble those of podiform chromite deposits. Compared to accessory, the segregated chromites generally contain higher amounts of Cr, Mg, and lower Fe, Al and Mn. Composition also varies amongst as well as within individual grains. Such variations are much more pronounced in the accessory chromite due probably to a greater degree of re-equilibration with the associated silicates. The within-grain variation is more frequent and drastic in the Shangla chromite and mostly involves enrichment in Fe, (Mn and Ti), and depletion in Al, Mg, and Cr, leading to the development of ferritchromite and, rarely, magnetite along fractures and margins of individual grains.
The composition of Bela olivine ranges from FO 89.0 to FO 91.2 in the silicate ultramafites. The very high 100 Mq/(Mg+Fe) ratios of mafic minerals (olivine: 99.7; clinopyroxene: 97.1-98.0: and orthopyroxene: 96.0-96.4) in chromitites reflect an Mg=Fe exchange between them and the associated chromite. The high to very high 100 Cr / (Cr+Al) ratios of their chromite group the Bela rocks with the alpine peridotites of arc-related petrogenesis.
The Shangla rocks display cumulus texture but contain abnormally magnesian olivine (FO 96.0-98.5). The 100Cr/(Cr +Al) ratios (56-86) of their chromite suggest a complex origin. These rocks may have formed under conditions transitional between those of arc and oceanic settings. The Shangla rocks underwent a low to ?medium-grade metamorphism as indicated by the development of talc and antigorite. This prograde metamorphic process probably also accompanied for the drastic chemical zoning of the Shangla chromite.
Key words: Ophiolite, chromite, Shangla, Swat.

A/520. Arif, M., 1994a. Studies of ultramafic rocks from the Swat valley ophiolite, northwestern Pakistan: Implication for the genesis of emerald and Ni-rich phases. Ph.D. thesis, Leicester University.

Key words: Ultramafic, ophiolite, emerald, Nickle mineralization, Swat.

A/521. Arif, M., 1994b. Occurrence of maucherite in Shangla (Swat), northwestern Pakistan. Geological Bulletin, University of Peshawar 27, 131-132.

Besides zoned grains of chrome spinel, the variably altered ultramafic rocks of the Swat valley ophiolite, northwestern Pakistan, contain trace amounts of highly reflectant phases. These are mostly sulphides. However, the finely disseminated, discrete grains in some of the completely serpentinized samples from the Barkotaki village in Shangla were found to be of arsenide. The chemical composition of this latter phase is rather simple and consist almost entirely of Ni (57.33 – 59.14 at. %) and As (39.11 – 41.04 at. %), with only traces of Fe (<0.06 – 0.33 at. %), Co (0.83 – 1.02 at &), and S (0.28 – 0.66 at %). The calculated metal (Ni + Fe + Co + Cu) to arsenic ratio ranges from 1.406 – 1.514 and corresponds to that of maucherite (Ni_3As_2), one of the three arsenides of nickel (i.e. niccolite, maucherite and orcelite or rammelsbergite).
Key words: Ophiolite, chemistry, Shangla, Swat.

A/522. Arif, M., 1996. Chemical characteristics of chrome spinel in the magnesite-rich rocks from Swat, northwestern Pakistan. Geological Bulletin, University of Peshawar 29, 9-15.

The magnesite-rich rocks (magnesite ± talc ± quartz ± fuchsite ± tourmaline ± chlorite), which locally host emerald mineralization, contain trace to accessory amounts of disseminated grains as well as nodular segregations of chrome spinel. The spinel displays unusually high Cr/(Cr+Al) and low Mg/(Mg+Fe^{2+}) ratios. A detailed investigation reveals that the present chemical characteristics of the chrome spinel are probably the result of modification related to the formation of the host rocks by a low-grade metamorphism in the presence of a CO2- bearing fluid.
Key words: Chrome spinel, magnesite, Swat.

A/523. Arif, M., 2000a. Petrology and mineralogy of the Ahingaro serpentinites, Kabal (Swat), NW Pakistan: Implications for their tectonic setting and timing of emplacement. Geological Bulletin, University of Peshawar 33, 29-38.

A small (-6 x 1 km), lens-shaped body predominantly consisting of ultramafic rocks, occurs at the Ahingaro Banda Kandao near Kabal, Swat. This body is enclosed within the Kamila amphibolites that constitute the basal part of the intraoceanic Kohistan island arc. The ultramafic rocks are highly fractured and almost completely serpentinized. They consist of abundant fine-grained serpentine, varying amounts of a variety of bastites after orthopyroxene, veins and stringers of magnetite, invariably altered disseminated grains of chrome spinel, trace amounts of relict clinopyroxene and traces of rather sparsely disseminated granules of sulphide (pentlandite). Some of the samples also contain thin veins of calcite.
The Ahingaro serpentinites display both pseudomorphic and non-pseudomorphic textures. The serpentine predominantly consists of the lizardite and chrysotile varieties, whereas the antigorite occurs rarely. The chrysotile is mostly distributed as veins. A detailed petrographic and mineralogical comparison with the serpentinized rocks of the Indus suture melange zone suggests that the Ahingaro serpentinites most probably represent the original Tethyan lithosphere that served as a substratum or platform for the construction of the KIA. These rocks were emplaced together with the enclosing amphibolites along the Kohistan fault during post-Early Oligocene.
Key words: Petrology, mineralogy, serpentinite, Swat.

A/524. Arif, M., 2000b. Zincian, manganiferous chrome spinel from the Swat valley ophiolite, NW Pakistan. Geological Bulletin, University of Peshawar 33, 103-110.

Metamorphosed basic volcanic rocks of the Swat valley ophiolite locally contain trace to accessory amounts of disseminated chrome spinel. The grains of chrome spinel are invariably altered along margins and fractures. They, therefore, consist of low reflectance (grey) cores patches that are bordered and traversed by highly reflectant (bright) zones. Compositionally. The cores are high-Cr. almost Mg-free chromites, containing unusually high amounts of Zn and Mn, and may thus be described as a solid solution of three end-member spinel compositions, i.e. chromite, gahnite and galaxite. The bright zones of alteration lack any notable amount of Zn or Mn and range from Cr-magnetite to magnetite. Compositional and textural relationships suggest that the markedly zincian and manganoan character of the spinel grains is the result of a hydrothermal activity that took place before the magnetite-forming alteration process. The Zn-, Mn-bearing hydrothermal fluids either reacted with the parental lava prior to or during its solidification or, alternatively, invaded the host rocks after their formation leading to the addition of Zn and Mn to, and concomitant removal of Mg from the already crsytallized magmatic chromite through dissolution-recrystallization.
Key words: Chrome-Spinel, ophiolites, Swat.

A/525. Arif, M., 2001. The Gujar Kili area, Swat, NW Pakistan: Nickeliferous phases in the emerald-hosting rocks. Abstracts, 4th Pakistan Geological Congress, Islamabad, 1-2.

The occurrence of three different types of mélanges, namely the blueschist mélange, the greenschist mélange and the ophiolitic mélange, mark the westward continuation of the Indus suture zone in northwestern Pakistan. The ophiolitic member of this group of mélanges occurs as blocks that are distributed within the metamorphosed sedimentary rocks of the northern margin of the Indo-Pakistan plate. In addition to typical ophiolitic lithologies, e.g.

mafic-ultramafic plutonic rocks, pillow lavas and pelagic sediments, the ophiolitic mélange contains carbonate (magnesite and, rather rarely, dolomite)-rich assemblages, which at places, such as the Mingora and Gujar Kili areas, host emerald deposits. Abundant quartz veins, which at places constitute stockworks, have traversed these rocks. Locally, their close spatial association with serpentinized ultramafic rocks suggests that the rocks under discussion might have formed from the latter through the process of carbonate-alteration. In addition to abundant magriesite and/ or dolomite, the emerald-hosting rocks of the Gujar Kili area contain talc or quartz as an essential mineral. Besides, chrome spinel (chromite, ferritchromite and/or Cr-magnetite) is a common accessory constituent of these rocks. Some of the rocks, especially those invaded by quartz veins, contain tourmaline and/or chlorite. Furthermore, some of the magnesite rich rocks of the Gujar Kill area contain highly reflectant opaque phases, which occur in the form of very fine-grained disseminations as well as veins. A detailed investigation through chemical analyses reveals that these phases are of two types, i.e. sulphide and sulpharsenide. The former category includes pentlandite, violarite, mackinawite, pyrrliotite and pyrite. Gersdorftite and, rarely, cobaltite are the two sulpharsenides that occur in the emerald-hosting magnesite-rich rocks of the Gujar Kili area. As they locally occur as veins that cut across the host magnesite-rich rocks, the formation of these phases clearly post-dates that of the latter. Some of these phases, e.g. gersdorffite, are reported to occur as inclusions in the Swat emeralds. This clearly suggests that the hydrothermal activity that resulted in emerald mineralization in Swat is also responsible for the formation of the investigated sulphides and supharsenides.
Key words: Ophiolite, sulphide and sulpharsenide, mineral chemistry, Gujar Killi, Swat.

A/526. Arif, M., Abbas, S.G. & Gingerich, P.D. 1997. First Paleocene-Eocene mammal from South Asia. Geological Survey of Pakistan, Records, 109, 76-77.

Key words: Vertebrate paleontology, mammal, Paleocene, Eocene.

A/527. Arif, M., Fallick, A.E. & Moon, C.J., 1996. The genesis of emeralds and their host rocks from Swat, northwestern Pakistan: a stable isotope investigation. Mineralium Deposita 31, 255-268.

Emerald deposits in Swat, northwestern Pakistan, occurring in talc-magnesite and quartz-magnesite assemblages, have been investigated through stable isotope studies. Isotopic analyses were performed on a total of seven emeralds, associated quartz (seven samples), fuchsite (three samples) and tourmaline (two samples) from the Mingora emerald mines. The oxygen isotopic composition of emeralds shows a strong enrichment in^{18}O and is remarkably uniform at + 15.6 ± 0.4permil (1sgr, n = 7). Each of the two components of water in emerald (channel and inclusion) has a different range of hydrogen isotopic composition: the channel waters being distinctly isotopically heavier (deltaD = –51 to –32permil SMOW) than the other inclusion waters (deltaD = –96 to –70permil SMOW). Similarly the oxygen isotopic compositions of tourmaline and fuchsite are relatively constant (delta ^{18}O = + 13 to + 14permil SMOW) and show enrichment in18O. The delta ^{18}O values of quartz, ranging from + 15.1 to + 19.1permil SMOW, are also high (+ 16.9 ± 1.4permil 1sgr, n = 7). The mean deltaD of channel waters measured from emerald (–42 ± 6.6permil SMOW) and that of fluid calculated from hydrous minerals deltaD calculated (–47 ± 7.1permil SMOW) are consistent with both metamorphic and magmatic origin. However, the close similarity between the measured deltaD values of the hydroxyl hydrogen in fuchsite (–74 to –6permil SMOW) and tourmaline (–84 and –69permil SMOW) with pegmatitic muscovite and tourmaline suggests that the mineralization was probably caused by modified (18O-enriched) hydrothermal solutions derived from an S-type granitic magma. The variation in the carbon and oxygen isotopic composition of magnesite, locally associated with emerald mineralization, is also very restricted (delta 13 sim –3.2 ± 0.7%, PDB; delta ^{18}O sim + 17.9 ± 1.27permil SMOW). On the basis of the isotopic composition of fluid (delta 13C ap –1.8 ± 0.7permil PDB;delta ^{18}O ap + 13.6 ± 1.2permil SMOW calculated for the 250-550 °C temperature), it is proposed that the Swat magnesites formed due to the carbonation of previously serpentinized ultramafic rocks by a CO2-bearing fluid of metamorphic origin.
Key words: Emerald, geochemistry, genesis, Swat.

A/528. Arif, M. & Hussain, S.T., 1992. Upper Siwalik vertebrate faunal correlation in sub-Himalayan. Abstracts, First South Asia Geological Congress, Islamabad, p.5.

The Upper Siwalik fluvial sedimentary history and paleontology of the Mangla-Samwal anticline (Azad Kashmir) have been studied, and faunal correlations are made with the Bhittani-Marwat Range in the west, Jammu Hills in the east and Pabbi Hills in the south. The rocks in this anticline are divided into the Samwal and Kakra Formations (ca. 3.4 to 1.1 Ma). The Samwal Formation was deposited by large and small river systems, whereas the conglomerates of the Kakra Formation were deposited as a result of the uplift of the Pir Panjal Range.
The study of vertebrate fossils indicates that the overall faunal composition in these areas is identical and they contain the characteristic Upper Siwalik fauna (e.g. Equus, Cervus, Hexaprotodon and Elephas). The faunal similarity also suggests that during the Plio-Pleistocene (the time for deposition of the Upper Siwaliks) these areas belonged to the same bio-province.
Key words: Vertebrate paleontology, Sub-Himalaya, Siwalik Molasse.

A/529. Arif, M. & Jan, M.Q., 1992a. Mineral chemistry of chromite and associated phases from Shangla, NW Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.5.

The partly to wholly serpentinized ultramafic rocks of the Shangla area, constituting the northern part of the Mingora ophiolitic melange, contain disseminated grains and massive bodies of segregated chromite. Field, textural, and chemical characteristics of the segregated chromite closely resemble those of podiform chromite deposits. The chemical composition of the chromite varies considerably from sample to sample with model proportion, from grain to grain within the domain of a thin section, and from core to margin within individual grains. In general, the segregated chromites are richer in Cr, Mg, but poorer in Fe, AJ and Mn than the accessory chromites. The inter- and intra-granular chemical variations are much more common and drastic in the case of accessory chromite due probably to a greater degree of subsolidus re-equilibration with the associated silicates. The intragranular variation, probably a result of alteration, mostly involves enrichment in Fe, (Mn and Ti), and depletion in AJ, Mg, and Cr, leading to the development of ferritchromit and, rarely, magnetite along fractures and margins of individual grains.
The Shangla rocks display cumulus texture but contain abnormally magnesian olivine (Fo96.G-98.5). The 100Cr/(Cr+A1) ratios of their chromite suggest a complex origin. These rocks may have formed under conditions transitional between those of arc and oceanic settings. The Shangla rocks underwent a low-to medium grade metamorphism as indicated by the development of talc and antigorite. This prograde metamorphic process probably also accounted for the drastic chemical zoning of the Shangla chromite.
Key words: Ophiolite, Chromite, Shangla, Swat.

A/530. Arif, M. & Jan, M.Q., 1992b. Mineralogy of the Indus Suture ophiolite and an investigation of the associated mineralizations in Swat, NW Pakistan. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, 4-5.

The Main Mantle Thrust (MMT), which signifies collision of the Indo-Pakistan plate with the Kohistan island arc in northwestern Pakistan, is marked by the occurrence of an assorted zone of rock sequences. These consist of blueschist, greenschist and ophiolitic mélanges and are well exposed and easily accessible in the region between Mingora town and Lilauni village of the Swat valley. The ophiolitic rocks in this area constitute a discontinuous belt of mafic-ultramafic and metasedimentary units which occur as thrust sheets and lenses incorporated within the continental metasediments of the Indo-Pakistan plate. The mafic and ultramafic rocks include bodies of peridotite, metamorphosed gabbros, greenstone, metabasalt and pillow lavas. The metasedimentary rocks, comprising both calcareous and siliceous varieties, are interbedded with lavas. The quartz-rich metasediments are locally manganiferous.
The varying degree of alteration of the ultramafic rocks has, at places, given rise to a zonal pattern consisting of a core of least altered dunite and peridotite surrounded by a broad and extensively developed zone of partly to wholly serpentinized rocks followed by a locally developed peripheral shell of talc-magnesite lithologies. Besides hosting uneconomically small, lenticular bodies of chromitite and containing disseminated grains of chrome spinel, the relatively fresh and the partly serpentinized rocks of the central and middle zones contain tiny grains of heazlewoodite, millerite and, rarely, relict pentlandite. The mineralization of Ni in the wholly serpentinized rocks is mostly in the in the form of an arsenid, maucherite. In contrast, the non-oxide opaque mineralization in the talc-magnesite rocks include more Fe-rich sulphide phases such as phases such as pentlandite, pyrrhotite, violarite and

secondary Ni-pyrite. Locally, the talc-magnesite rocks also contain tiny grains of gersdorffite and host emerald deposits which are being mined, notably near the Mingora town.
The non-carbonatized ultramafic rocks, apparently 'residual' peridotite in chemistry, are characterized by high to very high amounts of MgO [100MgI(Mg+Fe)=87-94] and very low to low contents of CaO (mostly less than 2.0 wt %) and $A1_20_3$ (not more than 3.0 wt %). The olivine in these rocks, occurring both as veins as well as a matrix phase with serpentine and, rarely, pyroxene, is also very highly magnesian [100MgI(Mg+Fe)=89-98]. It is usually associated with abundant grains and host preferentially oriented, submicroscopic lamellae of magnetite. The grains of pyroxene, dominantly diopside, have bent and kinked cleavages, are locally spindle-shaped and usually partly to wholly bastitized. The serpentine in these rocks is almost exclusively antigorite displaying interpenetrating textures. The grains of chrome spinels are invariably zoned with dark gray Cr-rich cores surrounded by thin to fairly thick and highly reflecting rims of ferritchomite and/or magnetite containing higher amounts of NiO (up to 1.5 wt %). In contrast, chrome spinel in the talc-magnesite rocks is a high Cr chromite without any compositional zoning. Moreover, these rocks are devoid of any of the primary mafic silicates, i.e., olivine and pyroxene.
The field and mineralogical characteristics indicate that these ophiolitic rocks suffered a prograde greenschist facies metamorphism under oxidizing conditions in the presence of abundant $C0_2$-rich hydrous fluids. The antigorite-serpentinites and talc-magnesite assemblages, so developed, at the expense of the ultramafic rocks, represent a gradient in the H_20 and CO_2 contents of the original fluid. Although the fluids were dominantly metamorphic in origin, they probably carried a Be-rich and S-and As-bearing hydrothermal/magmatic component that, at places, gave rise to the mineralization of emerald and sulpharsenides in the talc-magnesite rocks.
Key words: Mineralogy, Ophiolites, Indus Suture, Swat.

A/531. Arif, M. & Jan, M.Q., 1993. Chemistry of chromite and associated phases from the Shangla ultramafic body in the Indus suture zone of Pakistan. In: Treloar, P.J. & Searle, M.P. (Eds.), Himalayan Tectonics. Geological Society London, Special Publication 74, 101-112.

The partly to wholly serpentinized ultramafic rocks of the Shangla area constitute the northern part of the Mingora ophiolitic mélange which lies along the Main Mantle Thrust (MMT) zone between the Kohistan island arc and the Indo-Pakistan plate. These rocks contain disseminated grains and massive bodies of segregated chromite. Field, textural, and chemical characteristics of the segregated chromite closely resemble those of podiform chromite deposits. The chemical composition of the chromite varies considerably from sample to sample with modal proportion, from grain to grain in the domain of a thin section, and from core to margin within individual grains. In general, the segregated chromites are richer in Cr and Mg, but poorer in Fe, Al and Mn than the accessory chromites. The inter- and intragranular chemical variations are much greater and more common in the case of accessory chromite due probably to a greater degree of subsolidus re-equilibration with the associated abundant silicate matrix. The intragranular variation, probably a result of alteration, mostly involves enrichment in Fe, Mn (and Ti), and depletion in Al, Mg and Cr, leading to the development of ferritchromit and, rarely, magnetite along fractures and margins of individual grains.
The studied rocks from the Shangla area display cumulus textures but contain abnormally magnesian olivine (Fo96.0–98.5). The 100Cr/(Cr + Al) ratios of their chromite suggest a complex origin. These rocks may have formed under conditions transitional between those of arc and oceanic settings. The Shangla rocks underwent a low- to ?medium-grade metamorphism as indicated by the development of talc and antigorite. This prograde metamorphic process probably also accounted for the extreme chemical zoning of the Shangla chromite.
Key words: Chromite, ultramafics, Shangla, Indus Suture zone.

A/532. Arif, M. & Khattak, M.U.K., 1999. The emerald-hosting magnesite-rich rocks from Swat, NW Pakistan. Geological Bulletin, University of Peshawar 32, 63-70.

The Main Mantle Thrust melange zone in Swat contains carbonate rich rocks (Manganese ± talc ± quartz ± chrome spinel/ Cr-magnetite / ferritchromite ± fuchsite ± tourmaline ± chlorite) which locally host emerald mineralization. Detailed field and mineralogical studies suggest that these rocks were probably formed by talc carbonate alteration of the spatially associated, previously serpentinized ultramafic rocks in the area. This transformation may have taken place at 250 – 550 ºC and was probably caused by CO_2 – bearing fluid released by the metamorphism of the underthrusted sedimentary rocks of the Indian Plate.
Key words: Magnesite rocks, emerald, Swat.

A/533. Arif, M. & Moon, C.J., 1994. Occurrence, chemistry and genesis of the nickel-rich phases in the ultramafic rocks from Swat, northwestern Pakistan. Geological Bulletin, University of Peshawar 27, 29-41.

Trace amounts of finely disseminated Ni-rich phases, including heazelwoodite, pentlandite, millerite, godlevskite, violarite and awaruite, occur in the variably serpentinitized ultramafic rocks of the Swat valley. The mode of occurrence, textural relationships with each other and with the associated silicate and oxide phases, relative modal abundance and chemical variation; all indicate that only the pentlandite represents the original sulphide phase. The rest are derived from pentlandite by the process of alteration. The additional amount of Ni, required for the conversion of pentlandite to heazlewoodite and other Ni-richer phases, was possibly derived by the serpentinization of primary olivine.
Key words: Ophiolite, ultramafics, nickelifeous minerals, Swat.

A/534. Arif, M. & Moon, C.J., 1996a. Chemistry of tourmaline from the emerald-hosting rocks in Swat, NW Pakistan. Geological Bulletin, University of Peshawar 29, 81-89.

The ophiolitic emerald-hosting carbonated ultramafic rocks (magnesite + talc and / or quartz ± chrome spinel) in the Swat valley contain disseminated grains, clusters and veins of tourmaline and / or fuchsite. These late-stage hydrothermal minerals are especially abundant where the host rocks are traversed by ubiquitous veins and stockworks of quartz. Crystals of emerald, tourmaline and fuchsite also occur in the quartz veins. Besides, the metasedimentary rocks that are spatially associated with the emerald's host rocks also contain tourmaline. In contrast to that in the metasediments, tourmaline in the emerald-hosting altered ultramafic rocks and the invading quartz veins contain variable but distinctly high amounts of Cr_2O_3, MgO and NiO, and relatively low concentration of TiO_2. These chemical features, mode of occurrence and nature of associated phases suggest that the tourmaline may have been deposited form Si-rich, Al-, Be-, B- and K-bearing hydrothermal fluids which passed through and extracted Mg, Cr and Ni contents from the host carbonated ultramafic rocks.
Key words: Ophiolite, tourmaline, emerald, Swat

A/535. Arif, M. & Moon, C.J., 1996b. The platinum-group element geochemistry of chromitites and silicate rocks from Swat, northwestern Pakistan. Geological Bulletin, University of Peshawar 29, 1-8.

The concentrations of the platinum-group elements (PGE) and Au were determined in a limited number of samples which represent chromitites, altered ultramafic and mafic rocks of Swat valley ophiolite. The PGE characteristics of the chromitites mostly conform to trend exhibited by the podiform chromitites. However, being sulphide-poor and containing Cr-rich chromite, the Pd content of one of the samples is anomalously high compared to similar chromitites from other areas. This enrichment in Pd is probably caused by a localized hydrothermal activity. The Ir content of the chromite-poor, altered ultramafic rocks is remarkably uniform (4ppb) and close to the values in mantle materials but their Pd (10±3.7 ppb) and Au (5±3.5 ppb) abundance are distinctly higher than the latter. These features of PGE and Au concentration of the host ultramafic rocks are consistent with an origin involving partial melting followed by hydrothermal alteration.
Key words: Ophiolite, platinum-group elements, chromite, Swat.

A/536. Arif, M., & Moon, C.J., 1996c. Textural and chemical characteristics of olivine and pyroxenes in the ultramafic rocks from the Indus suture zone in Swat, NW Pakistan: implications for Petrogenesis and alteration. Schwiz, Mineral. Petrography, Mtg., 76, 47–56.

Key words: Olivine, pyroxene, ultramafic, Indus Suture, Swat.

A/537. Arif, M. & Moon, C.J., 1997. Mineralogy and geochemistry of ultramafic rocks from the Indus Suture ophiolite in Swat, NW Pakistan: Petrogenetic implications. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.9.

In the area around Mingora (Swat), the Main Mantle Thrust (MMT) is exposed in the form of a wedge-shaped complex zone containing litholigies with diverse geochemical characteristics and genetic affinities (blocks and slices of blueschist, greenschist, bodies of ultramafic rocks, mafic plutonic and volcanic rocks as well as metasediments) separated by faults of different ages. This assortment of rocks, collectively termed as the Main Mantle Thrust Mélange Group (MMTMG), is distinguished into three principal groups, each of which is itself a composite of lithologies, or a mélange -the blueschist mélange, greenschist mélange and ophiolitic mélange.

The ultramafic rocks (locally containing chromite pods), constituting a part of the ophiolitic member of the MMTMG, occur as lenticular bodies, distributed along the marginal part of the Indo-Pakistan plate. The majority of these rocks consist of abundant, fine grained serpentine, subordinate amounts of partly to completely bastitised, medium to coarse grained orthopyroxene, trace to accessory amounts of partly altered (zoned with ferritchromite and/or magnetite) chrome spinel, variable proportions of olivine, and accessory amounts of diopside. Thus the ultramafic rocks are dominantly harzburgitic in mineralogy and, therefore, the ophiolite as a whole can be classified as the harzburgite sub-type. The present petrographic characteristics and mineral-chemical composition of these rocks appear to be the result of a number of phenomena including partial melting, serpentinization, metamorphism and talc-carbonate alternation.

The only trace of the primary mineralogy are the relic (unaltered) cores of the original chrome spinel grains and the occurrence of pyroxenes. The former is Cr-rich [Cr #= 100 x Cr/(Cr+Al) = -50~70],

TiO_2-poor and has more or less uniformly low Fe^{3+} content. The pyroxenes are highly magnesian and contain relatively low amounts of Al (with Al_20_3 mostly <2.5 wt %). Consistent with these mineralogical characteristics, the bulk chemistry of the rocks is characterized by low to very low amounts of the easily fusible oxides (CaO, Aland Ti0) , low concentration of the moderately incompatible components (Sc, V, Cu, Zn and Ga) and high levels of the moderately to highly compatible elements (Fe, Mn, Cr, Co, Ni and Mg). These mineralogical and geochemical features suggest that the major bulk of the studied ultramafic rocks originated as a residue of the upper mantle. Geochemical comparison with residual rocks from other areas shows that, prior to their emplacement along the MMT, the studied rocks had suffered an intermediate degree (> 15 to < 30%) of partial melting.

Key words: Mineralogy, geochemistry, ophiolites, Indus Suture.

A/538. Arif, M. & Moon, C.J., 1998. Parentage and evolution of magnesite-rich rocks from the Indus Suture Zone in Swat, NW Pakistan. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 17-19.

The Indus-Tsangbo suture between the Indo-Pakistan plate and Kohistan-Ladakh arc assumes a broad wedge-shaped complex zone in the Lilaunai-Mingora area of Swat and contains diverse rock assemblages. This assortment of rocks, collectively known as the Indus Suture mélange group, is distinguished into three principal types of mélanges: the blueschist mélange, the geenschist mélange, and the ophiolitic mélange (Kazmi et al., 1984).

Rocks of the ophiolitic mélange occur as small to large lensoidal bodies distributed along the northern edge of the Indo-Pakistan plate. They possess well-preserved ophiolitic characteristics and consist of variably altered ultramafics, gabbros, lavas of basic to intermediate composition, and pelagic sediments including cherts as well as plagiogranites and albitites. Furthermore, carbonate-rich assemblages, which are known for producing one of the world's finest gemstone quality emeralds, form an integral part of the different occurrences of the ophiolitic rocks in the study area.

In most of the ophiolitic rock occurrences, the fine-grained, emerald-hosting carbonate-rich rocks are spatially associated with variably serpentinized ultramafic rocks. Although also present as small patches within the serpentinized rocks in some places, they mostly occur along the contact between the serpentinites and metasedimenst. These rocks are also traversed by abundant veins, locally producing stockworks, of quartz.

The studied rocks invariably consist of abundant magnesite and accessory to trace amounts of spinel (mostly Cr-magnetite-ferritchromite and, in some cases, Mg-poor but Cr-rich chromite) accompanied with one or more of such phases as talc, quartz and dolomite. The different relative proportion of these minerals has given rise to three major types of assemblage: (i) talc-magnesite or magnesite-talc, depending upon whether magnesite or talc is more abundant; (ii) talc-magnesite-dolomite; and (iii) quartz-magnesite. The texture of these rocks is related to the relative proportions of the different minerals, especially the absence or presence of talc in the paragenesis. That is, whereas the talc-free or talc-poor quartz-magnesite assemblages are massive, the talc-magnesite rocks are strongly foliated. In addition to the phases, mentioned above, some of the investigated magnesite-rich rocks also contain fine-grained disseminations, veins, and/ or clusters or clots of fuchsite and/ or tourmaline. The tourmaline is a Cr-rich dravite and the fuchsite shows variable but, in most analyses, anomalously high concentration of Mg and Ni and Ni (NiO reaching up to 9 wt.%).

Most of the geochemical characteristics of the investigated lithologies are broadly similar to those of typical ultramafic rocks. More importantly, the overall ranges for most of their major, minor as well as trace elements are almost identical to those of the carbonate-free, serpentinized ultramafic rocks in the area. This is particularly true for the concentrations of Al_2O_3, MnO, TiO_2, Cr, Ni, Co, V, Zn, Sc as well as Ga. Therefore, it seems reasonable to assume that the investigated rocks could be the result of alteration (carbonation) of the previously serpentinized ultramafic rocks in the area. The close spatial association between the two categories of the rocks lends further support to interpretation. Furthermore, comparison in terms of modal mineralogy and mineral chemical data with broadly similar assemblages from other occurrences in the world suggest that this transformation probably took place at 250-550°C and was brought about by CO_2-bearing metamorphic fluids.

Although most of the major and trace element contents of the investigated rocks fall within the corresponding limits for ultramafic rocks, the amount of SiO_2 in some of them is anomalously low. On the other hand, the SiO_2 content of a few of the samples is higher than most others. Besides, compared to typical ultramafic rocks, some of the rocks under discussion contain distinctly high amounts of some of the incompatible trace elements.

The distinctly high content of SiO_2 in some of the studied rocks could be due to the fact that precursors to these rocks, unlike the most others, were originally orthopyroxenites rather than peridotites or dunites. On the other hand, the abnormally low SiO_2 contents in the quartz-magnesite varieties of the studied rocks (less than 10 wt.%) cannot be attributed to original compositional differences because a type of ultramafic rocks having such a low amount of SiO_2 does not exist. The possibility for an alternative explanation that these lithologies were originally some sort of impure carbonate rocks of sedimentary parentage (e.g. siliceous dolomite) can easily be ruled out because their trace element contents (especially high amounts of Cr, Ni and Co) are typical of those occurring in ultramafic igneous rocks. The point to make here is that the low SiO_2 content in the studied rocks is probably a result of the process of carbonation. As their SiO_2 shows a strong negative correlation with the LOI values variable amounts of this component were probably removed from the rocks during the process of talc-carbonate alteration (Fig. 1).

As mentioned above, some of the studied samples, especially those representing the mining sites of emerald, contain distinctly high amounts of Be, B, Li, K, As, Pb, W, Zr, Y, Ba, Rb and/ or Sr. As the average abundance of elements like these is negligibly small in typical ultramafic rocks, their notably high values in the studied may have been the result of enrichment during later processes. The lack of a meaningful correlation of any one of these elements with the values of LOI precludes the possibility for their enrichment by one of the two main processes of alteration, i.e. serpentinization and/ or carbonation. Alternatively, the textural relations and mineralogical composition suggest that the mentioned incompatible elements may have been added to the studded rocks during a late-stage hydrothermal activity, most probably the one producing the quartz veins and associated phases, i.e. fuchsite, tourmaline and emerald.

Key words: Ophiolite, Paragenesis, Magnesite rocks, Indus Suture, Swat.

A/539. Arif, M. & Moon, C.J., 1999. Geochemistry of magnesite rich rocks from the Indus suture in Swat, NW Pakistan. Geological Bulletin, Punjab University 33 & 34, 111-118.

Key words: Geochemistry, magnesite, Indus Suture, Swat.

A/540. Arif, M. & Moon, C.J., 2000. Mineralogy and geochemistry of ultramafic rocks from the Indus Suture ophiolite in Swat, NW Pakistan. Abstract Volume, 15th Himalaya- Karakoram-Tibet Workshop, Chengdu (China), 113-114.

Genetically diverse lithologies, which include blueschist, greenschist, ultramafic, mafic plutonic, e.g. gabbros, and volcanic, e.g. pillowed basalts, and metasedimentary rocks, occur as a wedge-shaped zone in the area to the north of the Mingora town in Swat, NW Pakistan. This zone of fault-bounded rock bodies and blocks is distinguished into three principal groups, each of which is itself a composite of lithologies, or a mélange- the blueschist mélange, greenschist mélange and ophiolitic mélange. All these lie along the Main Mantle Thrust (MMT)- the westward

extension of the Indus-Tsangbo Suture Zone and the locus of collision between the Indo-Pakistan Plate and the Kohistan Island-Arc- and, are therefore, collectively termed as the Main Mantle Thrust Mélange Group (MMTMG).
The ultramafic rocks, locally containing chromite pods and constituting a part of the ophiolitic member of the MMTMG, occur as small to large lenticular bodies, distributed along the marginal part of the Indo-Pakistan Plate. They are invariably serpentinized to varying degrees and, therefore, consist of abundant, fine grained serpentinite which is mostly accompanied by subordinate amounts of completely bastitised, medium to coarse grained orthopyroxene, trace to accessory amounts of commonly altered (zone with ferritchromite and /or magnetite) chrome spinel, variable proportions of olivine, and accessory amounts of diopside. In other words, the ultramafic rocks are mostly harzburgitic in mineralogy and, therefore, the ophiolite as a whole can be classified as the harzburgite sub-type. Detailed field and mineralogical studies show that the present petrographic characteristics and mineral-chemical composition of these dominantly harzburgitic rocks are the result of a number of phenomena involving partial melting, serpentinization, metamorphism and talc-carbonate alteration.
Relict (unaltered) cores of the original chrome spinel grains and the occurrence of pyroxenes are the only primary mineralogical features of the studied ultramafic rocks. The former is Cr-rich [Cr=100XCr/(Cr+Al)=50~70], TiO_2-poor and has more or less uniformly low Fe content. The pyroxenes are highly magnesian and contain relatively low amounts of Al [mostly $_w(Al_2O_3)$<2.5%] and Ti [$_w(TiO_2)$<0.2%]. Consistent with these mineralogical characteristics, the bulk chemistry of the rocks is characterized by low to very low amounts of CaO, Al_2O_3 and TiO_2, low concentration of the moderately incompatible components (Sc, V, Cu, Zn and Ga) and high levels of the moderately to highly compatible elements (Fe, Mn, Cr, Co, Ni and Mg) (Fig. 1). These mineralogical and geochemical features suggest that the major bulk of the studied ultramafic rocks originated as a residue of the upper mantle left after partial melting. Geochemical comparison with residual rocks from other areas shows that, prior to emplacement, the studied rocks suffered an intermediate degree (>15% to 30%) of partial melting. The emplacement of these residual rocks was accomplished during the Cretaceous-Tertiary collision between the Indo-Pakistan Plate and the Kohistan arc along the MMT.
Key words: Mineralogy, geochemistry, ophiolites, ultramafic, Indus Suture, Swat.

A/541. Arif, M., Moon, C.J. & Christidis, G., 1996. Garnierites from the ultramafic rocks in Swat, northwestern Pakistan. Geological Bulletin, University of Peshawar 29, 69-79.

The serpentinized and / or carbonated ultramafic rocks of Swat valley ophiolite locally contain accessory to trace amounts of microscope to megascopically visible grains of garnierite. Such grains mostly occur in samples where the serpentinization and /or carbonation are rather pervasive and accompanied by supergene alteration. Their optical properties and chemical composition are extremely variable and differ greatly from spot to spot within individual grains which appear to be intimate mixture of different compositions. The highly variable and, in most cases, high to very high concentration of FeO (up to ~ 54 wt. %), and abnormally high CaO contents (ranging up to ~3wt. %) in the chemical analyses make them distinct from the serpentine varieties of garnierites reported from other localities.
Most of the garnierite grains seem to be pseudomorphic after, and contain relic patches of, pentlendite, and might have developed as a result of reaction between the ‘normal’ matrix serpentine or talc and the original magmatic sulfide. As their occurrence along fractures in the rocks is clear at least in some cases, their formation probably took place after the main episodes of serpentinization and carbonation and was probably brought about by the processes of weathering and supergene alteration. The association of calcite with garnierites in some of the rocks indicates that the fluid, which caused the alteration, was charged with calcium and CO_2 and this factor probably also accounted for the anomalously high values of CaO in the garnierites.
Key words: Garnierites, ophiolite, ultramafic, Swat.

A/542. Arif, M., Mulk, A., Mehmood, M.T. & Shah, S.M.H., 1999. Petrography and mechanical properties of the Mansehra granite, Hazara, Pakistan. Geological Bulletin, University of Peshawar 32, 41-49.

Rocks of granitic composition occur along the area around Mansehra (Hazara), Pakistan. These rocks are mostly used as building/ construction materials. In order to study the petrography of these rocks in detail and determine their geotechnical properties, representative samples were collected from different parts of the area. Detailed studies reveal that, compared to granitic rocks from elsewhere in northern Pakistan, the investigated rocks have very low values of compressive strength. This could be due to their older age, coarser texture, unevenness of grain size,

deformed/ metamorphosed character and weathered/ altered nature. Therefore, they cannot be recommended for use in the construction of large-scale engineering structures such as tunnels and dams. However, the compressive strength values and Cs/Ts ratio of the studied rocks are high enough for their use as building stones in the construction of railway tracks, bridges, roads, canals, drainage and embankments.
Key words: Petrography, geotechnics, granite, Mansehra.

A/543. Arif, M., Rafiullah & Hussain, S.H., 1989. Geology of Mir Pur area, Azad Kashmir. GSP, Information Release 445.

Key words: Geology, Mir Pur, Azad Kashmir.

A/544. Arif, M., Rehman, F. & Amjad, A., 1984. Petrology of Khawaza Khela area, upper Swat. M.Sc. Thesis, Peshawar University, 92p.

Key words: Petrology, Khawaza Khela, Kohistan arc, Swat.

A/545. Arif, M., Shah, S.M.I. & Vos, J.D. 1992a. Cervus Triplidens (Mamalia, Cervidace) from the upper Siwaliks of Pakistan. GSP Memoir 17(1).

This describes Cervus Triplidens from the upper Siwaliks of northern Pakistan.
Key words: Paleontology, Siwalik Molasse.

A/546. Arif, M., Shah, S.M.I. & Vos, J.D. 1992b. “Cervus Rewati” sp. Nov (Mamalia Cervidae) from the upper Siwaliks, Pakistan. GSP Memoir 17(2).

This describes Cervus Rewati from the upper Siwaliks of northern Pakistan.
Key words: Paleontology, Siwalik Molasse.

A/547. Armbruster, J., Seeber, L. & Jacob, K.H., 1978. The northwestern termination of the Himalayan Mountain Front; active tectonics from micro earthquakes. Journal of Geophysical Research 83, 269-282.

The seismicity of the northwestern Himalayan syntaxial bend and the geologically complex area to the west, between the Hazara thrust system (HTS) and the higher mountains of Indus-Kohistan, is examined in a wider tectonic context by using data from about 1,800 microearthquakes. The microearthquake data were obtained from a telemetered seismic network in northern Pakistan centered at Tarbela dam on the Indus River and were collected during an 11-month period prior to impounding of the Tarbela reservoir. The observed seismicity indicates that a branch of the main boundary thrust (MBT) traverses the region as a straight northwesterly extension of the Murree thrust, the mapped section of the MBT southeast of the syntaxial bend along the Kashmir Himalayas. Seismic release on this extension of the MBT, here named the Indus-Kohistan seismic zone (IKSZ), is highest in the upper 25 km of the crust and correlates with a pronounced topographic step. Deeper activity on the IKSZ extends to a depth of 70 km. Seismicity in the lower crust defines a second lineation 100 km southwest of the IKSZ and parallel to it. The syntaxial bend and the eastern HTS, microseismically virtually inactive at present but associated with recent and historical microseismicity, overprint the two northwesterly seismic lineaments. The two tectonic regimes may be simultaneously active at different depths separated by an incompetent layer. A set of steeply dipping faults, either parallel or perpendicular to the IKSZ, is active in the region between the HTS and the IKSZ. Seventeen composite fault plane solutions show a predominant pattern of either reverse or strike slip faulting with the inferred slip vectors oriented such that north-south compressional stresses are relieved. Such a stress field is compatible with the north-south convergence between the Indian and Eurasian plates inferred from plate tectonics.
Key words: Seismology, active tectonics, mountain front, Himalaya.

A/548. Arshad, C.M., 1985-87. The geology of Parrai-Dodahera Area, District Swat N.W.F.P. with special emphasis on mineralogy and petrology. M.Sc. Thesis, Punjab University, Lahore, 78p.

The topic of this thesis is Geology of Parrai-Dodahera area with special emphasis on mineralogy and Petrology. The prescribed area lies in the lower Swat region. The area consists of about 35 sq. miles. It lies between latitudes 34° 41' 30" to 34° 45' 00" Longitude 72° 11' 30" to 72° 15' 00' in toposheet No.43 B/2

The area was mapped by the part through foot traverses on eight times enlarged toposheet 1:50000. Notes were taken on different units, their lithology and contact relationship, geomorphology, and also on social set up of the people. Details regarding the structure of the area i.e. folds, faults, fractures, joints, foliation and lineation were taken. Stations were marked on the map. Samples were also collected. Photographs of geological and geomorphic features were also taken. Back in Laboratory, petrographic study of the thin section was carried out by microscope.

The project area is not very rich in economic minerals. No mine is present. However, the following rocks and minerals are of economic importance. These are Marble, graphitic schist, graphite and garnet.

Key words: Petrography, petrology, structure, Swat.

A/549. Arshad, M., 1977-79. Mineralogy and Petrology of Shangla Par Area, District Swat. M.Sc. Thesis, Punjab University, Lahore.

The Shangla Par Alpurai-Bazarkot area is a part of District Swat, situated about 13 miles from Khwaza Khela eastward on Khawaza Khela-Besham road.

The area comprised of igneous and metamorphic rocks. These rocks were originally deposited in eugeosynclinal conditions are argillaceous sediments and afterwards, these rocks are metamorphosed to schists and phyllites. Some amphibolites of para nature formed as result of regional metamorphism on calcareous sediments is also suggested. Subsequently the area has been strongly disturbed and intruded by ophiolites, which have now been metamorphosed to serpentinites and talc carbonate rocks. Blue schist rocks from Topsin and Shangla illustrate typical assemblages as are taken to mark plate subduction or obduction zones of Indian and Siberian plates. These are originated by the metasomatic metamorphism. The rocks form a part of lower Swat Buner Schistose group of Paleozoic age (Martin et al, 1962). By way of certain stratigraphical reasoning, a Paleocene age was attributed to the Shangla Blueschist. The area lies on the northwestern limb of the syntaxis and therefore, the prominent strike is South West-North East.

Key words: Petrography, petrology, structure, metamorphism, Swat.

A/550. Arshad, M., 1986. Gravity studies in the Margalla and Hazara Ranges. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 67p.

Key words: Gravity, Margalla, Hazara.

A/551. Arshad, M. & Shams, F.A., 1983. Geology and petrology of the Shangla blueschist zone, Swat Himalaya, NWFP Pakistan. Geological Bulletin, University of Punjab 18, 25-31.

Based on detailed mapping of the Shangla zone, Swat, petrographic description is given of various lithologic units. Major and trace element analyses are reported of blueschist rocks along with discussion on their petro-tectonic importance.

Key words: Petrology, blueschist, Shangla, Swat.

A/552. Arshed, A., 1981-83. Geology and Petrology of Shewa and Shahbaz Garhi Area, District Mardan, NWFP. M.Sc. Thesis, Punjab University, Lahore, 43p.

This report covers a comprehensive study of Shewa and Shahbaz Garhi area. The principal emphasis has been on detailed geological mapping of the area on the scale of 1:8333. The rocks in the area are porphyries, quartzitic schists and dolerites.

A fairly detailed account of the Geology is being given and the report also includes a detailed account of petrography of the porphyries based on extensive sampling.
Numerous photographs and sketches have also been included to illustrate the geology of the area. In the light of field, laboratory work and previous work petrogenesis of the porphyries has been discussed at length.
Key words: Petrology, mapping, Shewa Shahbaz garhi, Mardan.

A/553. Asad, A., 1996. Prospects of mineral resources and industries in the northern area of Pakistan. Geological Survey of Pakistan, Mineral Information Release 16.

Key words: Mineral resources, Industries, Northern Areas.

A/554. Asad, A.F., 2000. Feasibility study of Limestone of Gandghar Range and Associated deposits for Cement manufacturing. M.Phil. Thesis, University of Peshawar.

Limestone is a valuable raw material, which is widely used in the chemical and construction industries throughout the world. With huge deposits of limestone in Pakistan it is immensely used as cement manufacturing. The extensive deposits of pre-Cambrian limestone are exposed in Gandghar, Cherat and Khyber ranges around the southern Peshawar basin. It is light grey in colour, medium to thick bedded and massive. The limestone of Gandghar range has been evaluated mineralogically and chemically for its use for cement manufacturing during present study. Mineralogically, the studied limestone is dominantly calcite very fine grained. Quartz as anhedral small clastic sand grains, chert and chalcedony, some carbonaceous matter is also present in the form of layers or bands. Iron leaching and some of clay minerals by mixing of various raw material in different proportions then the portland cement of desired composition can be obtained. Chemically, the studied limestone of Gandghar range are compared with that of the normal and argillaceous limestone elsewhere in the world. All the three varieties of the studied limestone (Shekhai, Utch Khattak greenish grey) have more silica than normal limestone but less than that of the argilliceous limestone. Al2O3, and Fe203 are relatively high in the studied limestone as compared to that of normal limestone, MgO in the studied limestone is less as compared to that of the normal limestone and more as compared to that of argilliceous limestone, Al2O3 and Fe203 are relatively high in the studied limestone as compared to that of nomal limestone, MgO in the studied limestone is less as compared to that of nomal limestone and more as compared to that of argilliceous limestone. The CaO is high in the studied limestone as compared to that of both nomal and argilliceous limestone. Total alkalies in the studied limestones are relatively as compared to that of n o W l limestone. The average chemical compositions of various cements manufactured in N.W.F.P. are within the ASTM limits. The studied limestone of Gandghar range is generally free of dolomitization and has no other deleterious substances. This pre-Cambrian limestone of the Gandghar range is therefore, recommended.
Key words: Limestone, cement, Gandghar Range.

A/555. Asghar, M., 2001. Geophysical investigations of landslide in Murree Hill area. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 64p.

Geophysical investigations of three landslides in Murree were carried out by using seismic refraction, electrical resistivity and radon exhalation detection methods. The seismic data was acquired employing reverse shooting scheme and Conventional and Hagedoorn methods were used for velocity modeling. The resistivity data was interpreted in terms of true resistivity of subsurface material by curve matching technique. The radon emission was determined as track densities for every detector planted on the surface in a profile. The results of all the methods employed were interpreted and correlated in the light of geology of the area, meteorological and anthropogenic factors.
The study reveals that geological structure and lithologies play a major role in the formation of thick weathering layer which when wet/moistened exerts more downslide force thus causing landslides. The thickness of weathering layer determined by seismic refraction and resistivity methods for all the three landslides are in agreement. Also the radon emission measurements have delineated the stable and unstable areas within a landslide zone. Such investigations are recommended on all the major landslides of the area prior to damage control measures.
Key words: Geophysics, landslides, Murree.

A/556. Asghar, M., Ali, Ch.A. & Hussain, T., 1979. Geology of the Jogha Banj Saiqa Banda area with special emphasis on petrography of amphibolites and mixed zone. M.Sc. Thesis, Punjab University, Lahore.

Key words: Petrography, amphibolites, Kohistan arc, Swat

A/557. Ashfak, M. & Wakeel, A., 1969a. The study of the joint patterns and the other structures of the Manki slate and the Attock shale. M.Sc. Thesis, University of Peshawar, 42p.

Consult the following account.
Key words: Structure, Manki Slate, Attock Shale.

A/558. Ashfak, M. & Wakeel, A., 1969b. The study of the joint patterns and the other structures of the Manki slate and the Attock shale. Geological Bulletin, University of Peshawar 4, 24-32.

On the basis of a comprehensive study of the structures, especially the joint patterns of the Manki Slate and the Attock Shale, the two distinct argillaceous units of the Attock Group, it has been established that there was, most probably, a considerable lapse of time between their depositions. The Manki Slate, as a result of a powerful compression from the north, was later pushed over the Attock Shale along a thrust striking E – W.
Key words: Structure, Manki Slates, Attock Shale.

A/559. Ashok, S. & Kad, S., 1998. Initiation and Development of Northwestern Lesser Himalayan foreland basin: An Overview. Geological Bulletin, University of Peshawar 31. Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, p.173.

Excellent sections are available in Northwestern Lesser Himalayan region of India and Pakistan to document the evolution of Foreland basin that has taken place south of rising Himalayas. The present Indo-Gangetic basin is the southernmost and youngest in a series of foreland basin development which include the Siwaliks and Eocene-Oligocene i.e. mainly Murree group basins, which are the oldest, highly tectonically disrupted and most uplifted of all such basins.
The present paper attempts to understand initial stages of development of these Foreland basins spanning the first 25 m.y. of this development. It is based on investigated sequences in Dharampur-Kuniarhatti section, Dagshai type section and Subathu section in Shimla Himalayas and Kalakot, Sind-Khatuti sections in Jammu Himalayas.
The transition of a marine to continental basin is best studied in Dharampur, Dagshai and Kalakot sections. Transition is marked by a thick orthoquartzite band extending along the length of the basin delineating the transition. In most of the sections studied it is generally marine sequence below the orthoquartzite band but in Dharampur-Kumarhatti section, which makes an exception, some red beds are below this orthoquartzite band. It is generally believed, that a thick orthoquartzite layer may have beer coeval with India -Asia collision and all sediments above represent initial stages of subsiding basin.
The initial stages of this subsiding basin are characterised by alteration of Sandstone and shale usually red in colour to multiple palaeosol horizons with reworked nodular beds. They are poorly fossiliferous in nature except for some organic debris along with thin shale partings. Next stage of development in the foreland basin are Kasaulis which suggest a certain degree of stability and uplift of Murrees.
Key words: Foreland Basin, Lesser Himalaya.

A/560. Ashraf, A., 1989. Electrical resistivity survey for groundwater investigation in the area between Malpur and Quaid-i-Azam University. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 44p.

Key words: Resistivity survey, groundwater, Islamabad.

A/561. Ashraf, K.M. & Ismail, M., 1984. Characteristics of alluvial aquifers of Potwar Plateau. Abstracts, First Geological Congress, Lahore, 3-4.

Potwar Plateau exists in the northern part of Punjab Province, extending from the fool-hills of Himalayas to Jhelum River, and covers an area of about 9000 square miles; Potwar Plateau and its adjoining drainage basins were investigated on scientific basis for groundwater exploration by Hydrogeology Directorate, WAPDA, Lahore.
Geologically, the area is folded, faulted and over-thrusted. The rocks of the area are generally sedimentary in origin and range in age from Pre-Cambrian to Recent. The unconsolidated deposits of Sub-Recent to Recent age consisting silt, sand, gravel and clay form the main groundwater reservoir of the area while the consolidated rocks are far less permeable and in general serve as barriers to movement of groundwater. The aquifer material in Potwar occurs in lenses and strings 4 to 152 feet thick, elongated along the present and abandoned river channels. For determining the aquifer characteristics of alluvial deposits aquifer tests/pumping tests were performed at selected sites in the area. The data collected during these tests were evaluated and analysed by different analytical methods for different parameters of aquifer. The coefficients of transmissivity, permeability and storage determined by these methods range from 7000 gpd/ft, 86 gpd/ft^2 and 5.7X10^{-5} to 218000 gpd/ft, 4100 gpd/ft^2 and 7X10^{-2} respectively. The specific capacity of tubewells ranges from 4.6 gpm/ft of drawdown to 489 gpm/ft of drawdown.
Key words: Alluvial aquifer, groundwater, Potwar Plateau.

A/562. Ashraf, M., 1965. Geology of the Khaki area, Mansehra, District Hazara. M.Sc. thesis, Punjab University, Lahore.

This is a preliminary account of the geology of the Khaki area. Petrographic descriptions of low grade metamorphic rocks and agranitic intrusions are given.
Key words: Geology, Mansehra, Hazara.

A/563. Ashraf, M., 1969. Magnetite bearing amphibolites near Mari Banda, Swat. Geological Abstracts, 11th Annual Conference, Scientific Society of Pakistan, Multan, p. 22 (In Urdu).

Brief description of small magnetite lenses in amphibolites near Shah Dheri in Upper Swat is given. The host rock belong to what is now called southern amphibolite belt of the Kohistan magmatic arc.
Key words: Magnetite mineralization, amphibolite, Kohistan arc, Swat.

A/564. Ashraf, M., 1972. Geological and chemical characteristics of dolomite from Hazara and Mardan Districts. Pakistan Journal of Scientific Research 9, 62-66.

Key words: Chemistry, dolomite, Hazara, Mardan.

A/565. Ashraf, M., 1974a. Geochemistry and petrogenesis of acid minor bodies of Mansehra and Batgram area, Hazara District. Ph.D. Thesis, Punjab University, Lahore.

The acid minor bodies in the Mansehra and Batgram area were emplaced in the granitic rocks and the associated met sediments. These bodies have been identified as (i) Albitites, (2) albite-aplites/pegmatites, (3) ablate-(microcline)-aplites /pegmatites, (4) alit-microcline-aplites/tit/pegmatites, (5) microcline-albiteaplies/pegmatites and (6) complex aplites/pegmatites. The first 4 types occur as independent and composite bodies in the interior-lateral zone (1750 to 5500 feet above sea level), types 4 and 5 occur in the interior-marginal zone (5000 to 9000 feet above sea level) and types 5 and 6 are present in both interior-marginal zone and marginal exterior zone (over 9000 feet sea level). Field, mineralogical and chemical evidences show that the acid minor bodies are genetically related with the granitic rocks of the area. This genetic relationship is significant due to continued enrichment of soda in the granites from Susalgali granitic gneiss (a potassic facies) to Hackle tourmaline granite and Chail sar micro granite. The enrichment of soda is due to gradual cooling and increases in vapor pressure of the complex (in tightly closed environments) more than 10 kbs, where the acidic fluids shifted toward the albite apex. From this the release in external pressure at within the interior-lateral zone gave rise to soda rich liquids being deposited in the fissures. These fissures provided

the local in pressure by the opening the metasediments during the welling up and the expansion of the granites in the diapiric and much room like structures. Therefore, as the vapour pressure decreased with further cooling, the behavior of the system was reversed gradually, meaning thereby that quantity depended on the release in p(H_2O) in the three structural zones. The mineralogy and chemistry of these structural units is quite contrasting with the exception of some overlapping at places. Therefore, the present investigations show that the pegmatite residual solutions were derived from the albite rich solutions gradually with the introduction of K_2O and volatiles. This derivation is excellently exemplified by negative correlation of Na2o and positive correlation of k2o with Si02 and gradual but significant increase in the rare elements.
Key words: Geochemistry, petrogenesis, pegmatite, Aplite, Mansehra, Batgram, Hazara.

A/566. Ashraf, M., 1974b. Geochemistry and petrology of acid minor bodies from Mansehra and Batgram area, Hazara District, Pakistan. Geological Bulletin, University of Punjab 11, 81-88.

The acid minor bodies are emplaced in the granitic and the associated metamorphic rocks. The bodies identified are 1) albitities, 2) albite-aplites/pegmatites 3) albite- (microcline)-aplites/pegmatites, 4) albite-micorcline-aplites/pegmatites, 5) microcline-albite-aplites/pegmatites and 6) complex aplites/pegmatites and 7) various quartz veins. Field, mineralogical and chemical evidences show that the acid minor bodies are genetically related with the granites.
Key words: Petrology, Mansehra, Batgram, Hazara.

A/567. Ashraf, M., 1975. Composite albitite-aplite and pegmatite from Mansehra and Batgram areas, Hazara District, Pakistan. Special Issue IMA Papers 9th Meeting, Berlin. Fortschs, Miner 52, 329-344.

Key words: Pegmatite, albitite, aplite, Batgram, Mansehra, Hazara.

A/568. Ashraf, M., 1976. Origin of myrmekite of the acid minor bodies of Mansehra and Batgram areas, Hazara District. Geological Bulletin, Punjab University 12, 103-104.

Key words: Myrmekite, Mansehra, Batgram, Hazara.

A/569. Ashraf, M., 1977. Geology and mineral composition of various lithologic units presents in the Kingriali Formation of the Surghar Range. Geological Bulletin, University of Punjab 14, 55-62.

Kingriali Formation of Triassic age has seven lithologic units, which can be distinctly recognized in the field on the basis of color, porosity, and compaction of the rocks. The thickness of individual units varies from 8 – 42meters. The thickest unit is massive, white to pink colored and porous at places (sucrosic dolomite). The deposits were evaluated in the laboratory for their microscopic, chemical, differential thermal analyses (D. T. A.) and X-ray properties. The studies clearly indicate that most of the units are quite rich in dolomite mineral, (as MgO is 20 to 21% and CaO is 29 to 31%) with minor amount of Kutnoharite and ferrian dolomite.
Key words: Lithology, Kingriali Formation, Surghar Range.

A/570. Ashraf, M., 1983. Geochemistry of the acid minor bodies associated with the Hazara granitic complex, Hazara Himalayas, northern Pakistan. In: Shams, F.A. (Ed.), Granites of Himalayas, Karakorum and Hindu Kush, 123-141.

Consult the following account for further information.
Key words: Geochemistry, granitoids, Mansehra, Hazara.

A/571. Ashraf, M., 1992a. Petrogenesis of acid minor bodies of Mansehra granitic complex, Hazara Himalaya, NW Pakistan. Kashmir Journal of Geology 10, 1-26.

The acid minor bodies in the Mansehra and Batgram area were emplaced in the granitic rocks and the associated metasediments. These bodies have been identified as (1) Albite, (2) albite-aplites / pegmatites, (3) albite - (microcline) – aplite / pegmatites, (4) albite – microcline – aplites / pegmatites, (5) microcline – albite-aplites / pegmatites and (6) complex – aplites / pegmatites. The first 4 types occur as independent and composite bodies in the interior – lateral zone (1675m above sea level), and the types 4 and 5 occur in the interior- marginal zone (1525 to 2750 m above sea level) and types 5 and 6 are present in both interior – marginal zone and marginal – exterior zone (over 2750 m above sea level). Field, mineralogical and chemical evidences show that the acid minor bodies are genetically related with the granitic rocks of the area. This genetic relationship is significant due to continued enrichment of soda in the granites from Mansehra granitic gneiss (a potash facies) to Hake tourmaline granite and Chail Sar microgranite. The Mansehra granitic complex is itself a product of partial melting of Hazara and Lower Tanol Formations when they reached to metamorphic grade of kyanite-silliminite. The enrichment of soda is due to gradual cooling and increase in vapor pressure of the complex (in tightly closed environment) more than 10 Kb, where the acidic fluids shifted towards the albite apex. From this release in external pressure at place within the interior-lateral zone gave rise to soda rich liquids being deposited in the fissures. These fissures provided the local release in pressure by the opening of tension fissures parallel to the foliation of the granite and the metasediments during the swelling up and the expansion of the granites in the diapiric and mushroom lie structure. Therefore, as the vapor pressure decreased with further cooling the behavior of the system was reversed gradually, meaning thereby that SiO_2 and K_2O would be released along with the volatilize, and their quantity depended on the release in P (H_2O) in the three structural zones. The mineralogy and chemistry of these structural units is quite contrasting with exception of some overlapping at places. Therefore, the present investigations show that the pegmatitic residual solutions were derived from the albite rich solutions gradually with the introduction of K_2O and volatizes. This derivation is excellently exemplified by negative correlation of Na_2O and positive correlation of K_2O with SiO_2 and also gradual but significant increase in the rare elements.
Key words: Petrogenesis, geochemistry, Himalaya, Mansehra, Hazara.

A/572. Ashraf, M., 1992b. Asymmetrically zoned complex pegmatite of Bagarian area North of Oghi, Mansehra District, Hazara Himalaya, Pakistan. Kashmir Journal of Geology 10, 93-104.

The Bagarian asymmetrically zoned complex pegmatite occurrs associated with Mansehra granitic complex in the interior-marginal zone near Oghi subdivision of Mansehra District. This pegmatite body is the most developed zonally and is most evolved with contrasting mineral composition on both sides of the quartz core. The zones on east of core are border + wall zones with oligoclase, muscovite quartz and tourmaline; outer intermediate zone-microcline graphic granite; inner intermediate zone-subgraphic albite, quartz and muscovite. The zones on west side of quartz core are border + wall zone with albite, tourmaline, quartz and muscovite; outer intermediate zone-microcline perthite and minor muscovite; and inner intermediate zone-microcline perthite with minor quartz. Miaroolitic cavity filled minerals of aqueous vapor phase are beryl columbite, samarskite Rb-rich translucent microcline, Rb and Li-rich muscovite. The Mansehra granitic magma was formed after 40% partial melting of Hazara and Lower Tanol Formation pelites, which in turn gave rise pegmatitic magmatic solution to develop Bagarian pegmatite and aqueous phase modified for miarolitic minerals. It is envisaged that 75-90% fractional crystallization of granitic rest magma was responsible for the present shape of Bagarian pegmatite.
Key words: Zoned pegmatite, Mansehra, Hazara.

A/573. Ashraf, M., 1993. Application of a two-dimensional numerical groundwater flow model to investigate changes in the hydrogeology of the selected part of National Park area, Islamabad. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 77p.

Key words: Hydrogeology, groundwater, national park, Islamabad.

A/574. Ashraf, M., 1994. Bagrian complex pegmatite associated with Mansehra granitic complex, Hazara Himalaya. Abstracts, Second SEGMITE International Conference on the Export Oriented Development of Mineral Resources and Mineral Based Industries, Karachi, p. 20.

The Bagarian asymmetrically zoned complex pegmatite occurs associated with Mansehra granitic complex in the interior-marginal zone near Oghi subdivision of Mansehra district. This pegmatite body is the most developed zonally and is most evolved with contrasting mineral composition on both sides of the quartz core. The zones on east side of core are border+wall zones; intermediate zones graphic granite; the zones on west side of quartz core are border+wall zones, intermediate zones, dominantly microcline perthite. The Mansehra granitic magma was formed after 40% partial melting of Hazara and Lower Tonal Formation pelites, which in turn gave rise pegmatitic rest magmatic solutions to develop Bagarian pegmatite. An aqueous phase formed miarolitic minerals like beryl, columbite, samarskite, Rb-rich microcline and Rb and Li - muscovite. It is envisaged that 75-99% fractional crystallization of granitic rest magma was responsible for the present shape of Bagarian pegmatite. The petrographic and chemical composition of western pure microcline intermediate zone and quartz of core show that they are excellent materials for ceramic and glass industries. Bi, Nb, U etc. occur as miaralitic minerals.
Key words: Complex pegmatite, granite, Mansehra, Hazara.

A/575. Ashraf, M., 1995. Lagarban-Tarnawai phosphorite deposits of Abbottabad, Pakistan. Abstracts, International Symposium and Field Workshop on Phosphorites and other Industrial Minerals, Abbottabad, p.36.

Lagarban-Tarnawai phosphorite is the only sedimentary deposit known so far in Pakistan. Total reserves are of the order of about .19·million tones out of which 7.S million-tonnes are of measured category as reported by SDA. The phosphorite occurs in the upper Sirban formation of Cambrian age, which is associated with dolomite, siltstone and red beds. The phosphorite is considered to have been deposited as a single bed within upper Sirban Formation. Subsequent repetition is due to imbrication with plunge of deposit towards north as a result of Himalayan orogeny. The repetition of the ore bodies has been identified and explored as (1) Eastern Phosphorite,(2) Lagarban South phosphorite (3)Bataknala phosphorite and (4) South phosphorite. Assaying revealed that average P20S, MgO, and H203 in the above mentioned ore bodies are 29%, 0.26% and 3.47%; 28.6%, 2.2% and 3.7%; 30.2%, 3;8% and 2:2%; and 29.6 %, 2.5% and 2;8% respectively. Collophane is dominant phosphate mineral with minor as dahlite. The gangue minerals are dolomite, chalcidony, opal, quartz, goethite, chlorite, pyrite, mica, clay minerals, and organic matters. The phosphorite was deposited in a relatively calm sea in Lagarban to Bataknala whereas the East phosphorite was deposited in a very shallow sea with abundant wave activity.
Key words: Phosphorite, economic geology, Abbottabad.

A/576. Ashraf, M., 1997. The principle subdivisions of the Kamila amphibolites redefined in Kohistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p. 10.

The so called Kamila amphibolite was studied in details and was subdivided. The Kamila amphibolite in the area around Kamila-Dassu along the Indus canyon was subdivided into Dassu, Kayal, and Pattan complexes. The former Dassu is typical amphibolite formed from the metamorphism of plutonic rocks which is extremely deformed, poly-metamorphosed, epidote-garnet amphibolite banded gneiss. The metamorphic P-T conditions for Dassu are 5.5-6.5 kb and 520-580°C. The Kayal and Pattan plutonic complexes are locally metamorphosed to amphibolite with igneous hornblende and layering. The Dassu complex has limited aerial extent toward west whereas it extends beyond Thak valley in the east without Kayal and Pattan. The Pattan complex, however, is exposed intermittently westwards with outcrops near Khwazakhela, Landai, Tighak, Shahpur (Aspanr), etc. The ocean floor related tholeiitic amphibolites herein are called as Dir amphibolites which are found west of Lilunai everywhere as continuous outcrops to sporadic occurrences showing underplated relationship with calc alkaline arc related stuff like Chilas complex, Dassu, Kayal and Pattan complexes. Therefore, the Kamila amphibolite term may be disregarded and new subdivisions be followed which are different mineralogically/chemically and environmentally.
Key words: Amphibolite, Kamila, Kohistan.

A/577. Ashraf, M., 1998. Dir Amphibolite as an Ocean Floor Theoliites Underplated by Kohistan Calcalkaline Rocks in N. Pakistan. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 20-22.

Geological mapping of 673 km^2 area of Timargara-Lal Qila and Wari of District Dir NWFP was recarried out for the study of Petrology, structure, geochemistry etc. (first detail work after Chaudhry et. at., 1974 and 1974a). The area is part of the western extremity of Kohistan Island Arc, where the Mesozoic amphibolitized ocean floor of Kohistan in the south is sutured to the gneisses of Indian plate.

The amphibolites exposed in the southern and northern extreme of the mapped area were the parts of a single ocean floor under which the arc was built. These amphibolites were formed by the metamorphism of basic volcanics and pillow lavas of tholeiitic affinity. The subordinate interlayered sediments of argillaceous, arenaceous and carbonate composition were deposited on ocean floor away or near mid oceanic ridge (MOR). The concentration of metasediments in the southern exposure is relatively less and thin as compared to northern part of amphibolites where thick piles of these sediments were evident (Chaudhry et al., 1974a). The amphibolites exposed in the Dir area are different from Kamial amphibolites which were formed by the metamorphism of basic plutonic rocks like Dassu and Kayal complexes (Ashraf, 1997; Loucks et al., 1992). The Dassu complex represent the base of Kohistan Island Arc and is exposed near or around Nanga Parbat Syntexis due to uplifting and uncovering of base rocks. Whereas Dir amphibolites represent the supra crustal material of Kohistan under which the arc was built.

The discrimination diagrams show that Dir amphibolites are basalts and of tholeiitic character, as is evident from the SiO_2 and total alkalies (Cox and Panhurst, 1979) plots. The K_2O-TiO_2-P_2O_5 diagram (after Pearce et al., 1975) plots of Dir amphibolites show mainly oceanic floor volcanic nature. In AFM diagram (after Irvine and Baragar, 1971) most of the Dir Amphibolites plot in the tholeiitic field. Similarly, trace elements plots also indicate the tholeiitic nature of Dir Amphibolites.

The plutonics rocks exposed in the area consist of norite, gabbronorite, diorite, tonalite, trondhjemite, granite/adamellite, and quartz porphyries/aplites/pegmatites are intruded in the Dir amphibolites and were expose due to uplifting and uncovering of amphibolites. But the presence of small and large roof pendant of amphibolite in these plutonic rocks (which previously were called xenoliths and screens of amphibolites) evident the presence of amphibolites over there.

AFM diagram for norites, gabbronorites, diorite, tonalite, granites, adamallites, aplites and quartz porphyries display a calc alkaline nature of these rocks, Al_2O_3 Vs An reveal calc alkaline nature for the plutonic rocks in the Irvine and Baragar (1971) diagram. The Babien (1980) diagram plots Tio_2 Vs FeO/MgO for the Dir Plutonic rocks classifying them as orogenic rocks showing emplacements of plutonic magma during collision, underplating the oceanic crust of MORB nature.

Generally three types of ultramafic rocks are exposed in the mapped area. The first type of ultramafic are highly altered and metamorphosed. These ultramafic rocks are present as exotic blocks in amphibolites; the second types are those, which are present as roof pendent over the surface of some plutonic, rocks (i.e. granite adamellite and diorite). These ultramafic were emplaced in oceanic crust (amphibolites) during its development at MOR. The third type of ultramafics which are mostly hornblendites and scyelites are exposed both in amphibolites and plutonic rocks, were probably fractionated as hydrous magma and ascended to higher levels due to buoyancy acquired by their magmas as a result of residual liquid enrichment.

Structural studies shows that the rocks of Kohistan Island Arc exposed in the area are folded into northward dipping southward verging tight folds in the south (near MMT) which opens up northwards. The amphibolites has undergone at least two phases of isoclinal folding. In the first phase of recumbent or isoclinal folding S1 axial planner foliation was developed in these rocks. The first phase of deformation is probably related to the subduction of Kohistan mass under Eurasian plate. In the second phase these rocks were again folded. The second phase is probably related to the subduction of Indian plate under Kohistan. The rocks of Kohistan mass have undergone a third phase of deformation, which produced the shear zones and a retrograde metamorphism to chloride grade.

The southern part of Dir amphibolites near MMT mostly trend EW and dips 65 to 80° northwards, which is almost parallel to the trend of MMT. In the central portion of the mapped area, the plutonic rocks trend NE to SW and their dips varies from 40o to 70o NW and SE. Most of the fold axis in plutonic sequence is parallel to each other which mostly trend NE to SW and plunges from 12 to 50°. The northern part of Dir amphibolites mostly trend NE and dips 150 to 60º SE.

Key words: Amphibolite, petrology, Kohistan arc, Dir.

A/578. Ashraf, M., Ahmad, M. & Faruqi, F.A., 1976. Jurassic bauxite and kaolinite deposit of Chhoi area, Kala Chitta Range, Punjab, Pakistan. Geological Bulletin, University of Punjab 12, 41-54.

Sedimentary reworked bauxite and kaolinite deposits have been found in the Kala Chitta area for the first time. These deposits are of Jurassic age and they occur on an erosional unconformity at the top of Triassic rocks. Due to reworking of bauxite and kaolinite from the same source area the physical appearance of these deposits is almost identical. The bauxitic zones are occasionally more compact than the kaolinite zones. The basal bed always consists of kaolinite. The alternations of bauxite and kaolinite continue upward. This cyclic deposition is conceived due to alternate deposition of kaolinite and bauxite. Moreover, the occurrence of bauxitic nodules in the kaolinite zone at places show that the whole deposit is of reworked nature and cyclic. These bauxite and kaolinite zones have been evaluated in detail by chemical, X-ray and D. T. A. methods.
Key words: Economic geology, bauxite, kaolinite, Jurassic, Kala Chitta, Punjab.

A/579. Ashraf, M., Ali, R.S., Khan, H., Hamood, O., Asghar, I. & Zaidi, S.H., 1997. Some new informations on the geochemistry and economic geology of Timargara area, Dir District, NWFP. Geological Bulletin, Punjab University 31 & 32, 69-78.

Key words: Geochemistry, economic geology, Timargara, Dir.

A/580. Ashraf, M. & Chaudhry, M.N., 1974a. Geology of Dadar pegmatites, Mansehra area, Hazara District, Pakistan. Geological Bulletin, University of Punjab 10, 59-66.

Six complex pegmatite bodies have been located in the Dadar area. They are zoned. Most of the zones have been completely reconstituted. It is conceived that they are granite pegmatites, which have been derived from sodic solutions with gradual enrichment in potassic phase. The reconstitution occurred at pneumatolytic stage forming cleavelandite, muscovite and beryl. Replacement by tourmaline is local. In one of the pegmatites the replacement by cleavelandite is so extensive that small islands of mirocline perthite are left as relicts in the intermediate zone, even the outermost zone (wall zone) has also not survived replacement.
Key words: Pegmatites, Mansehra, Hazara.

A/581. Ashraf, M. & Chaudhry, M.N., 1974b. Quartz, quartz-ilmenite and quartz-kyanite veins in the Mansehra Batgram area of Hazara District. Geological Bulletin, University of Punjab 10, 67-72.

Simple quartz, quartz-ilmenite and quartz-kyanite veins have been found in the area. Simple quartz veins occur both in the metamorphics as well as in the granites. But quartz-ilmenite and quartz-kyanite veins have only been found in the metamorphics so far. They range from mere stringer to many hundreds of feet in dimensions. They are lensoid, lenticular and lenticular branching type. They are thought to be products of hydrothermal solution and metamorphic differentiation.
Key words: Quartz-Ilmenite/Kyanite Veins, Mansehra, Hazara.

A/582. Ashraf, M. & Chaudhry, M.N., 1974c. The geochemistry and petrogenessis of albitites from Mansehra and Batgram area, Hazara District, Pakistan. Geological Bulletin, Punjab University 11, p.97.

Consult Ashraf and Chaudhry, 1976 below.
Key words: Geochemistry, petrogenesis, albitite, Mansehra.

A/583. Ashraf, M. & Chaudhry, M.N., 1976a. Geology and classification of acid minor bodies of Mansehra and Batgram area, Hazara Division, Pakistan. Geological Bulletin, University of Punjab 12, 1-16.

Seven types of acid minor bodies have been identified in the Mansehra and Batgram region of Hazara division on the basis of their mineralogical composition and structures. The acid minor bodies classified are 1) albitites, 2) aplites, 3) simple pegmatites, 4) complex pegmatites, 5) albitized or replacement bodies, 6) composite bodies and 7) quartz veins. Subclasses of these minor bodies are made possible by detailed field and microscopic studies. They are distributed in the area in such a way that each type has a direct bearing on the site where it has crystallized. Three zones have been recognized, i) Interior-lateral zone (1750-5500 feet above sea level, containing albitites, albite-aplites/pegamtites, albite-(micorcline)-aplites/pegmatites), ii) interior-marginal zone 5000 to 9000 feet above sea level containing albite-microcline-aplites/pegmatites, microcline-albite-aplites/pegmatites and some complex pegmatites), and iii) marginal exterior zone (over 9000 feet above sea level; containing mainly complex pegmatites). The acid minor bodies vary in thickness from less than a centimeter to over 20 meters and in length from one to 100meters and occur as lensoid, lenticular branching, pinch and swell, patch, pod, pytgmatic, tabular bodies with regular and sharp boundaries and irregular to diffused contacts in a few cases. Internal structure of the bodies varies from one type to another. Zonation is perfect in some pegmatites. In other types the textural variation is marked from wall inwards.
Key words: Classification, acid bodies, Mansehra, Batgram, Hazara.

A/584. Ashraf, M. & Chaudhry, M.N., 1976b. The geochemistry and petrogenesis of albitites from Mansehra and Batgram area, Hazara District, Pakistan. Geological Bulletin, University of Punjab 13, 65-85.

Albitites are present in the granites and associated metamorphic rocks of the Mansehra and Batgram area. They have been classified as syenitic albitites of three distinct types: 1) pegmatitic albitites, 2) medium-grained albitites and 3) fine-grained albitites, the two former being associated with the granites and the latter with the metamorphic rocks. The albitites occur as streaks stringers and 1 – 10m wide and 5 – 70m long bodies. They occur either independently or as composite bodies and are associated with albite-aplites and albite-(microcline) aplites. The shape of these bodies is tabular to lensoid, showing usually sharp contact relationships with the granite and metamorphics. Mineralogically these rocks are usually formed of albite with quartz, muscovite, rutile, sphene, chlorite and apatite; zircon, tourmaline and magnetite may also be present. Chemically they contain SiO_2 66-67 %, Al_2O_3 19-21%, Na_2O 9-11%, K_2O 0.2 – 0.7%. The origin of these rocks is evaluated in the light of recent experimental work in the granitic system at 4 to 10 Kbs and it has been suggested that at a water vapor pressure 10 Kbs the granitic system shifts towards albite, thereby forming albititic solutions whose deposition and crystallization took place in fissures of the host rocks with gradual cooling of the system.
Key words: Geochemistry, petrogenesis, albitite, Mansehra.

A/585. Ashraf, M. & Chaudhry, M.N., 1976c. Origin of chessboard albite present in the acid minor bodies of Mansehra and Batgram area, Hazara Division, Pakistan. Geological Bulletin, University of Punjab 13, 93-98.

Primary chessboard albite is widely developed in the albitites and albite-aplites/pegmatites. Replacement and stress or deformation is also postulated for the development of chessboard albite on a minor scale. Exsolution chessboard albite is found only in a few complex pegmatites in the outer intermediate zone. Exsolution is shown by mirocline.
Key words: Albite, Mansehra, Batgram, Hazara.

A/586. Ashraf, M. & Chaudhry, M.N., 1977a. A discovery of carbonatite from Malakand. Geological Bulletin, Punjab University 14, 89-90.

Carbonate rocks carrying vermiculite and iron oxides were reported by Fayyaz and Shafiq from near the village of Silai Patti which is 19 miles from Dargai (in the Malakand Agency) on the Dargai Bajaur road. The

authors studied the area and carried out laboratory studies on the rocks and concluded that the rocks were carbonatite bodies. Following is a brief description of the occurrence.
The carbonatites occur as dykes, sills and ring type bodies in the pelitic-psammitic schists of possibly Pre-Cambrian age (The dykes and sills are from 50' x 10 feet to 300' x 60 feet). The politic rocks have been thrust against calcareous and quartzitic rocks of Cambrian age intruded by granites (Chaudhry et al. 1976, E.C.L. 1977).
The rocks are composed of calcite, arfvedsonite, siderite, ilmenite/magnetite, vermiculite, apatite, chlorite and some feldspar. The minerals show uneven distribution and local segregation. The rocks are coarse grained and from porphyritic to subporphyritic. Calcite is the main mineral and ranges from 50 to 90% in most cases. However, where Fe-Ti oxides or vermiculite increase in amount the amount of calcite may fall below 50%. Some siderite crystals are also present.
Vermiculite occurs unevenly distributed and ranges in size from 1 mm to 3 mm and occasionally upto 8 cm in size. Fe-Ti oxides (magnetite/ilmenite) are generally below 5% however, at a few places they may be as high as 50% 9as pods and lenses). These oxides occur from subhedral to anhedral crystals. Arfvedsonite ranges from 2 to 25% of the rock. It forms subhedral to euhedral crystal. Apatite ranges from 2 to 12%. It occurs as subhedral to anhedral crystals. It may be partly enclosed by the carbonates. Vermiculite and amphibole at places alter to chlorite. K-Feldspar ranges from 0 to 5%. It occurs as randomly distributed crystals.
Key words: Carbonatite, Hazara.

A/587. Ashraf, M. & Chaudhry, M.N., 1977b. A chromium muscovite bearing zoned complex aplite from hill Khwar, Batgram area Hazara Division, NWFP, Pakistan. Geological Bulletin, University of Punjab 14, 39-44.

A chromium muscovite bearing zoned complex aplite has been reported for the first time from the Batgram area of Hazara Division. The aplite, which occurs in the pelitic metamorphics close to the contact of the granite gneiss, shows two well-developed zones i.e., an intermediate zone and a core. One chemical analysis, one spectrographic analysis and one modal analysis of each of the zone along with their normative composition is presented. One analysis of chromium muscovite is also presented. Both the zones contain chromium muscovite but the core is distinctly rich in this mineral. The intermediate zone contains 800ppm and the core contains 1000pmm chromium. The relative enrichment in chromium in such a body is attributed to contamination with the host metamorphics.
Key words: Muscovite, Hill Khwar, Batgram, Hazara.

A/588. Ashraf, M. & Chaudhry, M.N., 1980. Clayey bauxite and clay deposits of Kotli District, Azad Kashmir. Contribution to the Geology of Pakistan 1, 87-112.

Bauxite and underlying fireclay deposits occur over an erosional unconformity of possibly post Mesozoic age in the two big inliers of Kotli District, Azad Kashmir. Thickness of the bauxite so far noted is highly variable, being at a maximum in Nikial area (upto 2.4 m thick). The thickness of clay ranges from 0.6 to 2.5 m. Irregularities in thickness are mainly erosional/depositional. Dip of the deposits generally varies between 10^0 to 20^0. Mineralogically the bauxite consists of boehmite, gibbsite, kaolinite, quartz/chalcedony, haematite/limonite, pyrite, carbonaceous matter and chlorite. The fireclay consists of major kaolinite and minor gibbsite, boehmite, quartz/chalcedony, haematite/limonite, pyrite, carbonaceous matte, calcite, chlorite and tourmaline (studied by microscopic, D. T.A. and X-ray methods).
Chemically the bauxite rocks contain $A1_2O_3$ (X=49. 8B, S= 7. 08), SiO_2 (X= 27.93, S= 8.10), Fe_2O_3 (X= 4.87, S= 4.96). The fireclay Rocks contain $A1_2O_3$ (X= ~8. 47, S= 9.34). SiO_2 (X= 41 . 54, S= 9. 34) and Fe_2O_3 (X= 2. 68, S= 3. 27).
The results of spectrochemical studies are also presented.
Industrial studies show that the silica content is difficult to reduce by physical processing methods. Soda-lime sinter process and/or pechiney acid process may be applicable for the ore. Bricks were prepared using four samples of fireclay of Kotli mixed with plastic clay from Mianwali. A mixture containing 35% plastic clay gave better results compared to a mixture with 25% plastic clay. The crushing strength of the former was higher than the latter. The proved and inferred reserves of the bauxitic ore are of the order of 2.722 million tons and 5. 577 million tons respectively. And that of the fireclay are 3.228 and 21.177 million tons respectively.

Mining of the exposed deposits along with fireclay deposits will be possible by open cast/quarrying method. The working face be laid out in steps. The bauxite step will be leading by 15 feet.
Key words: Bauxite, Economic geology, Kotli, Azad Kashmir.

A/589. Ashraf, M. & Chaudhry, M.N., 1984a. A Cambrian unconformity represented by Galadanian Formation in Abbottabad District, North West Frontier Province, Pakistan. Abstracts, First Pakistan Geological congress, Lahore, 19, 19-20.

Consult Ashraf and Chaudhry, 1987 below.
Key words: Unconformity, Galadanian Formation, Cambrian, Abbottabad.

A/590. Ashraf, M. & Chaudhry, M.N., 1984b. Petrology of Lower Siwalik Rocks of Poonch Area Azad Jammu and Kashmir. Kashmir Journal of Geology 2, 1-10.

Sandstone (lithic arenites) and shale of Lower Siwalik of Poonch area have been studied petrographically, chemically and spectro-chemically. By comparing the overall composition of these rocks and specially the types and compositions of the rocks fragments in sandstone, it has been established that these rocks have been derived from the crystalline as well as sedimentary rocks lying due north towards the Pir Panjal Ranges.
Key words: Petrology, Siwalik Molasse, Poonch, Azad Kashmir.

A/591. Ashraf, M. & Chaudhry, M.N., 1985. Crystalline graphite deposits of Agra-Silai Pattai area Malakand Agency, NWFP, Pakistan. Kashmir Journal of Geology 3, 1-12.

The crystalline graphite occurs in Agra-Silai Pattai are at a distance of 32 to 40 km by truckable road from Dargai railway station. The graphite is a part of the pelitic-psammitic rocks of the area. Important graphite bearing rocks occur in Silai-Patti, Haspur South, Haspur North, Agra and Rang Dheri localities. The thickness varies from about 5m to 52m and the deposits extend intermittently over a length of 8 km. The petrographic study showed that graphite and predominant grain size upto 0.25mm. While flakes more than 0.5 to 1mm were rare. The crystalline graphite contents in the rock are 19.32, 18.32, 21.70 and 17.53% on average in the localities mentioned above.
The dominant gangue minerals in the rock are quartz(X=31.8 to 40.79), muscovite (X=23.01 to 35.83), geothite/limonite/haematite (X=7.43 t0 9.57), boehmite (X=1.19 t0 4.10), and minor andalusite, pyrite, feldspar, clay, magnetite, epidote, chlorite, tremolite, sillimanite etc. The ore microscopy and X-ray studies confirm the presence of crystalline graphites.
Chemically the graphite rocks contain carbon (X=14.99 t0 17.82), amorphous carbon (X=1.41 t0 1.80), SiO2 (X=50.78 to 54.15), Al_2O_3 (X=12.48 to 14.113), Fe_2O_3 (X=7.20 to 7.39), FeO (X=0.60 to 0.87), MgO (X=1.27 to 2.02), CaO (X=0.29 to 1.13), Na_2O (X=0.63 to 0.81), K2O (X=2.43 to 3.08), H2O (X=0.99 to 1.22).
Textural relations suggest that graphite may be released as particles passing about 70 BBS mesh. This limits the recovery of flakes of appropriate size which would have otherwise produced flakes in appreciable quantities. However, optimum liberation of graphite was found to be between 200 to 250 BBS mesh for achieving better flotation. Reserves of inferred category are 16.10 million tonnes which include 2.94 million tonnes of indicated category.
Key words: Graphite, Economic geology, Silaipatti, Malakand.

A/592. Ashraf, M. & Chaudhry, M.N., 1986. Plate tectonic and mineralization associated with alkaline province, N.W.F.P., Pakistan. Abstracts, Symposium/Workshop on Plate Tectonics and Crust of Pakistan. Institute of Geology, Punjab University, Lahore, 1-2.

Nepheline syenite and associated alkaline rocks are known from north western part of Pakistan as an alkaline igneous province trending WSW-ENE. Important exposures so far known are at Loe Shilman, Warsak, Malakand, Shewa, Koga and Tarbela. The distribution of the alkaline magmatism in a narrow belt suggest a zone of crustal weakness during late Eocene/Oligocene in the Indian block and was caused by the influence of compression. Butt Chaudhry and Ashraf (1980) proposed that while the leading edge of the Indian plate was being collided with Asian

block, compressional ‘features were produced within the zone of deformation a complimentary zone of tension was created within Indian block. These tensional opening provided sites for intrusion of highly alkaline magmas.
The economically important alkaline magmatism is seen in Koga area as medium to coarse grained nepheline syenite, sodalite nepheline syenite, foyalites, litchfieldite and carbonatites. The first four rocks are prone to ‘beneficiation to produce a product useful for the manufacture of colourless glass and quality ceramic wares. The carbonatites are quite interesting as they contain Ce (0.07%), Sr (0.9 to 2.46%), Y (0.005%), Ba (0.09%). Apatite contents are quite interesting as it is about 15 & 18% in two samples of carbonatites, 5 and 6% in fenite and lamprophyres.
Interesting occurrences of carbonatites are found by Ashraf and Chaudhary (1977) in Malakand. They occur as composite bodies having Nb (100-300 ppm), Sr (0.3%), V (0.01%), Y (100 to 200 ppm), Zr (0.01%), Sc (traces) La (400 ppm) and Yt (3 to 5 ppm). P2O5 in the six samples studied is 6 to 12%. Loe Shilman is also very interesting deposit regarding trace/rare earth elements and phosphate contents.
Key words: Mineralization, nepheline syenite, plate tectonics, alkaline provinces.

A/593. Ashraf, M. & Chaudhry, M.N., 1987. A Cambrian unconformity represented by Galdanina Formation in Abbottabad District, NWFP, Pakistan. Kashmir Journal of Geology 5, 43-49.

In Abbottabad District Galdanian Formation is formed at the top of Abbottabad Formation. The Upper Abbottabad Formation contains marine phosphorite deposit which laterally changes over to turbidite phosphorite bed associated with Galdanian variegated beds and to Galdanian continental deposits. It is evident from such lithologies that in Upper Abbottabad times the geological environments were such that deep sea conditions were lacking. However, the continental to shelf environments were dominating. In the deeper shelf conditions normal inorganic precipitation of phosphorite was in progress whereas bauxitization and lateritization was occurring continuously on projections (small islands) above sea level. The intervening zones between continental projections and sea conditions contained reddish to brown red siltstone, brownish red cherty dolomite, reddish cherty siltstone or chertstone and overlain fine-grained quartzose siltstone.
The present study, therefore, envisages that phosphorite is facies equivalent of Galdanian Formation whereas Hazira Formation is definitely younger than both of them and is possibly not related to Galdanian Formation.
Key words: Unconformity, Galdanina Formation, Cambrian, Abbottabad.

A/594. Ashraf, M., Chaudhry, M.N. & Baloch, I.H., 1991. Sedimentary petrology of Lagarban phosphorite, Northern Pakistan. Kashmir Journal of Geology 8 & 9, 25-38.

The Lagarban phosphorite of Cambrian age occurs in the Hazara District of Northern Pakistan in the upper dolomite member of the Sarban Formation. The geology is complicated by imbricate reverse faults which run more or less parallel to the regional strike and separate the phosphorite into the different structural blocks of Largarban phosphorite, Bataknala phosphorite, East phosphorite, South phosphorite and Middle phosphorite. The displacement along the imbricate faults appears to be large, because the rocks of different facies of phosphorite have been brought into juxtaposition. The faults separate the East phosphorite of shallow water marine facies from the western phosphorite of open-marine facies. This is confirmed by petrographic study of the two major types. The former type shows evidence of reworking of the phosphate and associated sediments, whereas the latter type is represented by undisturbed, normal deposition of phosphate oolites and associated dolomite.
Key words: Sedimentology, petrology, phosphorite, Abbottabad, Hazara.

A/595. Ashraf, M., Chaudhry, M.N., & Hussain, S.S., 1979a. Magnetite deposits of Lower Kohistan district, Hazara division. The Pakistan Metallurgist, 1, 2. & 1980, 2(1, 2), 15–23.

Key words: Mineral deposits, magnetite, Kohistan, Hazara.

A/596. Ashraf, M., Chaudhry, M.N. & Hussain, S.S., 1979b. Petrology of Koga nepheline syenites and pegmatites of Swat District. Geological Bulletin, Punjab University, Special Issue.

Key words: Petrology, nepheline syenite, pegmatite, Swat.

A/597. Ashraf, M., Chaudhry, M.N. & Hussain, S.S., 1979c. Molybdenum mineralization associated with igneous-metamorphic rocks in Kohistan-Swat Districts along Karakoram Highway. Pakistan Metallurgist 1 & 2, pp. 11-14.

Key words: Mineralization, molybdenum, igneous, metamorphic, Kohistan, Swat.

A/598. Ashraf, M., Chaudhry, M.N. & Hussain, S.S., 1980. General geology and economic significance of the Lahore granite and rocks of southern ophiolite belt in Allai Kohistan area. Geological Bulletin, University of Peshawar 13, 207-213.

Geological mapping of the toposheets (43 $^{B}/_{13}$ and $^{F}/_{1}$) carried out shows the following rock units in Besham-Kohistan and Allai areas: (1) Granitic rocks: Lahore granite and associated Shang granite gneiss and Mansehra (Susalgali) granite gneiss (2) Metamorphics: Thakot group, Tanawal group, Salkhala series, Hazara type slates and dolomitic rocks and amphibolites (garnet amphibolite and normal ortho-amphibolites) (3) Jijal ultramafics: dunite/peridotites and pyroxenites. Economic mineral deposits found so far are magnetite (in skarns, hornblendites and ultramafics), sphalerite/galena (in skarns, veins and altered granite), chromite (in dunites/peridotites and pyroxenites) and molybdenite (in silicified skarns, altered, altered granites and pegmatites). Anomalous values of Sn, W, Bi, Cd and Mn mineralization have been found in skarns, altered and silicified Lahore granite. The skarn type mineralization appears to be associated with the Precambrian Lahore granite rocks, which have intruded into the rocks equivalent to Salkhalas. This granite is unconformably overlain by Hazara type slates and Abbottabad Formation (dolomitic).

Two very important structural features have been noted in the area. They are one older thrust separating Thakot group and associated Lahore granitic rocks and Tanawal group and associated Mansehra granite gneiss. The other very major thrust is the Main Mantle Thrust bringing ophiolite/amphibolite rocks onto Lahore granite, Thakot group, Tanawal group, Mansehra granite gneiss and the Salkhalas.

Key words: Granites, economic geology, ophiolites, Lahore, Allai Kohistan.

A/599. Ashraf, M., Chaudhry, M.N. & Hussain, S.S., 1987. Mineralization associated with the alkaline rocks and carbonatites in NWFP, Pakistan. Kashmir Journal of Geology 5, 51-64.

Nepheline syenite and associated alkaline rocks are known from northwestern part of Pakistan as alkaline igneous province trending WSW-ENE. Important exposures so far known are at Loe Shilman, Warsak, Malakand, Shewa, Koga and Tarbela. The distribution of the alkaline magmatism in a narrow belt suggests a zone of crustal weakness during late Eocene/Oligocene in the Indian block and was caused by the influence of compression. Butt, Chaudhry, and Ashraf (1980) proposed that while the leading edge of the Indian plate was being collided with Asian block, compressional features were produced within the zone of deformation, a complimentary zone of tension was created within Indian block. These tensional opening provided sites for intrusion of highly alkaline magmas.

The economically important alkaline magmatism is seen in Koga area as medium to coarse-grained nepheline syenites, sodalite nepheline syenites, foyaites, litchfieldites and carbonatites. The first four rocks are prone to beneficiation to produce a produce useful for the manufacture of colorless glass and quality ceramic wires. The carbonatites are quite interesting as they contain Ce (0.07%) Sr (0.9 to2.46%), Y (0.005%), Ba (0.09%). The P2O5 contents are quite interesting as they range from 15 & 18% in two samples of carbonatites, 5 and 6% in fenite and lamprophyres.

Interesting occurrences of carbonatites were found by Ashraf and Chaudhry (1977) in Malakand. They occurs as composite bodies having Nb (100-300 ppm) Sr (0.3%) V (0.01%), Y (100-200 ppm), Zr (0.01%), Sc (traces), La (400 ppm) and Yt (3-5 ppm) P2O5 in the six samples studied is 5 to 11%. Loe Shilman is also very interesting deposit regarding race/rare earth elements and phosphate contents.

Key words: Mineralization, alkaline rocks, carbonatites, NWFP.

A/600. Ashraf, M., Chaudhry, M.N. & Hussain, S.S., 1994. Geology of the lead - zinc-molybdenum, copper and iron skarns of Besham area Kohistan, NWFP, Pakistan. Kashmir Journal of Geology 11 & 12, pp. 1-27.

At the leading edge of Indo-Pak plate magnetite, sphalerite, galena, chalcopyrite, molybdenite etc. bearing skarn mineralizations occur in the Besham group of rocks. Geologically the Besham group or rocks consists of psammites, pelitic psammites, pure to impure carbonates, graphitic pelites and Lahor basement granitic complex including small to large acid pegmatite bodies. Exotic small ultrabasic to basic metamorphosed intrusions are also found at places. Base-metal mineralization has been found in rocks of carbonate character i.e. they are pure carbonate to impure carbonate rocks. In the former magnetite is the dominant replacive mineral as grain, streaks, patches, lenses etc. with overall contents of 12 to 96%. The impure carbonate rocks formed well-developed skarn mineralogy with sphalerite and galena as major base-metal minerals with contents of 1 t0 15% along with molydenite at places.
It is envisaged that magmatic solutions evolving from Lahor granitic complex and its derivatives were responsible for the development of skarn mineralogy and base-metal precipitation in three stages. The stage I was magnetite carbonate skarn. The stage II was for the formation of dense base-metals, developing in impure carbonate rocks with skarn minerals like pyroxene (CPX), amphibole, calcite/dolomite, pyrite/pyrrhotite, garnet, epidote, pyrolusite/puenselite etc. This is overlapped by silicification of stage II mineralogy (surrounding metasediments and apophyses of granite, as patches lenses and lenticular bodies increasing the base - metal contents in them. The stage III is subsequently developed from stage II as vein formation.
Key words: Skarns, Metallic mineralization, Besham

A/601. Ashraf, M., Chaudhry, M.N. & Malik, R.H., 1984. Bituminous/anthracitic coal of Kotli District, Azad Kashmir. Abstracts, First Geological Congress, Lahore, 54-55.

Consult the following account.
Key words: Coal, Kotli, Azad Kashmir.

A/602. Ashraf, M., Chaudhry, M.N. & Malik, R.H., 1986. Bituminous and anthracitic coal of Kotli District, Azad Kashmir. Kashmir Journal of Geology 4, 1-12.

Coal occurs at two horizons within Patala Formation in the Kotli anticline (a continuation of Riasi anticline in Jammu). Most commonly the coal lies over the bauxite as in Sawar, Tattapani, Dondili and Karela. The second horizon occurs within the carbonaceous shales about 9 to 15m above bauxite bed as in Kamroti, Barmoach, Bangang and Nikial. The exposed thickness of individual seams ranges from 0.02 to 1.0m which in underground working is from 1.0 to 2.2m in thickness.
Petrographic studies of coal show the presence of carbonaceous matter (X=63), Clay (X=30.14), quartz (X=2.79) haematite/limonite (X=2.53), carbonate (X=0.12), and muscovite/sericite (X=0.24). Carbonaceous shale has the same minerals as in coal but in quite different proportions. Chemical studies of the coal indicate a wide range of variation. The coal samples can be classified as high fixed carbon (max. 86.75%) to low fixed carbon (35.31%), low volatile matter (7.25 to 13.56%) low ash (down to 3%) and high ash (26 to 49%) Coal.
Washibility study on coal samples shows that using sink/float, heavy media separation and flotation techniques on different size fractions such as 25X4 mm, 4X0.5 mm and less than 0.5 mm reduced ash from 34% to 21% and sulphur from 3.4% to 1.2%. This shows that coal is amenable to cleaning to a limited extent as ash forming mineral matter is uniformly and finely disseminated in the coal. Some coal samples collected from Balmi, Sohra Seri, Kamroti, Bangang and Kandel are low in as (3.32% to 14.61%) and high in fixed carbon (51.56 to 86.75%). These coals can be blended with clean coal from other localities of Kotli to obtain a product containing 14 to 16% ash. Such a coal blend may be used for cooking purposes. The Kotli coal is of bituminous to anthracitic variety having decidedly better rank than any of the coal deposits found in Pakistan so far. The numerous coal exposures all along the strike on both limbs of eroded anticline are encouraging and are indications of the occurrence of large coal deposits.
Key words: Coal, Kotli, Azad Kashmir.

A/603. Ashraf, M., Chaudhry, M.N. & Qureishi, K.A., 1983. Stratigraphy of Kotli area of Azad Kashmir and its correlation with standard Type areas of Pakistan. Kashmir Journal of Geology 1, 19-30.

In Kotli area, rocks, Precambrian to Pleistocene age have been found and studied. The Precambrian rock formation is, Dogra Slate which has been reported by author for the first time in Nail Nala. Cambrian rocks are correlated with Abbottabad Group (consisting of basal boulder bed and overlain by thick sequence of Sirban dolomite/quartzite). In this area apart from Cambrian (Abbottabad Group) all the formation of Paleozoic and Mesozoic are missing. Either they were not deposited ore were weathered to form bauxite/laterite-representing an unconformity of a big gap. In the Tertiary period Patala Formation, Margalla Hill limestone, Murree Formation and rocks of Siwalik Group were deposited. Section measurements were done to establish the stratigraphy etc.
Key words: Stratigraphy, Kotli, Azad Kashmir.

A/604. Ashraf, M. & Faruqi, F.A., 1973. Diaspore and clay deposits of Kala Chitta Range, Punjab. Abstracts, 24th Pakistan Science Conference, Islamabad, p.H-6.

Key words: Diaspore, clay, mineral deposits, Kala Chitta, Punjab.

A/605. Ashraf, M. & Hamood, O., 1997. Tectonic reinterpretation constraints of the Western most Kohistan complex in Timargara, Dir District, Pakistan. Geological Bulletin, University of Peshawar, 30, 311-323.

No detailed tectonic and structural studies were carried out in the western most extremity of the Kohistan area. People have been concentrating mostly along Indus canyon and Swat valley for geotectonic, structural, petrological and geochronological studies. Present investigation is the first study to thoroughly work out tectonic reinterpretation constraints of the western most Kohistan complex particularly in Timargara quadrangle and adjoining area of Warai consisting of 673 sq.km. The concept of underplating for the emplacement of major plutonic complexes is advocated in this area as well, as was also found out in Swat and Indus canyons, i.e., the Balambat norite and Timargara gabbronorite which are different from Chilas complex magma type underplated the Dir tholeiitic amphibolites. These plutonic rock types are more evolved than those of main Chilas complex. The latter underplated Dassu metaplutonic complex of Kamila amphibolites. The Kamila amphibolites are further subdivided into Kamila group metaplutonic calc-alkaline amphibolites and Dir metavolcanic tholeiitic amphibolites or precisely as Kamila amphibolites and Dir amphibolites which are advocated to be adopted due to their different provenances.
Key words: Tectonics, Kohistan complex, Timargara, Dir.

A/606. Ashraf, M., Hamood, O. & Khan, H., 1999. Structural geology of the western extremity of the Kohistan Island Arc in Dir area, NWFP. Geological Bulletin, Punjab University 33 & 34, 71-81.

Structural studies show that the rock of Kohistan island arc exposed in the area are folded into northwards dipping southwards verging tight folds in the south (near MMT) which opens up northwards. The amphibolite have undergone at least IWO phases of isoclinal folding. In the first phase recumbent or isoclinal folding S1, axial planner foliation was developed in these rocks. The first phase of deformation is probably related to the subduction of Kohistan Island Arc under Eurasian plate. In the second phase these rocks were again folded. The rock of Kohistan Island Arc has undergone a third phase of deformation which produced the shear zones resulting into retrograde metamorphic chlorite grade rocks. That is related most probably to the collision of India plate with Kohistan complex. The southern part of the Dir amphibolite near MMT mostly trend EW and dips 65' to 80' northwards which is almost parallel to the trend of MMT. In the central portion of the mapped area the plutonic rocks trend NE to SW and their dips varies from 40’ to 70’ NW und SE. Most of the fold axes in the plutonic sequences are parallel to each other which mostly trend NE to SW and plunges from 12’ to 50’. The northern part of the Dir amphibolites mostly NE and dips 15O to 60’ SE.
Key words: Structure, Kohistan island arc, Dir.

A/607. Ashraf, M., Haq, R., Qureshi, M.H. & Faruqi, F.A., 1971. Magnesite occurrence in Hazara District. Pakistan Journal of Scientific and Industrial Research 14, 538-541.

Magnesite occurs as three lens-like bodies near Sherwan (Hazara) in the Abbottabad Formation of Upper Paleozoic system. Total length of two outcrops is around 900 ft and width about 150 ft. The third outcrop is 150 ft. long and 20 ft wide. The deposit is probably hydrothermally metasomatized type. The properties of the magnesites were determined by utilizing microscopic, chemical, X-ray diffraction and differential thermal techniques.
The conclusion drawn from the results obtained is that ores are fairly rich in magnesite with some minor impurities such as calcite, hematite, clay, siderite, quartz and limonite.
Key words: Magnesite, economic geology, Hazara

A/608. Ashraf, M. & Hussain, K. 1994. Economic geology and mineralogy of PGE-Au in dunite of Chilas, northern area-Pakistan. Abstracts, Second SEGMITE International Conference on the Export Oriented Development of Mineral Resources and Mineral Based Industries, 20-21.

Platinum group elements (PGE)-gold (Au)-copper (Cu) occur in dunite rocks of Thurli and Chilas in northern area of Pakistan. Dunite rocks in Thurli are dominantly fresh olivine rich from 93-98%. The impurities are CPX 2 to *5%*, chromite/magnetite 1 to 2% and sulphides like covellite, chalcopyrite, bomite, pentlandite, chalcocite and pyrrhotite containing PGE and Au from 0.2 to 2%. The olivine is dominantly forsterite (Fo 85-92%). In a 50m dunite zone near Thurli Cu is about 0.4%, Ni 0.2%, PGE + Au 800 ppb to 2800 ppb. The POE minerals are moncheite, michinerite and merenskyite with electrum and tetra-auricuprite as Ag. Au and Au.Cu alloys. Texturally dunite in Chilas area is very compact to moderately compact with grain size of about 0.3 to 2mm. The valuable POE+Au+Cu+Ni bearing minerals of Thurli dunite can be liberated by crushing the dunite rocks down to 0.3 to 1.0mm size. With the removal of valuables, the tailings obtained are pure forsterite sand. The size of such deposit near Thurli is about 30 million tonnes and the one that is pure compact forsterite is 50 million tonnes near Chilas.
Key words: Economic geology, platinum-group mineralization, dunite, Chilas Complex.

A/609. Ashraf, M. & Hussain, S.S., 1983. Chromite occurrences in Indus Suture ophiolites of Jijal, Kohistan, Pakistan. In: Sinha, K.A. (Ed.), Contemporary Geoscientific Researches in Himalaya 2, 129-132. Singh, Dehra Dun, India.

Key words: Chromite, Jijal, Indus suture, Kohistan.

A/610. Ashraf, M., Khan, M.A. & Asghar, I., 1999. Geotechnical properties of Balambat norite, Panjkora diorite and hornblendite of Timargara area, Dir District, NWFP. Geological Bulletin, Punjab University 33 & 34, 149-156.

Gabbronorite, norite, diorite and hornblendite occur as very large to large deposits in the Kohistan Island Arc of Timargara area Dir district. These rocks are very fresh and compact at many places. Texturally Balambat norite and Panjkora diorite are fine to medium grained whereas hornblendite are medium to coarse grained. The rocks were tested to know their geotechnical properties for usefulness as building material and as polished dimension stones/slabs. The tests carried out are like absorption of water, soundness, compression/crushing strength. Absorption value of norite is 0.59% maximum, of diorite is 1.01%, and that of hornblendite is 0.98%, soundness value for fine losses is 0.83%, 1.05% and 1.05% respectively for sieve size 35". Unconfined compressive strength is 8644, 6483 and 6915 PSI respectively. These rocks take good to very good polish and are thus useful as decorative stones and for building purposes.
Key words: Geotechnical, norite, diorite, hornblendite, Dir.

A/611. Ashraf, M. & Khan, M.S., 1992. General geology & stratigraphy of Muzaffarabad and Poonch area in Azad Jammu & Kashmir. Abstracts, First South Asia Geological Congress, Islamabad, p.51.

General Geology and stratigraphy of the Poonch and Muzaffarabad areas are quite interesting due to fact that various formations in Hazara, Azad Kashmir and occupied Kashmir are continuous in Precambrian to Cambrian & Tertiary Time and discontinuous during rest of the Paleozoic and Mesozoic times. From this it appear that there were definitely some stratigraphic barriers in those areas but they were not as reported by Ghazanfar and Chaudhry (1987) the three stratigraphic provinces. In our view the three regions had same geological environments during Precambrian times, depositing Sharda/Salkhala sediments overlain by Hazara/Dogra Slates and Tanol quartzites and pelites. The Cambrian conditions remained similar as well in all the three areas by depositing dolomites, limestone etc of Abbottabad Formation, with Tanakki unconformity at base. In all the three stratigraphic areas, during Late Cambrian times unconformity is seen in Hazara in the form of Galdanian Formation, (Ashraf et al. 1983), with subsequent non-deposition till the formation of Datta/Sarnanuk Formation of Jurassic and further Cretaceous formations. But there are no such formations even upto Late Cretaceous times in the Muzaffarabad -Kotli basin. That is, a pre-Tertiary unconformity is regionally present in Hazara, Kashmir, Potwar & Salt Range. Whereas in Kahuta-Pir Panjal Range Gondwana Formation of Carboniferous age occurs and are not seen in other two basins. Panjal Group of rocks consisting of pyroclasts and lava flow occur as rift related submarine to aerial rocks in both Kahuta and Muzaffarabad areas with Triassic sediments at places. And lastly there was only one basin/geosyncline forming Paleocene to Lower Miocene rocks everywhere.
Key words: Stratigraphy, Poonch, Muzaffarabad, Azad Kashmir.

A/612. Ashraf, M., Khan, M.S., Awan, M.A., Yasir, A., Warraich, M.Y., Khan, A. & Awan, M.S., 1991. Geology and petrology of Jijal and Pattan layered ultramafic-mafic complexes in the vicinity of Jijal, Duber and Pashto, NWFP, Pakistan. Kashmir Journal of Geology 8 & 9, 193-196.

The project area covers about 300 km^2 located in the vicinity of Jijal, Duber and Pashto (Fig. 1) in Districts of Kohistan and Mansehra. Geological mapping was carried out of the area on a scale 1:50,000 of toposheet No. 43A/12, 43A/16, 43E/4 and 43F/1 of Survey of Pakistan.
The geological sequence of Jijal complex consists of ultramafic and mafic cumulates. The ultramafic cumulates are divided into dunite, wehrlite, websterite, garnet-pyroxenite and garnet-hornblendite whereas mafic cumulates are garnet gabbro. The geological sequence of Pattan complex also consists of ultramafic and mafic cumulates, the ultramafic cumulates are chromite, dunite and (meta)-wehrlite, whereas mafic cumulates are divided into two pyroxene gabbronorite and two pyroxene quartz-diorite.
Previously, the metamorphosed mafic complexes of the Kohistan island arc have been lumped together as an undifferentiated mass called Kamila amphibolite. Now, the Kamila amphibolite has been divided into three complexes i.e., Dassu complex, Kayal complex and Pattan complex. The Dassu complex is the oldest pluton which is polymetamorphosed, isoclinally folded and banded amphibolite augen gneiss that grades from metatonalite at its top downward to melancratic garnet amphibolite at its base some 5 to 6 km down section. Dassu complex is underplated by the Kayal complex, has a metamorphosed agmatitic intrusive breccia at its roof and grades downward from moderately banded metadiorite gneiss in it upper part to melanocratic garnet-amphibolite at its base. Again Kayal complex is being underplated by the Pattan complex which is least metamorphosed partly to greenschist facies. The Pattan complex is underplated by Jijal complex.
Field evidences suggest that the Pattan complex was emplaced along the pre-existing metamorphosed Kayal cumulate complex. The top of the Pattan complex is marked by a spectacular, intrusive, polymictagmatite breccia. In Duber and NW of Duber the Pattan complex is overthrust on to the Jijal complex. While in Pattan area and SE of Pattan, there is a faulted (strike slip) contact between Pattan complex and Jijal complex.
The Jijal complex is the southern most, layered ultramafic-mafic cumulate complex of the Kohistan tectonic province, the Main Mantle Thrust (MMT) is the southern boundary of the Jijal complex, which in turn is the southern boundary of Kohistan arc complex. The Main Mantle Thrust (MMT) and Duber thrust wedges out Jijal complex NW of Duber near Charri, on the other hand Main Mantle Thrust and Pattan fault (strike slip fault) wedges out the Jijal complex on the eastern side near Pashto.
Key words: Petrology, ultramafic complex, Jijal, Kohistan.

A/613. Ashraf, M. & Loucks, R.R., 1991. Platinum-group element mineralization in high-pressure, layered, ultramafic-mafic cumulates of the Jijal and Chilas complexes. Abstracts, 1st Postgraduate Training Course in Plate Tectonics, Punjab University, Lahore, 8-9.

Key words: Platinum-group mineralization, mafic-ultramafic, cumulates, Jijal, Chilas.

A/614. Ashraf, M. & Loucks, R.R., 1992. New concepts in geology, petrology and economic potential of the Kohistan island arc, northwest Himalayas, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.5.

Key words: Petrology, economic geology, Kohistan arc, Himalaya.

A/615. Ashraf, M., Loucks, R.R., & Awan, M.A., 1989. Serpentinization of cumulate ultramafites and development of Heazlewoodite-Pentlandite-Awavruite-Magnetite and Pentlandite-Chalcopyrite-Pyrrhotite association in Alpurai and Khishora, Swat, Pakistan. Kashmir Journal of Geology 6 & 7, 8-18.

Ultramafics of Alpurai and Khishora areas of Swat District have been found to occur as cumulates. These ultramafic bodies occur along the Main Mantle Thrust which marks the part of the suture zone between the Asina and Indo-Pakistan plates. The present study elaborates the classification of ultramafics of the two areas, their chemico-mineralogical composition, distribution of minor elements, ore microscopy and electron microprobe composition of some sulfides. The Alpurai rocks are found to be, stratigraphically upward, hurzburgits, olivine websterite, wehrlite, dunite, wehrlite, websterits, dunite and lherzolite. All these members are altered variably to serpentine minerals. The Kishora rocks are dominantly a part of a of an ultramafic mantle tectonite i.e., a harzurgites which is overlain by dunite. All these rocks are pervasively serpentinized. In both Alpurai and Kishora areas nickel mineralization is present in two distinct ore mineral assemblages as heazlewoodite-awaruite-pentlandite-magnetite and pentlendite-chalcopyrite-pyrrhotite-pyrite associations respectively. These associations appear to have developed from hydrothermal alteration of ultramafic rocks by the introduction of water, sulfur and or carbon dioxide. The Ni values found in the ultramafic rocks appear to be low i.e. 1500-2000 ppm. But most of Ni is in the form of nickel sulfides and alloy.
Key words: Ultramafics, Metallic mineralization, Alpurai, Kishora, Swat.

A/616. Ashraf, M. & Malik, M.I., 1983. Prospects and development of phosphate deposits of Lagarban area Abbottabad, Pakistan. Kashmir Journal of Geology 1, 77-82.

Sedimentary Phosphorite of Lagarban is 7.831 million tonnes as in-situ rock and is 5.093 million tonnes recoverable reserves from East, Bataknala, Southern and Lagarban South Phosphorite. 840 tonnes can be mined per day. The undiluted ore contain 28.55 to 30.20 % P_2O_5 in the four ore bodies. Mineralogically the ore consists of collophane with minor dahllite as phosphorite minerals. The other ubiqutous to accessory minerals are dolomites, chalcedony, chert, quart, goethite, pyrite, chlorite, clay, mica, organic matter etc. It is that variation in grade and the proportion of impurities is a function of original sedimentary variations, and the amount and nature of contamination and dilution during and after the deformation are by physical & chemical mechanisms. The beneficiation of the ore is possible by HMS and acid leaching methods but the proposition appears expensive. However, ROM blending with Jordan ore may be viable after some more plant trials and tests.
Key words: Phosphate, mineral deposits, Abbottabad.

A/617. Ashraf, M., Qureshi, M.H. & Faruqi, F.A., 1972. Geological and chemical characteristics of dolomite from Hazara and Mardan Districts. Science and Industry, Pakistan, 9, 62-66.

Chemical analyses and brief mineralogical details are given for 14 samples of dolomite rock suitable for use in ceramics and metallurgy.
Key words: Economic geology, dolomite, Hazara, Mardan.

A/618. Ashraf, M., Qureshi, M.H. & Faruqi, F.A., 1975. Studies on quartzite and ganister–raw materials for refractories from NWFP and Punjab. Geological Bulletin, University of Peshawar 7 & 8, 89-100.

Quartzite and ganister have been located and studied from different areas of NWFP and Punjab for the manufacture of silica refractories. Brief geology of silica bearing rocks of those areas is given discussed. In the laboratory the samples were studied and analyzed for their mineral constituents and oxide components. Furthermore, their physical properties have been evaluated for suitable uses for the manufacture of silica refractories. It is found out that quartzite from Attock and Haripur area is one of the best for refractory purposes while ganister from Musakhel and quartzite form Swabi and Tarbela can be used for making semi-silica bricks.
Key words: Mineral deposits, quartzite, refractories, NWFP, Punjab.

A/619. Ashraf, R., 1989. Electrical resistivity survey for groundwater investigations in an area between Quaid-i-Azam University and Murree Road with special emphasis on anisotropy. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 35p.

Surface electrical resistivity measurements were made at 20 geophysical observation stations in an area between Quaid-e-Azam University and Murree Road (longitudes 73° 7’ 48” to 73° 10’ 40” E and latitude 33° 43’ 55” to 33° 46’ 33” N), Islamabad in order to delineate the suitable ground water aquifer zones using Schlumberger electrode configuration keeping the maximum current electrode spacing AB/2= 200 meter with ABEM Terrameter. The interpretative results deduced various subsurface geological units named as clay, compact clay, gravels + clay + silt sand with minor amount of clay or silt, boulders (moist & dry).
For ground water investigation, the field resistivity data was interpreted by partial curve matching technique to obtain the interpreted electrical and geological sections in the form of vertical electrical and geological columns for each resistivity station. Besides, four geological sections have also been prepared. An anisotropic contour map has also been prepared to see the isotropic and anisotropic regions in the study area.
The combined interpretative results of all these maps indicate layers of permeable formations at various depths, but these formations are not good aquifers as the recharging mainly depends upon weather condition of the area, especially rain. The anisotropic contour map shows 3 anisotropic zones with a maximum anisotropy of 1.5. This anisotropy shows a good contrast in lithology which is due to boulder and compact clay.
Key words: Electrical resistivity, geophysics, groundwater, Islamabad.

A/620. Asif, M., Habib, M. & Jan, M.Q., 1985. Ultramafic and mafic rocks of Thurly Gah and their relationship to the Chilas Complex, North Pakistan. Geological Bulletin, Peshawar University 18, 83-102.

Detailed field and petrographic studies in Thurly area substantiate the idea of a two-fold subdivision of the Chilas Complex. Much of the area is occupied by the association of “Main Norites" with subordinate pyroxenites and anorthosites displaying only local layering. Apparently intrusive into these is the association of ultramafic-mafic rocks occurring principally in a 2.5x1 km lensoid body. These possess well-developed sedimentary features, especially layering and comprise dunite, peridotites, pyroxenites, troctolite, norite, anorthosite, and olivine/ pyroxene pegmatites, there are distinct differences in the mineralogy of the two associations, especially in the composition of plagioclase and oxide minerals. It is suggested that the ultramafic-mafic association was derived from a picritic magma emplaced in the floor of crystallizing (main) noritic magma. There is a strong concordance in the planar structures of the two associations and the crystallization of the ultramafic mafic rocks apparently preceded all deformational events.
Key words: Ultramafics, Thurley Gah, Chilas complex.

A/621. Asif, M., & Tahirkheli, T., 1980. Petrology and Mineralogy of Tarbela alkaline complex. M.Sc. Thesis, Peshawar University, 132p.

Key words: Petrology, mineralogy, alkaline complex, Tarbela.

A/622. Asim, M., Karim, A. & Khan, M.H., 1999. Geology of Shamozai area in Lower Dir District, NWFP, Pakistan. Geological Bulletin, University of Peshawar 32, 51-55.

Rocks of the Main Mantle Thrust and associated suites have been investigated in a 100 km2 area in southwestern Dir district. Field investigations and thin section study reveal that the succession of rock units from south to north is that of the Indian plate rocks, ophiolitic mélange zone, and Kohistan arc terrane. The Indian plate rocks comprise granitic gneisses along with minor calcareous schists and phyllites. The ophiolitic mélange zone, which is reported for the first time from the area, mainly comprises serpentinized dunite, talc-carbonate schist and crystalline limestone blocks in a matrix of phyllite and minor graphitic schist. The arc terrane is represented by amphibolites, intruded by quartz porphyries and tonalites in a number of places.
Key words: Metamorphism, Shamozai, MMT, Dir.

A/623. Asim, M., Majid, M. & Shah, M.T., 2000a. Geology, geochemistry and tectonic setting of ophiolitic rocks from the Waziristan ophiolite complex, NW Pakistan. Geologica 5, 109-132.

The Waziristan Ophiolite Complex occupies about 5000 km (super 2) area in a north-south elongated belt in the north and South Waziristan Agencies. It demarcates the spatial disposition of the suture zone between the Indian plate and the Afghan block in the Waziristan area. The complex consists of a chaotically arranged stack of thrust slices. Section(s) showing a complete sequence is not preserved but all members of a typical ophiolite are separately present in the area. Basic volcanics, ultramafics and jasperites within the ophiolite belt respectively contain copper, chromite and manganese. A 40 km (super 2) area near Boya, west of Miranshah in the North Waziristan Agency was selected for detailed study. Dominant rocks of the study area include basic lavas, ultramafics and gabbros with subordinate amounts of mafic dikes, granites, and pelagic sediments. Representative samples were studied in thin sections and analyzed for major elements. The major elements data of the studied rocks have been interpreted to reveal the tectonic environment at the time of generation and emplacement of the ophiolite sequence. The petrochemical indices of the mafic volcanics, in particular, correspond to a transitional character (from tholeiitic to calc-alkaline) developed in an island arc environment in general and MORB in little. The geochemical parameters substantiates the assumed prevalence of the arc-related structures in the Waziristan section of the suture zone before collision of the Indian plate and the Afghan block. On the basis of geological and geochemical signatures of the constituent rocks, it is suggested that the WOC was formed in supra subduction zone setting probably by marginal basin or back-arc basin rifting and was later on obducted on to the Indo-Pakistan plate.
Key words: Geochemistry, tectonics, ophiolites, Waziristan.

A/624. Asim, M., Majid, M. & Shah, M.T., 2000b. Mineral chemistry and origin of ophiolitic rocks from the Waziristan ophiolite complex, NW Pakistan. Geological Bulletin, University of Peshawar 33, 39-52.

Consult the following for more information.
Key words: Mineralogy, geochemistry, ophiolites, Waziristan.

A/625. Asim, M., Majid, M. & Shah, M.T., 2001. Mineral chemistry and origin of ophiolitic rocks from the Waziristan complex, NW. Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.1.

The Waziristan ophiolite complex demarcates the spatial disposition of the suture zone between the Indian plate and the Afghan block in the Waziristan area. The complex is located along the western margin of the Indian plate and consists of a chaotically arranged stack of thrust slices. Section(s) showing a complete sequence is not preserved but

all members of a typical ophiolite are separately present in the area. Dominant rocks include basic lavas, ultramafics, gabbros, dikes, granites, and pelagic sediments. Major minerals (pyroxene, spinel, serpentine and plagioclase) within the rocks were analyzed using Jeol Superprobe Micro-analyser. Pyroxenes from basalts, apparently crystallized at temperatures above 1000^{0}C, plot in the field of volcanic arc basalts and ocean floor basalts. Pyroxene and chromite data have been further interpreted to reveal the tectonic environment at the time of generation and emplacement of the ophiolite sequence. The pyroxene data show a transitional character (from tholeiitic to calc-alkaline) and ocean floor to island arc type environment. Chromite data, with moderate to high Cr#, also exhibit oceanic (abyssal) to arc affinities. The chemical data on pyroxene and chromite suggest a complex origin for the Waziristan ophiolite such as oceanic+island arc, back arc or infant arc.
Key words: Mineralogy, geochemistry, ophiolites, Waziristan.

A/626. Aslam, A. & Kaneda, H., 1993. Mineralogical study of the Kakul phosphorite deposit, Abbottabad District. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad, 7, 17-33.

The present study has been carried out as a research exercise to improve and evaluate the analytical precision of the XRD and Microscopic techniques. The XRD and Microscopic investigation of the Abbottabad phosphorite ore deposit shows considerably important information related to ore mineralization and mineral resource.
The following mineral species have been identified by means of the XRD analysis; dolomite, ferroan dolomite, calcite, quartz, hematite, hydroxyapatite and fluorapatite. On the basis of XRD, volume and weight percentages of constituent minerals of ores have been determined. The volume percentage data shows that the carbonaceous minerals in the studied area consist mostly of ferron-dolomite. Relatively large amounts of ferroan- dolomite occur within phosphorite ore beds and in the associated rocks. In particular, the ores from the northwestern sites (Q site in Figure 1) are rich in ferron-dolomite, which occupy 24.5 volume % of all specimen. The volume % relationship among carbonate minerals, quartz and apatite minerals shows that ore samples from the Q site are relatively rich in carbonaceous minerals compared to quartz. The ore grade of the Q site is higher than the Kakul mine site. It is considered that ferroan dolomite and large amounts of carbonaceous minerals are associated with ore formation. The weight percent analysis has been performed on the basis of standard calibration method, and belongs to the technique of quantitative analysis. The data shows that the carbonaceous minerals / quartz weight values are quite different in the two sample sites. The carbonaceous minerals / quartz ratios vary from 0 to 0.5 for the mine site and on the contrary, range from 1.04 to 19.6 for the Q site. This suggests that the ore at the mine site is relatively rich in quartz. This result is identical with the data of volume percent analysis. Microscopic observation gives more useful information about the mineralogy and mode of occurrence of minerals. A major ores forming phosphorite mineral is cellophane which is an aggregate of amorphous P-bearing hydrous phases. The collophane often occurs in a host dolomite mass filling the interstices and cavities. The massive phosphorite ores show the following two distinctions with respect: to the minerals occurring along grain boundaries of collophane. One is that the cement is composed mostly of calcite, and another is that the cement is predominantly quartz. The former occurrence is from the Q-site, khile the latter from the mine site. This occurrence under the microscope is concordant to the XRD results. It is concluded that carbonaceous minerals, in particular ferroan-dolomite and the carbonate/quartz ratio plays an important role in ore formation. In order to make clear the ore genesis and to evaluate the ore resources, mineralogical and geochemical studies are essential.
Key words: Phosphorite, economic geology, Abbottabad

A/627. Aslam, A. & Thewissen, J.G.M., 1996. Preliminary evaluation of paleosols and implications for the interpretation of vertebrate fossil assemblages, Kuldana Formation, northern Pakistan. Palaeovertebrata, 25, 261-277

Key words: Vertebrate Paleontology, Paleosols, Kuldana Formation.

A/628. Aslam, M., 1964. The chemical study of rocks contacts from Mansehra area, Hazara. M.Sc. Thesis, Punjab University, Lahore, 42p.

Key words: Geochemistry, Mansehra, Hazara.

A/629. Aslam, M., 1979. Uranium exploration in Pakistan. Proceedings, International Seminar on Mineral Exploitation Technology. PCSIR, Peshawar.

Key words: Mineral exploration, Uranium.

A/630. Aslam, M., Din, A. & Faruqi, F.A., 1984. Industrial minerals used in the glass industry. Abstracts, First Pakistan Geological Congress, Lahore, p.27.

Silica sand, feldspar, nepheline syenite, limestone and dolomite are the principal naturally occurring industrial minerals that are used in the glass industry. This paper describes briefly their occurrence, formation, mineralogy, physical and chemical characteristics and their utilization in the glass industry. Physical and chemical characteristics of these minerals suited to the glass industry have also been discussed. Since silica sand is the main and important constituent of all commercial glasses, samples of sand from all commercially exploited deposits were collected and chemical analyses of raw as well as washed samples, including grain size distribution and some other properties, have been determined and compared. Similarly, chemical and physical properties of some other minerals collected from different parts of Pakistan have been determined and discussed with particular reference to their use in the glass industry.
Key words: Minerals (Industrial), Glass industry.

A/631. Aslam, M., Khan, A. & Khan, R.N., 1999. Revised stratigraphy of the Khyber Agency, NWFP, Pakistan. Additional abstracts, IGCP 421, North Gondwanan mid-Palaeozoic Bioevent/Biogeography Pattern in Relation to Crustal Dynamics, Peshawar Meeting, 1p.

Key words: Stratigraphy, biostratigraphy, Khyber Agency.

A/632. Aslam, M., Khan, A., Khan, R.N., 2000. Geological Map of Chitral district, NWFP, Pakistan. GSP Geol. Map Series, NWFP. Map 1.

Key words: Geological map, Chitral.

A/633. Aslam, M., Khan, M.A. & Sadin, M., 1982. Geology of Gandao quadrangle, Mohmand Agency, NWFP, Pakistan. GSP, Information Release, 130, 24p.

Key words: Gandao, Mohmand Agency.

A/634. Aslam, M. & Khan, S., 1979. Geology of pegmatites of upper Neelum valley, Azad Kashmir. GSP, Information Release 112.

Key words: Pegmatites, Neelam Valley, Azad Kashmir.

A/635. Asmatullah, Saeed, M. & Latif, M., 2002. Electrical resistivity investigation of groundwater in Rawla Kot area, Azad Kashmir. Geological survey of Pakistan, Information Release 762.

Key words: Geophysics, electrical resistivity, groundwater, Rawla kot, Azad Kashmir

A/636. Asrarullah, 1960. Geology of chromite in West Pakistan. CENTO Symposium on chrome ore, Ankara, Turkey, CENTO Publication, 38-53.

Key words: Chromite, geology.

A/637. Asrarullah, 1961a. Chromite and its mining in West Pakistan. Pakistan Geological Review 16(2), 1-13.

Key words: Chromite, chromite mining.

A/638. Asrarullah, 1961b. Chromite mining in Pakistan. Natural Resources 1(2), 17-22.

Key words: Chromite, chromite mining.

A/639. Asrarullah, 1962. Some decorative building stones of West Pakistan. Natural Resources Magazine 1(8), 21-24.

A compilation of data on the occurrence of marble, limestone, and granitic, dioritic, and other rocks suitable for building or ornamental stone in West Pakistan; includes descriptions of individual deposits
Key words: Decorative/Building Stones, Marble, Khyber, Swat.

A/640. Asrarullah, 1963a. Marble deposits of West Pakistan. CENTO Symposium on Industrial Rocks and Minerals, Lahore, 179-188.

Key words: Marble, Swabi, Khyber.

A/641. Asrarullah, 1963b. Rock salt resources of Pakistan. CENTO Symposium on Industrial Rocks and Minerals, Lahore, 303-313.

Key words: Rock Salt.

A/642. Asrarullah, 1963c. Rock salt resources of Pakistan. Pakistan Geological Review 18(1).

Key words: Rock Salt, Kohat, Salt Range.

A/643. Asrarullah, 1972. Non-glamorous economic mineral resources of North West Frontier Province. Geological Survey of Pakistan, Geonews II, No. 2, 47-55.

Key words: Mineral resources, NWFP.

A/644. Asrarullah, 1976. Iron ores in Pakistan. Geological Survey of Pakistan, Information Release 108, 33p.

Key words: Economic geology, Iron ore.

A/645. Asrarullah, 1978. Iron ores in Pakistan. National Seminar on Development of Mineral Resources, Lahore March 6-9, 116-137.

Key words: Economic geology, Iron ore.

A/646. Asrarullah, & Ahmed, Z., 1984. Water potential and climatology of the Parachinar Valley. GSP, Mineral Information Release 1, 33p.

This paper is a study of the Parachinar valley, describing the physiographic and climatic conditions of the area. Data are given on glaciers, mean monthly temperature and rain fall ranges and water resources along with recommendations for optimum use of water resources.
Key words: Water resources, climatology, Parachinar, Kurram Agency.

A/647. Asrarullah, Ahmad, Z. & Abbas, S.G., 1979. Ophiolites in Pakistan: An introduction. In: Farah, A. & DeJong, K.A. (Eds.), Geodynamics of Pakistan. GSP, Quetta, 181-192.

Key words: Ophiolites, Bela, Zhob, Waziristan, Kohistan.

A/648. Asrarullah, & Ali, S.I., 1963. Damar Nisar iron ore deposit of Chitral State, West Pakistan. CENTO Symposium on Iron Ore, Isphahan, CENTO Publication, 403-409.

Key words: Mineral deposits, iron ore, Damar Nisar, Chitral.

A/649. Asrarullah, & Hussain, A., 1984. Marble deposits of North West Frontier Province, Pakistan. Geological Survey of Pakistan, Information Release 128. 23p.

A study of marble deposits of the North West Frontier Province of Pakistan has been carried out in the years 1983 and 1984 primarily to update the previous work on this commodity and also to additionally investigate some of the new and the little known occurrences.
The marble deposits in the area under study are mostly associated with metasedimentary rocks of varying age and composition, displaying a wide array of colour shades and grain sizes. The marble from most of these deposits has a pleasing appearance, takes good polish and meets the standard specifications for specific gravity, water absorption, flexural strength and other physical properties.
Key words: Marble, Mullaghori, Khyber, Swabi, Swat.

A/650. Atudorei, V., Baud, A. & Sharp, Z.D., 1995. Late Permian and early Triassic carbon isotope and sequence stratigraphy of the northern Indian margin. Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETCH Zurich) Switzerland.

The Northern part of Great-India was subjected to an early rifting phase in the late Paleozoic, just at the end of the large scale Gondwanian glaciation. The beginning of the rifting processes is marked by large hiatuses and discontinuities (paraconformities) between the early or middle Paleozoic sedimentary succession and the discontinuous middle-late Permian Panjal Traps and transgressive sediments. The North Indian passive margin consists of the present High and Lower Himalaya and a small part of the Indian craton and its sedimentary cover (from Zanskar, Chamba and Kashmir synclinoria to the Salt Range), and belongs to an upper plate separated from a lower plate (Ladakh and Karakoram continental crust with their former sedimentary cover) at the end of the Permian (Baud et al., 1989). The Permian rift shoulder is partly located in the N Lahul-Kashmir Himalaya and part of it in the underthrusted Lower Himalaya. The rim basin (landward of the shoulder) is developed in the Potwar-Salt Range area.
From rifting to drifting stages (early late Permian to early Triassic time) the sedimentary evolution is characterised by three transgressive-regressive (T-R) second order cycles. These overlie the Panjal Traps plateau basalts, which were deposited during the Murgabian time on the broad rift shoulder.
Profiles of inorganic carbon and oxygen stable isotopes were studied in marine carbonates from the Himalayan province (Guryul Ravine and Palgham, Kashmir; Salt Range, Pakistan; Thini Chu Valley, Kali Gandaki, Nepal).
The first T-R cycle (upper Murgabian to lower Dzulfian) is fully developed on the rim basin and consists of the transgression and the growth of the Wargal shallow carbonate platform. On the rift shoulder, this T-R cycle is present only in Kashmir with the sandy limestone of the Member A and B of the Zewan Formation. Positive $\delta^{13}C$

values (+2-4‰) occur within this first T-R cycle. In Central Nepal, stratigraphic indications are too scarce as to the age of the Thini Chu Group.
The second T-R cycle (Dzulfian-lower Changhsingian) corresponds to a sudden terrigenous influx occurring both on the rift side and on the land side. A shallow water mixed carbonate-clastic ramp is developed in the rim basin (Chhidru Formation) and overlies the Wargal shallow carbonate platform. To the north, the submerged part of the shoulder develops an offshore mixed clastic carbonate deltaic complex, the upper Zewan Formation (Member C and D). Positive $\delta^{13}C$ values (+2-4‰) occur for both areas, but a large shift of about 3‰ is recorded with the regressive phase of this cycle. This important negative excursion is documented worldwide. It is thought to be due to the oxidation and removal of the light organic carbon stored on the emerging continental shelf, after the huge regression marked by the Permian-Triassic boundary. On the emerged part of the shoulder, the marine Kuling sandstones and shales are transgressing on older sediments. This T-R cycle, with the marine submersion of the shoulder, indicates the beginning of the thermal subsidence and the transition to the drifting stage.
The third T-R cycle belongs to the Lower Triassic and is characterized by an important change in sedimentation. The age of the first transgressive sediments is still in dispute; it is either latest Permian or earliest Triassic (age of the lowest *Otoceras* zone and the problems of reworking during transgression). The first transgressive sediments consist of high energy dolomitic grainstone with glauconite and reworked quartzarenite (Lower Katwai Member) in the Salt Range area, of thin bedded *Claraia* limestones and shales with “Permian brachiopods” overlain by black shale with ammonoid lenses in Kashmir (Member El and E2 of the Khunamuh Formation) and of high condensed nodular limestone (Otoceras beds) in the Tethys Himalaya (Panjang member).
At the Kashmir sections, the negative excursion of $\delta^{13}C$ continue in the Early lnduan Otoceras zone and the lowest value (-4‰) is reached in the overlying Ophiceras zone. Above the low &‘3C value samples in *the Ophiceras* zone, we note a progressive rise in the 8130 values at the base of the overlying *Vishnuites* zone (late lnduan).
For the Thini Chu Valley profile, samples from the Panjang member (sensu Hatleberg & Clark, 1984) and the lower part of Tamba Kurkur Formation show negative values ($\delta^{13}C$=-0 5±0 7‰) with no significant trend suggesting a lower lnduan age and make possible the correlation with the E Member of the Khunamuh Formation from the Kashmir sections.
A generalisation of the pelagic limestone deposition corresponding to the maximum flooding surface is realised at the beginning of the late lnduan time with the Lower Ceratite Limestone in the proximal part of the margin (Salt Range) and thin, condensed Limestones and shales in the distal part.
It is interesting to note that the 8180 values for the KaIi Gandaki and Kashmir sections are very low comparative with Salt Range section and others Tethyan sections, ranging from -9‰ to -l2‰ (v.PDB). These low values can be explained by the thermal metamorphism process that affected the Kashmir and Nepal sections, documented by the high Color Alteration Index of conodonts (Wang, 1990; Garzanti et al. 1994). For the limestones from the base of Tamba Kurkur Formation (Kali Gandaki section) anomalous values of -20±3‰ occur. There is no correlation between carbon or oxygen values and the different types of carbonate cement.
Key words: Carbon isotopes, stratigraphy, Indian Plate, Late Permian, Early Triassic.

A/651. Auden, J.B., 1932/33. On the age of certain Himalayan granites. Geological Survey of India, Record 56, part 4, 461-471.

Key words: Granites, Himalaya.

A/652. Auden, J.B., 1934. Notes on the Biafo Glacier in Baltistan. Himalayan Journal 6, 67-76.

Godwin Austen, of the Survey of India, made the original survey of the Hispar and Biafo glaciers in 1860-1 (Survey Maps 42 P, 43 M), but did not reach their upper neve fields. He marked the Biafo as running almost due NW.-SE. In 1892 Martin Conway (now Lord Conway) made the first complete traverse of the two glaciers, starting from Hispar village, crossing the Hispar pass, and descending the Biafo to Askole. In his map the orientation of the Biafo glacier is more nearly NNW-SSE.
The Workmans visited the Biafo glacier twice, in 1899 and in 1908. The orientation of the glacier, as determined by them, corresponds more closely with that originally given by Godwin Austen. Neither Conway nor the Workmans were able to explore the snowfield or neve, called by the former Snow Lake, and on the modern map the Basin of the Biafo Glacier. The Workmans found snow conditions in this flat area too unpleasant.

On the 5th June we motored from Srinagar in heavy rain to Pahlgam, hoping to cross by Astanmarg and Amarnath to the Gamru valley, just below Machhoi (Map 43 N). The snow-line was found to be as low as 10,000 feet, and the Pahlgam coolies were unwilling to go over Astanmarg under such abnormal conditions. On the 6th we therefore motored back to Srinagar and on to Woyil bridge, marching the same day to Gund. The Leh route was followed over the Zoji La as far as the suspension bridge below Kargil (43 N, 52 B). We then branched down the Shingo river, dismissing our ponies at Olthing, and taking on men from there onwards at every stage. From Parkutta (43 M) we left early with excellent coolies for the ferry across the combined Shyok and Indus rivers. Across the ferry the Kiris coolies took us on to Narh. From Narh to Shigar is a short march. By taking this route one is saved a day, since the long detour through Skardu is avoided. Shigar was reached on the 16th. There was still too much snow on the south-west side of the Skoro La for that pass to be easily negotiable, so the longer route along the Shigar and Braldu rivers was followed. We hoped to reach Askole on the 20th, but were held up three miles from that village by late afternoon flooding of the streams, due to rapid melting of the glaciers by which they are fed.

There is little of interest along the route from Dras to Askole. The valley sides were barren and hot, and the apricots near the villages as yet unripe. We were unfortunately not told of the aquamarine mine at Dusso until arrival at Askole. At Chongo there is a series of hot springs which deposit extensive mounds of tufa. We bathed, buoyed up in bliss by effervescent bubbles of sulphuretted hydrogen. The temperature of the water in one spring was 98° F. De Filippi mentions it as 120° in 1909.

The 21st was spent at Askole collecting coolies. Besides the pukka coolies for transport, others were required for carrying up ata, and, after Camp 4, wood as well. After several hours of bickering, Gregory managed, with the help of some conjuring tricks with magnets and corks, to make them decide on a wage of Rs. 1 /1 per day, and a daily ration of 1 seer of ata. For economy we had not brought boots, except for the coolie mate or sirdar and one or two others. Apart from the factors actually responsible for the failure of the trip, this lack of boots would have eventually led to great difficulties, since the local paboos stand up very badly to wet snow conditions. In a good year it would not be necessary to provide boots for all the coolies, but solely for those taking part in the actual survey of the Snow Lake and in any climbing of the adjacent peaks. Under good conditions the glacier itself should be dry enough for the transport coolies to use their paboos.

Key words: Glaciology, Biafo, Baltistan.

A/653. Auden, J.B., 1935a. The snout of the Biafo Glacier in Baltistan, Geological Survey of India Records, 68(4), 400–413.

Key words: Glaciology, Biafo, Baltistan.

A/654. Auden, J.B., 1935b. Traverses in the Himalaya. Geological Survey of India, Records 69, 123-167.

Key words: Himalaya.

A/655. Auden, J.B., 1938a. Geological Results. In: Shipton, E. (Ed.), The Shaksgam Expedition, 1938. Geographical Journal 91, 335-336.

Key words: Expedition, Shaksgam.

A/656. Auden, J.B., 1938b. Resume of geological results, Shaksgam Expedition, 1937. Himalayan Journal 10, 40-48.

The area described in this account1 occupies about 2,000 square miles and is situated on both sides of the Karakoram Range, extending northwards up to the Yarkand river at approximately latitude 36° 22′ N. It is included partly within the provisional issues of Survey of India J-inch maps 42 p, 43 m, and 52 a. Most of our time was spent in the area covered by the as yet unpublished map 51 d. The visit was made in the company of E. Shipton (leader), H. W. Tilman, and M. A. Spender. I wish to record my thanks to Shipton for the invitation to join his expedition and for the well- planned arrangements that were made throughout. Spender and I had little of the worry connected with coolies and the distribution of food supplies, and were spared the monotony of relaying, which Shipton and Tilman

unselfishly supervised. Moreover, when mountaineering difficulties did occur, if was often their experience and skill which allowed us to carry out our programme.
It is true that geological work would have been easier and more detailed if I could have been relieved of carrying a rucksack loaded with personal and survey equipment, and had there been no necessity of keeping rigidly to a time-table. For reasons of economy, however, it was imperative to cut down the porters to the absolute minimum, and the rapid flooding of the rivers in July necessitated our being on the Indian side of the Shaksgam by a settled date. The flooding of the rivers, both daily in the afternoons, and seasonal as the summer progressed, became for us the chief bogy. Indeed, it was a fortunate spell of cloudy and snowy weather at the beginning of July which, by lessening the melting of the glaciers and lowering the Shaksgam, allowed us ever to return across this river. When I reached the Shaksgam with Lhakpa and Mahadi on the 28th June, after crossing the Aghil col, we were somewhat dismayed at the expanse of water, and had fears of all of us having to go north again, over the Aghil pass, with food exhausted, and the prospect of an uncertain welcome by Yarkandis below Bazar Dara.
Apart from the reconnaissance map of Professor Desio, which included the Panmah and Sarpo Laggo valleys and part of the Shaksgam, there were no topographical data upon which to base a geological map. Geological sketch plans were made throughout the expedition, and it is hoped to adapt these to the topographical map on which Spender has been working since our return. Spender tirelessly carried out the main survey, based on K2peak, 28,250 feet, while Shipton and I used a light 3-inch theodolite, belonging to the Royal Geographical Society and fitted with a Leica photographic attachment, to fill in details of areas he was not able to visit. These included the K2 glacier, surveyed by Shipton, and the lower Shaksgam valley and Nobande Sobande glacier, done by myself. Spender has the more difficult and exacting task of incorporating these results in the general map.

Key words: Expedition, Shaksgam.

A/657. Auden, J.B., 1939. Glaciers. Calcutta Geographical Review 1, 48-52.

This is a brief account of the occurrence of the glaciers of the Himalayan mountains.
Key words: Glacier.

A/658. Auden, J.B., 1956. Report to the Government of Pakistan on geological reconnaissance of damsites in the former Frontier Province of Pakistan. United Nations, FAO, Report 476, 56p, Rome, Geological Survey of Pakistan, File No. 762-25.

Key words: Dams, reconnaissance.

A/659. Auden, J.B., 1974. Afghanistan-West Pakistan. In: Spencer, A.M. (Ed.), Mesozoic-Cenozoic orogenic belts. Geological Society of London, Special Publication 4, 235-253.

Key words: Orogenic belts, Afghanistan, Pakistan.

A/660. Austromineral, Vienna, Austria, 1976. Indus Gold Project. Austromineral, Vienna, Austria. Final Report, 235p.

This is a detailed report dealing with the exploration of gold in the middle Indus valley, including study of placer deposits.
Key words: Gold, Exploration, Himalaya.

A/661. Austromineral, Vienna, Austria, 1978a. Feasibility study, mineral exploration and mineral development in Chitral district. SDA, Peshawar. Report, Part I & II, 291p.

The Chitral area has many showings of mineral occurrences of possible economic interest. Detailed studies were carried out by Austromineral of the area concerning exploration of the mineral occurrences.
Key words: Mineral exploration, Chitral.

A/662. Austromineral, 1978b. Mineral exploration and mine development, Chitral District. Report for Sarhad Development Authority, Peshawar.

The Chitral area has many showings of mineral occurrences of possible economic interest. Detailed studies of the district were carried out by Austrominerals. These studies concerned mineral exploration and mine development of the mineral resources.
Key words: Mineral exploration, mine development, Chitral.

A/663. Awais, M., 1991. Small scale mining and mineral based industries in North West Frontier Province. Proceedings, First SEGMITE Symposium, 1991, Peshawar, 27-33.

This paper gives a brief description and developmental cost estimates of some mineral deposits of the province. These include chromite, marble, barite, calcite, and abrasives.
Key words: Economic geology, NWFP.

A/664. Awan, A.R.A.A., 1986-88. Lithostructural mapping and Geology of Bagh-Sehri Area, District Abbottabad. M.Sc. Thesis, Punjab University, Lahore, 106p.

Key words: Structure, mapping, Abbottabad.

A/665. Awan, M.A., 1973. Petrology of Thellichi area with special emphasis on diorite complex (Gilgit Agency). M.Sc. Thesis, Punjab University, Lahore, 130p.

Key words: Petrology, diorites, Thellichi, Gilgit.

A/666. Awan, M.A., 1989a. Application of the olivine spinel and two pyroxene geothermometer to the Dargai ultramafic complex Pakistan. Kashmir Journal of Geology 6 & 7, 51-56.

Seven olivine-spinel and two pyroxene geothermometers were applied to the Dargai Ultramafic Complex, Pakistan. Using olivine-spinel geothermometer, the temperatures were estimated between 675 ^{0}C-825 ^{0}C whereas the temperatures fall between 900 ^{0}C – 950 ^{0}C when pyroxene data were plotted on pyroxene quadrilateral. This discrepancy is attributed more likely due to various degree of re-equilibration in two thermometers.
Key words: Geothermometry, mineralogy, ophiolite, ultramafics, Dargai, Malakand.

A/667. Awan, M.A., 1989b. Metamorphism of the obducted Dargai ophiolite, Pakistan. Kashmir Journal of Geology 6 & 7, 57-60.

The secondary minerals in the rocks of the Dargai Complex resulted through polymetamorphism. Field petrologic, and geochemical studies show that the complex passed through hydrothermal metamorphism at the mid oceanic ridges. A retrograde metamorphic event is discerned from the gabbroic mineral assemblages. The syn-tectonic metamorphism involved the obduction of the Dargai Complex which produced the dynamothermal effects in the underlying metasediments. The presence of antigorite and garnet mica schist near the southern (lower) boundary contact is related to dynamothermal metamorphism.
Key words: Metamorphism, geochemistry, ophiolites, Dargai, Malakand.

A/668. Awan, M.A., 1992. Petrotectonic interpretation of the Dargai ultramafics complex Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.52.

Field observation support the interpretation that the Dargai ultramafic complex is an ophiolite. These include (i) lack of major thermal effects at margins ii) absence of lamination in tectonites, and iii) fault contact, not intrusive contact with structurally underlying rocks.
It is proposed here for the first time that Dargai Klippe is sitting on the Main Mantle Thrust (MMT). The trace of the MMT in the surrounding area is missing due to extensive erosion below the MMT into Indian Plate rocks. The southern boundary fault of the Dargai complex is the trace of the MMT while the northern boundary fault is related to post -Eocene southward thrusting.
Petrologic data also support the contention that the Dargai complex is a supra-subduction zone ophiolite that constitutes part of the fore-arc shelf of oceanic crust in front of the Kohistan Island Arc. Petrochemical discriminant diagrams show that its lithologies have compositions corresponding to Oceanic Ridge Crust.
Key words: Petrology, tectonics, ultramafics, Dargai, MMT, Malakand.

A/669. Awan, M.A., 2000. A petrologic approach origin of the Dargai ultramafic-mafic complex of Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.120.

The Dargai Ultramafic-Mafic Complex occupies fore-arc position with respect to Kohistan Island Arc. The chemistry of ultramafic Tectonite and a Ultramafic cumulates represent the differentiated nature of the Dargai Complex which is marked by presence of more Mg. rich olivine in Tectonites than in Ultramafic cumulates.
Major and trace elements data of the rocks from the Dargai complex are plotted in a number of discriminant diagrams, which show:
i) Whole rock ppm Ba verses wt % Si02 indicates mid oceanic ridge affinity.
ii) Al/Ti from pyroxenes of the Dargai complex also indicates ophiolitic nature.
iii) Cr ppm verses Ti02 Wt % of the Dargai ultramafic represents its formation at supra-subduction stage.
The Dargai complex is quite distinct from Jijal and Chilas complexes as increase of K20 Wt % with respect to Na20 Wt % confirm it fore-arc position from the Shangla subduction trench.
Key words: Petrology, ophiolite, Malakand.

A/670. Awan, M.A., Khawaja, A.A. & Jadoon, I.A.K., 1991. Strike-slip faulting along the western boundary of Indian Plate, in Pakistan. Kashmir Journal of Geology 8 & 9, 117-120.

In northern and western part of Pakistan some strike-slip faults are considered lateral ramps of thrust sheets. However, in this area, systems of strike-slip Riedel R and R' shears is expected to develop due to a dominant component of simple shear along the western transform boundary of the Indian plate. The majority of strike-slip faults trend between N-S and NNW-SEE, close to the expected orientation of R shears. A few strike almost parallel to the expected orientation of R' shears. Faults close to R shears show sinistral and those to R' shears show dextral sense of displacement.
Both the orientation and sense of displacement suggest that the majority of these strike-slip faults are secondary Riedel shears, developed in response to plate scale sinistral simple shear, along the Chaman transform fault.
Key words: Structure, Indian Plate.

A/671. Awan, M.S., 1988-90. The geology and petrology of Jijal and Pattan layered ultramafics-mafic complexes in the vicinity of Jijal & Duber with special emphasis on petrogenesis of these complexes. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 90p.

The project area covers about 368 sq. Km. located in the vicinity of Jijal & Duber, District Kohistan. The work has involved geological mapping of the area on a scale of 1:50.000 of toposheet No. 43 A/16 of Survey of Pakistan. This thesis deals with the geology, petrography and petrogenesis of the Jijal and Pattan complexes in particular and the relation of these complexes with other complexes of Kohistan Arc complex has also been discussed.
The geological sequence of Jijal complex consists of ultramafic and mafic cumulates. The ultramafic cumulates are divided into dunite, wehrlite, websterite, garnet-pyroxenite and garnet-hornblendite, whereas mafic cumulates are garnet gabbro. The geological sequence of Pattan complex also consist of ultramafic and mafic cumulates. The ultramafic cumulates are chromite, dunite and (meta) wehrlite, whereas mafic cumulates are divided into two pyroxene gabbronorite and two pyroxene-quartz-diorite.

Field evidences suggest that Pattan complex was emplaced along pre-existing metamorphosed kayal cumulate complex. The top of the Pattan complex is marked by a spectacular, intrusive polymagmatitic breccia. In Duber and NW of Duber Pattan complex is overthrusted onto the Jijal complex, which is also a layered cumulate complex. While in Pattan area and SE of Pattan there is a faulted (strike slip) contact between Pattan complex and Jijal complex.
The Jijal complex is southern most, layered ultramafic-mafic cumulate complex of the Kohistan-Ladakh tectonic province. The Main Mantle Thrust (MMT) is the southern boundary of the Jijal complex, which interns is the southern boundary of Kohistan Arc complex. The Main Mantle Thrust (MMT) Duber Thrust Fault wedges out Jijal complex NW of Duber near Chert. On the other hand Main Mantle Thrust and Pattan Fault (strike slip fault) wedges out the Jijal complex on the eastern side near Pashto. The Jijal and Pattan complexes are generated by precipitation from subduction generated, hydrous, low K, picritic high Mg tholeiitic magmas and there is a strong possibility of finding economic metallic mineral deposits with in these layered cumulate complexes.
Key words: Petrology, Jijal, Pattan, Kohistan.

A/672. Awan, M.Z., 1999-2000. Geological mapping of Kohala-Muzaffrabad area with special emphasis on rock failure due to shale undercutting and road widening along Muzaffarabad-Kohala Road. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 61p.

The slopes along Muzaffarabad-Kohala roadways are highly disturbed during most part of year due to differential weathering conditions. Along the road at left bank of river Jhelum Murree Formation is exposed. Murree Formation consists of alternate bedding of Shale, Sandstone, Mudstone, Claystone, Silty clay and Silt. The rocks are differently weathered and tectonically highly disturbed due to Main Boundary Thrust (MBT). The Shales and Claystone are highly weathered, erodible during severe weathering conditions and undercut due to differential weathering, undercutting of sandstone, mudstone, claystone and siltstone results in rockfall, rockslide, rock toppling and wedge failure in the area. The area is divided into the stable and unstable zones to prevent undercutting, which induced failure. The rate of undercutting is measured. Ten sites were located along Muzaffarabad-Kohala located road for evaluation. The sites consist of road cut for road widening shale, mudstone, claystone, and siltstone undercutting. The sites were selected because the road was undercut by blasting and shale was undercut by differential weathering.
The amount of each site was carefully measured along the entire length of the cut information regarding the data of road cut was collected from Highway Department record. The measured rate of undercutting at road cut and the age of cut were used to estimate the rate of shale undercutting since the time of excavation. Samples of the undercutting units were collected from each site and tested for slake durability and Atterberg limits. The results suggest the shale undercutting can be remediated by grouting or installing bericles to prevent rockfall, rockslide and toppling failure.
Key words: Mapping, natural hazards, Muzaffarabad, Himalaya.

A/673. Awan, T.R., 1986-88. Geology and petrology of the Eastern Chilas calc-alkaline complex in the vicinity of Chilas (District Diamir) with special emphasis on petrogenesis of the rock units. M.Sc. Thesis University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 105p.

A geological map of 301 sq. km. between Pain Ges Gah Helor Gah in the north of the Indus River and Thurly Gah in the south in Chilas area is presented at the scale of 1:25,000 on toposheet No's 43 E/15, 43 I/9 and 43 I/7 issued by the survey of Pakistan.
Most of the project area lies in the vicinity of the north side of the eastern Chilas Complex. The exposed sequence of rocks in the project area is a part of the northern limb of the Chilas Complex, where ultramafic rocks occur in the core of the anticline and is overlain by norite, gabbronorite and diorites. This is capped by metadiorites of Early Jurassic age which is a part of Kamila Amphibolite.
Field and petrographic study show that the rocks of the Chilas Complex are formed with in a separate magma chamber and igneous in nature. There is younger silt like leuco dioritic pluton emplaced in metadiorite. The leuco diorite hosts a small ultramafic body which has probably been formed by a magmatic protrusion of ultramafic composition and is not related to ultramafic rocks in core of the Chilas Complex.
Key words: Petrology, petrography, Chilas Complex, Diamir.

A/674. Ayub, A., Ali, Z. & Rahman, Z., 1983. Petrography and microfacies analyses of Shekhan Formation, Kohat quadrangle, North West Frontier Province. M.Sc. Thesis, University of Peshawar, 173p.

Key words: Petrography, sedimentology, Shekhan Formation, Kohat.

A/675. Ayub, M., 1976. Report on lithostructural mapping of Paras area, Kaghan Valley with special emphasis on petrography and petrogenesis. M.Sc. Thesis, Punjab University, 127p.

Key words: Lithostructure, mapping, petrography, petrogenesis, Kaghan.

A/676. Ayub, M., Yusaf, M. & Lodhi, S.A.K., 1987. Pegmatitic albitites and aplites of Mansehra area, N.W.F.P., as indigenous raw materials for pottery wares (Cornish stone). Abstract with Programs, Mineral Resources and Geology of Pakistan, Quetta, Pakistan.

Key words: Pegmatite, albitite, aplite, pottery, economic geology, Mansehra.

A/677. Ayub, M., Yusaf, M., Lodhi, S.A.K. & Ashraf, M., 1987. Pegmatitic albitites and aplites of Mansehra area, N.W.F.P., as indigenous raw materials for pottery wares (Cornish stone). Acta mineralogical Pakistanica 3, p.66.

Consult the following account for further information.
Key words: Pegmatite, albitite, aplite, pottery, Mansehra.

A/678. Ayub, M., Yusaf, M., Lodhi, S.A.K. & Ashraf, M., 1993. Geology and utilization of pegmatitc albitites and aplites of Mansehra Area, NWFP as indigenous raw materials for pottery wares. Pakistan Journal of Scientific and Industrial Research 36(10), 397-00.

Various samples of pegmatitic albites and aplites were collected from Mansehra area NWFP of Pakistan. It was found that only pegmatitic albitites, albite aplites and albite-microcline aplites were the rocks suitable for making pottery wares. For this purpose petrographic and chemical analysis were carried out. The crushed samples were used for the purpose of making porcelain bodies as well for glazes to be used on their respective bodies; the presence of small quantity of TiO_2 and Fe_2O_3 was successfully used to impart cream to orange cream color to both bodies and glazes. The studies were carried out to replace conventional feldspar totally and quartz partially.
Key words: Pegmatite, albitite, aplite, pottery, economic geology, Mansehra.

A/679. Azam, J., 1976. Geological mapping of the Gandaf Irrigation Tunnel, Tarbela Dam Project with special emphasis on engineering geology problem associated with the tunnel alignment and its construction. M.Sc. Thesis, Punjab University, 127p.

Key words: Mapping, engineering geology, Tarbela.

A/680. Azam, M., 1983-85. Biostratigraphy of the Jhalar-the Kala Chitta Range, Attock District. M.Sc. Thesis, Punjab University, Lahore, 91p.

A geological map of the Jhalar area -the Kala Chitta Range, on a scale of 1" to 0.789 mile or 1:50,000 and covering an area of 16.43 square miles has been prepared to discuss the stratigraphy and micropaleontology of the area. An attempt has been made to discuss the importance of foraminiferal content of these rock units, for determining the

depositional pattern and age, the geological sequence of the Kala Chitta Range with a view to recognize the continuity or unique aspects of the lithostratigraphic units in the adjoining area.
The various geological events that occur in the area and their geological implications have also been discussed. In the Kala Chitta Range there are some eighteen lithostratigraphic units but the area under discussion comprises ten lithostratigraphic units mostly of marine environments and with non-marine units.
Key words: Biostratigraphy, Kalachitta range, Attock.

A/681. Aziz, M.A., 1968. Structure and geology of Ghari Habibullah, Taranna Area, Hazara. M.Sc. Thesis, Punjab University, Lahore, 77p.

A. B. Wynne was the first pioneer (1887-89) to work in this area followed by Middlemiss (1890-93). But the first complete map ever produced of the region including the project area was by D. N. Wadia on a 1" = 16 miles scale. Both D.N. Wadia and Middlemiss had included pisolitic formation of Rinjata in their Eocene (Geology of India PP 336) and Nummulitic (although he did that for convenience sake) .This pisolitic formation is placed in cretaceous. This work is first of its nature in the subject area so for as details and accuracy is concerned.
Although repeated phases of orogenesis had to great, extent blurred the picture, a try has been made to give a clearer picture of the events that took place in the Geological past. Detailed study has revealed the presence of different sets of faults which have been differentiated on the basis of age, trend and direction of movement. Different behaviour of sedimentaries and metamorphics to the deformational forces has come to light. Presence of Syringoporoid corals is noted for the first time and the age of Kakul dolomites assigned. A close study of Talhatta metaconglomerates and quartzites is given.
Metamorphics of the area are found to grade from slates through phyllites to Biotite schist grade and described. Probable age of injection of acidic fluid in the Balakot Injection Gneisses and the probable reasons for injection only in these rocks are discussed. Reasons for no evidences of metamorphism in Kakul dolomite and younger sedimentaries of the area are discussed. An appendix is included to give the microscopic mineral determination & features of structural importance of various rocks.
Key words: Structure, Gari Habibullah, Hazara.

A/682. Aziz, N., 1994. The study of groundwater contamination of the Sihala Industrial Triangle Islamabad with a special emphasis on physiochemical, hydrochemical, biochemical and flow net analysis. M.Sc. Thesis, Quaid-i-Azam University, Islamabad, 74p.

This physiochemical, hydrochemical, and biochemical studies of groundwater aquifer of Sihala Industrial Triangle were made. Water sample collected randomly from thirty two preexisting dug wells/tube wells were analyzed in N.I.H. Laboratory. Chemical data was projected graphically on stiff pattern and trilinear piper diagrams using U.S.G.S Software. HC-GRAM. The STIFF PATTERN diagrams thus developed for each dug well/tube well are projected on location map to visualize the distribution of ground water chemistry. Bivariate statistical analysis were applied on scattered data points of TDS (total dissolved solids) and coliform bacteria h +ve and –ve growth of F. Coliforms to study their relationship. The equipotential line map was prepared to develop the flow net. Two plumes of contamination were marked in flow net map. Results indicate that study area has better groundwater on basis of physiochemical analysis and poor quality of groundwater on basis of Hydrochemical and biochemical analysis. Soan River behaves like an effluent stream.
Key words: Groundwater, contamination, Islamabad.

A/683. Aziz, Z., 1963. Geology of Mansehra, Oghi and Darband, Hazara. M.Sc. Thesis, Punjab University, 28p.

Key words: Geology, Mansehra, Darband, Hazara.

A/684. Aziz, Z., 1978-80. Litho-structural mapping and geology of Thandiani-Bins Gali Area, Distt. Abbottabad, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 179p.

Approximately 15 miles^2 of Tandiani-Bins Gali area in the form of a rectangle on the Northwest side of Abbottabad has been mapped at a scale 1:10,000. It is a mountainous humid region with fairly high relief. The stratigraphic sequence ranges from Pre-Cambrian Hazara slates to the Lockhart Limestone of Paleocene age. The structure of the area is in the form of a major synclinorium, which is interrupted and deformed by high angle thrust faults. Over 50 thin sections were studied under the microscope and detailed petrography and petrogenesis are included.
Key words: Structure, stratigraphy, Abbottabad.

A/685. Azizullah, 1978. Report on lithostructural mapping on Paras area, Kaghan valley with special emphasis on tectonics. M.Sc. Thesis, Punjab University, Lahore.

Key words: Lithostructure, tectonics, mapping, Kaghan.

A/686. Azizullah, 1997a. Lithostratigraphy and depositional system of Siwalik of Shinghar-Surghar Range, Thatti Nasrati-Shanawah area, District Karak, Pakistan. Abstracts, 3rd GEOSAS Workshop on Siwaliks of South Asia, Islamabad. Geological Survey of Pakistan, Records 109, 11-13.

The Himalayan molasse sediments, the Siwalik Group, Pliocene to Pleistocene (in Trans-Indus) in the Thatti-Nasrati and Shanawah area were studied in order to understand the nature, origin and conditions of deposition.
The Siwalik Group is comprised of four formations i.e. Chinji, Nagri, Dhok Pathan and Soan Formation. The Rawalpindi Group is absent in this area. The Chinji Formation unconformably overlies the Mitha Khatak Formation (Fig-i). The Chinji Formation consists of maroon and reddish brown colour shale and subordinate sandstone horizons. The thickness of the Chinji Formation varies from 1 160m to l400m. The Nagri Formation is marked by thick sequence of massive sandstone with lot of paleochannels. Shales are absent or present as thin patches. The thickness of the Nagri Formation varies from 1050m to 2075m. The Dhok Pathan Formation exhibits excellent development of cyclic deposition of alternate shale and sandstone sequence. The thickness of this formation varies from 950m to 1200m. The Soan Formation may be divided into Tatrot and Pinjor stages. The sandstones and shales of different colours are present here. A portion of Pinjor stage is absent in some area. The lower portion of Pinjor and Tatrot are represented by 300-500m thick sequence.
The study of lateral and vertical accretion deposits, presence of scouring, channel abandonment behaviour, facies occurrences and channel fill of the Siwalik Group show that it is mainly deposited by braided river system. The Siwalik Group of the Shinghar-Surghar range was deposited from 12 M.a. to 0.5 M.a. as compared to the Siwaliks of the Potwar Plateau, where these molassic sediments begun to be deposited prior to 15 Ma. The sedimentation rate of the Siwalik Group was generally higher in the Trans-Indus ranges than that of the Potwar Plateau area. The entire molasse sequence covering the time span of 12 M.a. to 0.5 M.a. is conformable. There was no tectonic activity except subsidence of basin till folding begun about 0.5 Ma. which stopped the Siwaliks sedimentation in the study area. These molassic sediments were deposited by high velocity streams as indicated by the presence of pebbles, cobbles and boulders. Poor sorting, angular to subangular rock fragments show immature nature of sediments.
The study area is covered by toposheet No.3 8 P/1 and 38 0/4, the latitudes and longitudes of the study area are as follows.

A.	71º03” / 32º48”	D.	7lºl5” / 33º00”
B.	71º03 / 33º00”	E.	7lº09” *I* 32º57”
C.	71ºl5” / 30º05”	F.	7lº09” *I* 32º4l”

The area is mapped on 1:10,000 scale. The study area is 225 Sq. Km. it is accessible by jeepable roads both from Thatti-Nasrati as well as Isa Khel.
Three geological cross-sections were measured at suitable intervals for studying vertical and horizontal variations and stratigraphic correlation.
Detailed sedimentological studies were carried out on the rocks of the Siwalik Group exposed in the study area. All the four formations namely the Chinji, Nagri, Dhok Pathan and Soan Formation are well exposed.
In these studies, in general, the facies models presented by Miall (1977, 78, 85&88) have been utilized. General criteria for distinguishing, comparing and contrasting braided and meandering rivers presented by Miall have been used. Additional criteria have also been used for the Siwalik Group in order to distinguish between braided and meandering river systems. Observations of important sedimentological features in the area were made. This study helped in defining the fluvial facies and interpreting the conditions of deposition. It further helped to design the

hydrodynamic conditions during sedimentation. The rate of sedimentation depends strongly on the relief of the source area as well as subsidence of the basin during deposition. The relief in turn in the active collisional mountain ranges, depends strongly on factors like uplift and exhumation, which in turn depends upon the rate of convergence as well as total crustal shortening. Crustal shortening is accommodated by folding and thrust piling. Series of napes development in the collisional mountain ranges sometimes in a piggy-back fashion. During process of uplift and exhumation, successively deeper structural levels are exposed through tectonic erosion and denudation. Thrusting alone cannot explain the exposure of deeper crustal levels. This is only possible through a combination of thrusting and exhumation. Another mechanism which can expose deeper levels is the tectonic collapse and gravity structures in the mountain fold belts. Successive phases of uplift and exhumation are excellently reflected in the Siwalik molassic detritus of the foreland basin. The vertical sequences in these deposits have faithfully recorded the effects of successive uplift and exhumation phases.
Key words: Stratigraphy, Siwalik Molasse, Shinghar Range, Karak.

A/687. Azizullah, 1997b. Petrotectonic framework of the Siwalik group of Shinghar Range with special reference to its petrography. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.11.

No petrological/petrotectonic account from Thatti Nasrati Shava-Shanawah area (Shinghar Range) for the Siwalik Group with reference to its petrotectonic framework has yet been published. It was therefore, important to carry our detailed petrological/petrotectonic studies in order to understand the nature, origin and condition of deposition of Siwaliks in this area.
In the past, it was generally considered that the Siwaliks were deposited by the mighty Siwalik River (ancestral Indus). But subsequent studies have indicated that Siwaliks show great lithological as well as petrographic diversity. Siwaliks of different areas have been derived from different source of regions. Therefore, it was important to trace the sources of Siwalik sediments in this region and to relate them to an evolving petrotectonic framework.
Correlation of Siwaliks on the basis of gross lithological variation (sandstone/shale ratio) has not proved very satisfactory. Similarly, faunal correlation is not always possible, because the distribution of fossils is not uniform. So it was planned to correlate the Siwaliks of the area on the basis of petrographic studies. It has now enabled the author to build a better picture and develop a better understanding of the stratigraphy and sedimentation of the study area.
Petrotectonic studies require a thorough understanding of the tectono-stratigraphic evolution of the hinterland as well as the nature of detritus shed by them both in time and space. The focus of sedimentation and the basin geometry undergo changes concomitant with changes in the source regions.
In order to understand the dynamics of the tectono-stratigraphic evolution of the source areas and changing sedimentary pattern, lithologies and the composition of the sediments, and integrated scenario has been presented.
Key words: Tectonics, petrography, Siwalik Molasse, Shinghar Range.

A/688. Azizullah, 2001. Nuclear fuel potential of the Surghar Range, Bannu basin. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.13.

The collision of Kohistan island arc with Eurasian plate occurred at about 90-100 Ma. resulting in an Andean type of margin. At 40 to 65 Ma. the Indian plate collided with the Eurasian plate sandwiching the island arc. As a result of this collision the Himalayan molassic sediments started to deposit in S-shaped foredeep. Depositional environment was changed from marine to continental. Except for an arid red-bed paleoclimate represented by the Chinji Formation, the semi-arid and sub-tropical environments dominated during this period. Under these tectonic and paleoclimatic conditions in the foredeep basin, a paleo Siwalik drainage was developed and a thick fluvial sequence was deposited. Within this sequence the Dhok Pathan Formation controls the general distribution of the sandstone type uranium mineralization in Pakistan.
The sandstone type uranium mineralization discovered till today is mainly distributed in the east-west trend in the Dina-Kallar Kahar-Chakrala (Potwar Plateau) and in the north-south trend in Thatti Nasrati, Shanawah, Isa Khel and Simu Killi (Bannu Basin) and also in similar trend in Baghalchur, Rakhuchur, Nagar Nai and Rajanpur areas (the eastern flank of Sulaiman Range). Although uranium potential of these rocks is confirmed, however, the uranium resources so far discovered are not commensurate with the widespread mineralization phenomena observed on the outcropping area. It is therefore essential to understand the regional uranium mineralization in its true perspective.

Key words: Nuclear fuel, Surghar range, Bannu.

A/689. Azizullah & Khan, M.A., 1997. Petrotectonic framework of the Siwalik Group of Shinghar Range with special reference to its Petrography. Geological Bulletin, University of Peshawar 30, 165-182.

Detailed petrological/petrotectonic account from Thatti Nasrati Shava-Shanawah area (Shinghar Range) of the Siwalik Group with reference to its petrotectonic framework has yet been published. It was therefore, important to carry out through petrological/petrotectonic studies in order to understand the nature, origin and condition of deposition of Siwaliks in this area.

In the past, it was generally considered that the Siwaliks were deposited by the mighty Siwalik River (ancestral Indus). But subsequent studies have indicated that Siwaliks show great lithological as well as petrographic diversity. Siwaliks of the different areas have been derived from different source of regions. Therefore, it was important to trace the sources of Siwalik sediments in this region and to relate them to an evolving petrotectonic framework.

Correlation of Siwaliks on the basis of gross lithological variation (sandstone/ shale ratio) has not proved very satisfactory. Similarly faunal correlation is not always possible, because the distribution of the fossils is not uniform. So it was planned to correlate the Siwaliks of the area on the basis of petrographic studies.

Petrotectonic studies require a thorough understanding of the tectono-stratigraphic evolution of the hinterland as well as the nature of detritus shed by them both in time and space. In order to understand the dynamics of the tectono-stratigraphic evolution of the source areas and the changing pattern of composition of the sediments, an integrated scenario have been presented.

Key words: Petrology, petrography, tectonics, Siwalik Molasse, Shinghar Range, Karak.