M/1. Macbryde, D.H., 1963. Scientific report of studies carried out on the Minapin Glacier by Members of the Cambridge Expedition to Nagir, Karakoram, 1961.

Key words: Glaciology, Minapin glacier, Hunza.

M/2. MacDonald, K.I., 1989. Impacts of glacier-related landslides on the settlement at Hopar, Karakoram Himalaya. Annals of Glaciology 13, 185-188.

Although the landslides have a history decades long, the land slide problem has more recently assumed heightened significance in relation to rapidly occurring economic and social change such as the introduction of wage labour and seasonal outmigration.
Key words: Landslides, glaciers, Himalaya.

M/3. Madin, I.P., 1986. Geology and neotectonics of northwestern Nanga Parbat-Haramosh massif. M.Sc. thesis, Oregon State University, Oregon, 160p.

Consult the following account for further information.
Key words: Geology, neotectonics, NPHM.

M/4. Madin, I.P., Lawrence, R.D. & Rehman, S., 1984. Neotectonics of the western Haramosh Range. EOS 65, p.1094.

The structure bounding the western Haramosh range has been mapped as part of the MMT, the suture between Indian and Asia. Recent mapping indicates that this structure is an active E dipping fault zone separating “Indian” metasediments of the Haramosh range from diorites and amphibolites of the Kohistan island arc. Displacement on the fault is reverse slip, with some right lateral strike slip. The bedrock trace of the fault is marked by gouge and mylonite zones, drag folds, intense hydrothermal alteration and active hot springs. The width of the fault zone and associated mylonite zones implies displacement on the order of kilometers.
Neotectonic activity is indicated by deformation of Wisconsin age till and glaciofluvial deposits and recent talus slopes. Laminated fluvial sands beneath Wisconsin age basal till are tilted 20 to 40 degrees. A scarp in Wisconsin till has a vertical displacement of 122 meters. Assuming till deposition ceased 8,000 to 12,000 years ago, this scarp represents an uplift rate of 1.0-1.5cm/yr, comparable to regional uplift rates for the area calculated by Zeitler (1982) on the basis of fission track annealing dates.
Key words: Haramosh, neotectonics, Western Himalaya.

M/5. Madin, I.P., Lawrence, R.D. & Rehman, S., 1989. The Northwestern Nanga Parbat-Haramosh massif: evidence for crustal uplift at the north-western corner of the Indian craton. In: Malinconico, L.L. & Lillie, R.J. (Eds.), Tectonics of the Western Himalaya. Geological Society of America Special Papers 232, 169-182.

The Nanga Parbat-Haramosh (NPHM) massif is a unique structural and topographic high in the northwestern corner of the Himalayan convergence zone. Previously, the NPIIM was thought to be bounded by the Main Mantle Thrust (MMT), a fault along which the Kohistan-Ladakh island arc was obducted onto the northern margin of India. This study presents field evidence that the recently active dextral reverse Raikot fault truncates the MMT and forms the western boundary of the NPHM.
The Raikot fault separates medium-grade, Mesozoic to middle Cenozoic mafic metasedimentary and intrusive rocks of the Kohistan lsland arc (Kohistan Sequence) from high-grade Proterozoic metasedimentary rocks (Nanga Parbat Group) and orthogneisses of the Indian craton. The Kohistan Sequence rocks have experienced one tight lo isoclinal folding event, probably associated with obduction of the island arc, and a second folding event associated with movement on the Raikot fault. The Nanga Parbat Group rocks were transposed by an early (possibly Proterozoic) isoclinal folding event and have subsequently been folded around east-trending axes in the early Cenozoic by the obduction of Kohistan, then around north-trending axes In late Cenozoic time lu association with the uplift of the

NPHM and initiation of the Raikot fault. The Raikot fault consists of both mylonite zones and numerous major and minor faults. Slickensides and mylonitic lineations both indicate dextral reverse slip. The Raikot fault and associated folds appear to have accommodated as much as 15 lo 25 km of uplift during late Cenozoic time. The localization of the uplift and the involvement of the Moho suggest that the Raikot fault follows a major crustal structure, possibly a pre-collision Indian plate boundary. If this is the case, rotational underthrusting of greater India along the MMT would require dextral slip along the Raikot fault. It is proposed that the Raikot fault is a terminal tear fault on the MCT.
Key words: NPHM, tectonics,

M/6. Magsi, H.Z., 1984. Evaluation of seismic danger zones in Pakistan based on the interpretation of landsat data. Abstracts, 1st Pakistan Geological Congress, Lahore, p.46.

Key words: Seismology, Remote sensing.

M/7. Mahboob, T. & Shah, M.S., 1979. Petrography of the Shilman carbonate complex Khyber Agency. M.Sc. Thesis, University of Peshawar, 73p.

Key words: Petrography, carbonatites, Shilman, Khyber Agency, NWFP.

M/8. Maheo, G., Rolland, Y., Guillot, S. & Pecher, A., 2001. Metamorphic and magmatic evidence for slab breakoff process below NW Himalaya. Journal of Asian Earth Sciences 19, 43-44.

In the southern Karakorum, NW-SE metamorphic zonation coeval with nappie stacking between 90 and 37 Ma is crosscut by a recent (20-5 Ma) E-W thermal anomaly, underlined by migmatitic domes North of the MKT suture zone. These domes evolved in two stages. Mid-crustal granulitic rocks were first heated from below 600°C to above 750°C during a slight pressure drop, from 0.7 to 0.5 GPa. This heating triggered muscovite and biotite dehydration melting. The retrogressive PT path crosscut the relaxed geotherm of a tectonically thickened crust. Further, geochronological data suggest rapid cooling and rapid exhumation rate (>5 mm y - 1.) since 6 Ma, and structural analysis show that the observed retrogressed P-T-t path can be explained by rapid exhumation during fold amplifications of previously molten midcrustal levels in a N-S shortening context. The main question raised by this evolution is: how to explain the formation of HT granulites in the India-Asia convergent context? These granulites are temporally and spatially associated with granulites and lamprophyres. On the northern edge of the domes area, the 20 Ma Baltoro batholith and associated lamprophyres as well as Hunza dykes show initial εNd (-13 to -6) and 87Sr/86Sr (0.705-0.725) intermediate between crustal and mantle isotopic end members (Searle et al., 1992; Crawford and Searle, 1993). South of the Baltoro batholith, close to the Dassu Dome, the 9-10 Ma Hemasil syenite and associated lamprophyres have much higher initial εNd (3.0-4.4) and lower initial 87Sr/86Sr (0.704-0.705) (Lemennicier, 1996), suggesting increased contribution of a mantellic source. Similar geochemical characteristics have been found in Neogene (23-12 Ma) volcanic rocks of S-Tibet, close to the Indus suture zone. The selective enrichments in LREE vs. HREE and in LILE vs. HFSE and intermediate mantle-crust isotopic signatures have been explained to result from melting of a metasomatized lithospheric mantle with little crustal contamination (Turner et al., 1996; Miller et al., 1999). The increased mantellic affinity of Hemasil syenite compared to Tibetan volcanics could be interpreted as a result of the melting of metasomatized asthenosphere below Karakorum, in the mantle wedge above subducting Indian lithosphere. Such magmatism and associated metamorphism with a specific location suggest heat advection through mantellic magmas intrusions. In S-Karakorum this narrow E-W striking zone of thermal anomaly is underlined by a strong negative gravity (bouguer) anomaly, which can be due to a hot body underplate below the crust. In the India-Asia convergent context, we propose that this tectono-metamorphic and magmatic evolution is due to slab breakoff of the Indian continental lithosphere starting at circa 20-25 Ma. Moreover, magmatic evolution is consistent with melting of a deeper mantellic source (from lithosphere to asthenosphere), related to a downward propagation of the slab gap.
Key words: Metamorphism, plate tectonics, Himalaya.

M/9. Mahmood, A., 1976. Geological mapping of the Gandaf Irrigation Release Tunnel, Tarbela Dam Project with reference to the effect of structure and geohydrology on the construction of the Tunnel. M.Sc. Thesis, Punjab University, Lahore, 142p.

Key words: Engineering geology, structure, hydrology, Tarbela Dam.

M/10. Mahmood, A., 1985-87. Geology of Dunga Gali-Barian Area, District Abbottabad. M.Sc. Thesis, Punjab University, Lahore, 105p.

This report incorporates a comprehensive geological study of nearly 25 sq. km. area between Dunga Gali and Barian on the Murree-Abbottabad road. The study includes the preparation of a geological map on the scale 1:7040. Stratigraphically the rock units range from Upper Jurassic to Eocene and represent the sequence of the Hazara Province of the Kohat-Potwar Basin. It is primarily a limestone-shale sequence reflecting a stable shelf facies. Structurally, the area shows the development of a few synclinoria and anticlinora, within which a generally tight parallel to similar asymmetric to overturn style of folding predominates. A number of dipslip-strike faults, both of the normal and reverse type are present. A petrographic study of all rock units, based on fairly representative field sampling, is also present.
Key words: Geology, Abbottabad, Hazara.

M/11. Mahmood, A. & Ahmad, S.A., 1986. Petrography and geology of the Jogabunj-Sadiqa banda area, Dir District, Pakistan. Acta Mineralogica Pakistanica 2, 93-99.

A geological map covering about 66 square miles of the Jogabunj-Sadiqa banda area on the scale of 1=0.789 miles is presented. The area is mainly composed of metasedimentary complexes; the units are amphibolite, granodiorite, pegmatite and hornblendite. The amphibolite are the oldest rocks. After their formation, an acidic magma intruded the amphibolites, resulting in the formation of granodiorite: the contact between them is sharp. Dykes are present both in granodiorite and amphibolite, showing the late residual composition of the granodioritic magma; quartzo-feldspathic and pegmatite veins are present in the whole area. Garnet-bearing quartzofeldspathic rocks are intrusive.
Model analyses and petrography of 32 selected samples are presented and mineralogical statistical variation diagrams are plotted. The petrogenesis of the amphibolite and granodiorite is briefly discussed.
Key words: Petrography, amphibolits, granodiorite, Dir.

M/12. Mahmood, A., Ahmad, S.A. & Dawood, H., 1985. Geology of Warai-Jogabung area, District Dir Trans Himalayan island arc, Pakistan. Acta Mineralogica Pakistanica 1, 83-89.

A geological map covering about 45 miles2 of Warai-Jogabung area of Dir district from toposheet 43 A/4 is presented. The area contains amphibolites, diorite and granite with small patches of quartzofelspathic veins, pegmatites and hornblendites. The amphibolites are the oldest rock units formed from calcareous quartzite. Diorite late on intruded as patches veins and dykes of granitic material. Petrology of granitic rocks is presented in detail. Modal analyses and petrography of 24 selected samples are given.
Key words: Petrology, petrography, amphibolites, Dir, Himalaya.

M/13. Mahmood, A. & Anwar, R., 2000. Microfacies and depositional environment of Shekhan Formation, Panoba Section, Kohat, N.W.F.P. M.Sc. Thesis, University of Peshawar, 46p.

Key words: Microfacies, Shekhan formation, Kohat.

M/14. Mahmood, F., 1985-87. Geotechnical studies of landslides with special emphasis on slope stability along Karakoram Highway (from Batgram to Thakot, District Mansehra). M.Sc. Thesis, Punjab University, Lahore, 95p.

The Project area is related to Hazara and Kohistan region of North West Frontier Province. Topographically the area is occupied by rugged rocks consisting of high peaks and alluvial deposits. The predominant, rock types are granite, granite gneiss, schists and various other minor bodies as dykes and sills. All the structural features coincide excellently to give NE trend that indicates NW-SE direction of tectonic forces.
The main objective of "Geotechnical Studies" is to analyse the scope of stability of rocks along roadside. For this purpose, various modes of failure, i.e. plane failure, wedge failure, toppling failure, rock fall, and circular failure etc. were observed. Theoretical models based on the actual readings (data) presented in the forthcoming chapters are intended to provide rational basis for the design of rock slope. It should however, be made clear that successful design of slope depends not only on the choice of correct theoretical model but also upon a number of other considerations which cannot be conveniently quantified .
A map has been provided which classifies the road segments as stable, unstable and potentially unstable. Stable segments are those which geometrically do not manifest any sign or chance of failure or show a high factor of safety i.e. 2.5 or 3. Unstable segments are those where small scale failures are kept on taking place with every successive rainfall. Similarly, potentially unstable segments are those which are stable in actual practice but the ratio of their resisting forces to driving forces is less than one.
Study of various roads alignment was made to emphasize on the effects of sliding. Different modes of failure were encountered, and their factors of safety were calculated. Finally, it was decided whether dangerous road or not and an attempt has been made to give remedial measures.
Key words: Landslide, KKH, Batgram, Thakot, Mansehra.

M/15. Mahmood, K., 1976. Thesis on litho-structural mapping and geology of Chalt–Hini area, Hunza valley (Gilgit Agency) with special emphasis on the Plate Tectonics. M.Sc. Thesis, Punjab University, Lahore.

Key words: Lithology, structure, Hini, Hunza, Gilgit.

M/16. Mahmood, K., 1994-96. Sedimentary petrology/sedimentology of Hangu Formation and Lockhart limestone of Early Paleocene age and lithostructural mapping of Dhamtaur area, southern Hazara, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 155p.

A comprehensive study of Geology and structure of Dhamtaur area is presented along with special constraints on the sedimentology of Hangu Formation and Lockhart limestone of Early Paleocene. Large-scale (1:10000) Geological mapping of a small segment of the Lesser Himalaya in the Dhamtaur area is presented. The lithostratigraphic unit range from upper Paleocene to Precambrian, Hazara Formation being the oldest. Structurally the area comprises NW-SE trending major anticlinorium. The folds are tight to isoclinal and opposing southeast and northwest vergence on the two sides of the lower formation. Some anticline shows plunge to the southeast direction. Almost all faults have vergence parallel to the folds developed in the core on the two sides of the main anticlinorium. Most are reverse faults although some may be of the normal type. Faulting appears to be dipslip to oblique slip and in general involves a maximum displacement of few hundred meters.
Hangu Formation from Bagnotar and Mohar, District Abbottabad and from Chahla Bandi, Azad Kashmir has been studied for microfacies, petrographic characteristics, and environment of deposition and diagenesis in relation to sedimentary basin.
The formation shows variable lithology. The section from Bagnotar is totally residual deposit, whereas the sections from Mohar and Chahia Bandi are predominantly composed of siliceous clastics with few beds of residual deposits. The three topmost beds of Chahla Bandi section composed of coal and Bauxitic clay.
The environment of deposition varies from continental, supratidal, upper shore phase and lower shore phase. The section of Lockhart limestone near Chahla Bandi is thin to medium bedded. The Lower contact of Lockhart is disconformable with Hangu Formation and upper contact of Lockhart Limestone with Patala Formation is sharp unconformable. This section is comprises of 14 microfacies and 5 facies ranging from mudstone, wackestone and packstone, have been defined on the basis of field observation and petrographic studies. The deposition of Lockhart Limestone took place in open marine shallow shelf conditions. Neomorphism of syndepositional micrite has taken place under various conditions during different phases of tectonic activity. Mechanical and chemical compaction are present in the forms of aligned are fracture and vug.
Key words: Sedimentology, lithostructural mapping, Hangu Formation, Lockhart limestone, Eocene, Hazara.

M/17. Mahmood, M.T. & Shah, S.M.H., 1998. Petrography and mechanical properties of granitic rocks from Mansehra, N.W.F.P. M.Sc. Thesis, University of Peshawar, 51p.

Key words: Petrography, granites, Mansehra.

M/18. Mahmood, N., 2000. Calcium and magnesium in calcite and dolomite using EDTA and atomic absorption spetrophotometric techniques. Abstracts, Third South Asia Geological Congress, Lahore, 174-175.

Key words: Calcite, dolomite, geochemistry.

M/19. Mahmood, Q., 1986-88. Geology and structure of Balakot-Garhi Habibullah-Batrasi area Kaghan valley District Mansehra, N.W.F.P. 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, quatrz 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. Minor 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.

M/20. Mahmood, S., Sattar, A. & Khan, I., 1985. The geology and structure of the central part of the Attock-Cherat Range, District Peshawar (N.W.F.P.), Pakistan. M.Sc. Thesis, department of Geology, University of Peshawar, 103p.

The area under investigation is a part of the Attock-Cherat Range which forms the southern boundary of the Peshawar Basin. The area is bound by upper Tarkhel village in the north, Khairabad-Nizampur road in the south, Inzari village in the east and Drangkhwar in the west. The relief of the area is moderate to high; the elevation range from 2500 to 3200 feet, the highest peak is 3200' feet high. The general trend of the Range is east-west which coincides with the strike of the rocks.
The area consists of three types of rocks i.e. the Precambrian Dakhner formation on the extreme north, the younger formations of tertiary sequence in the center and the rocks of Silurian-Devonian sequence forming the southern limits of the Attock-Cherat Range. An outcrop of Jurassic limestone is also observed.
Following lithological units are distinguished

1. Dakhner Formation	)	Precambrian
2. Darwazai Formation	)	
3. Hisartang Formation	)	
4. Inzari limestone	)	Silurian-Devonian
5. Jurassic limestone	)	Jurassic
6. Lockhart limestone	)	Paleocene

7. Patala Formation) Paleocene-Eocene

8. Murree Formation) Miocene

9. Quaternary Deposits) Recent

The area exhibits extremely complex structural features. One major thrust fault, running along the northern extremities of the area, traverse the area in the east-west direction. This thrust fault is known as the Cherat thrust. A gravity fault, which separates the Silurian-Devonian sequence from the tertiary rocks, run parallel to the Cherat thrust. Faults of smaller dimensions, which are oblique to the Cherat thrust, are also present in the area. Several Drag folds are present near the thrust which reflect the direction and sense of slip along the fault.
The Silurian-Devonian rocks are overturned in response to the thrusting from the north. Enough evidence is gathered supporting the overturning of the Attock-Cherat Range, its southern limb being eroded away by the Indus River and burried under the alluvium.
Key words: Geology, structure, Attock-Cherat, Nizampur, Peshawar.

M/21. Mahmood, S., 1975. Detailed Geology, Petrology and Economic Geology of Shangla Par Alpuri Area. Survey of Pakistan, Topographic 438/9 with special emphasis on Plate Tectonics. M.Sc. Thesis, Punjab University, Lahore.

Key words: Economic geology, petrology, plate tectonics, Shangla,

M/22. Mahmood, S.S. & Hashmir, A.K.S., 1979. The geology and the structure of the area between Kund and Khair Abad, District Peshawar (N.W.F.P.), Pakistan. M.Sc. Thesis, University of Peshawar, 92p.

Key words: Mapping, structure, Khairabad, Peshawar.

M/23. Mahmood, T., 1981-83. Geology and Petrology of Darel Valley (District Diamer). M.Sc. Thesis, Punjab University, Lahore, 54p.

This thesis presents a geological map of the 30 miles2 of project area (DAREL) on scale 1 inch=1 mile. The project area (Darel) lies in Gilgit Agency district Diamer. The area is located in the centre of Kohistan. Area is disturbed tectonically, being involved in Himalayan Orogeny. The area is composed of igneous and metamorphic rocks. The main rock units in the area are Norite, Diorite, Amphibolites and Granodiorite. Mineralogical description and petrographic analysis of this rock are reported in detail. An attempt is made to interpret the petrogenesis of rock types. The thesis presents a detailed geological and petrologic investigation of the project area. Norite and amphibolites represent oceanic crust while diorite and granodiorite etc. represent plutonic equivalents of arc.
Key words: Petrology, petrography, Kohistan island arc, Himalaya.

M/24. Mahmood, T., 1986. Appraisal of two marble deposits from Northern areas, Pakistan. Acta Mineralogica Pakistanica 2, 161-162.

This is a short communication giving brief details of two marble deposits of northern areas. These are Khyber area, Gilgit district and Chutran area, Baltistan, to check the mineability of these marble deposits. Geochemical analyses of samples from these deposits are also given.
Key words: Marble, Northern areas, Pakistan.

M/25. Mahmood, T., 1985-87. Geology and mapping of Dulai-Kohala area with special emphasis on engineering characteristics of soils. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 91p.

Nearly 175 square km area has been mapped from Dulai to Kohala on both sides of the river Jhelum. The aim is to study the engineering characteristics of soils in detail and to classify them for the civil projects.
The engineering characteristics of soil reveal that

(A=22.6 g-36.2 g)	(B=10 g-22.2 g)
(C=7.6 g-24.9 g)	(D=14.8 g-28.4 g)
(E=5.6 g-52.5 g)	(F=1.67 g-1.83 g)
(G= 62.7 -106.7) and	(H=14.9 lb/ft^3)

is found to be suitable for construction after compaction.

A- Liquid limit.
B- Plastic limit
C- Shrinkage limit
D- Moisture content
E- Swelling test
F- Compaction test
G- Soil hardness test
H- Field density by sand replacement method
Key words: Mapping, engineering geology, soil, Azad Kashmir.

M/26. Mahmood, T., 1986-88. Geology and Structure of Azizabad-Baragali Area, District Abbottabad. M.Sc. Thesis, Punjab University, Lahore, 166p.

Large-scale geological map at the scale 1:9434 of Azizabad-Baragali area is presented. A detailed description of the Precambrian to Eocene rock units specifically in the area of investigation has been recorded. On the basis of large number of sections measured and interpreted. A study of Kawagarh Formation indicates its deposition in deeper water above carbonate compaction depth. Subsurface structure has been described and illustrated in the form of a number of sections and stereograms. Most folds are open to tight asymmetric double plunging and trend NE-SW. A latter fainter NW-SW trending fold set is superimposed on the earlier NE-SW. The faults are dip-slip strike type some normal others reverse generally medium to high angle. Most structure verge to NW. The economic potential of various limestones, laterite and slate has been assessed and an analysis of Dor River aggregate carried out suggests that the Dor River bed gravels are unsuitable and even harmful for durable construction.
Key words: Mapping, structure, Precambrian, Eocene, Kawagarh Formation, Abbottabad.

M/27. Mahmood, T., 1990-92. Geology and structure of Changla Gali Area, District Abbottabad. M.Sc. Thesis, Punjab University, Lahore, 143p.

Key words: Structure, Changla Gali, Abbottabad.

M/28. Mahmood, T., 1992-94. Sedimentary petrology/sedimentology of Hangu Formation and Lockhart Limestone of Early Paleocene age and Lithostructural mapping of Dhamtur Area, southern Hazara, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 200p.

A comprehensive study of Geology and structure of Dhamtaur area is presented along with special constraints on the sedimentology of Hangu Formation and Lockhart Limestone of Early Paleocene. Large scale (1:10,000) Geological mapping of a small segment of the Lesser Himalaya in the Dhamtaur area is presented. The lithostratigraphic unit range from upper Palaeocene to Pre-Cambrian, Hazara Formation being the oldest. Structurally the area comprises NW-SE trending major anticlinorium. The folds are tight to isoclinal and opposing southeast and northwest vergence on the two sides of the lower formation. Some anticlines show plunge to the southeast direction. Almost all faults have vergence parallel to the folds developed in the core on the two sides of the main anticlinorium. Most are reverse faults although some may be of the normal type. Faulting appears to be dipslip to oblique slip and in general involves a maximum displacement of few hundred meters. Hangu Formation from Bagnotar and Mohar, District Abbottabad and from Chahla Bandi, Azad Kashmir has been studied for microfacies, petrographic characteristics, environment of deposition and diagenesis in relation to sedimentary basin.

The formation shows variable lithology. The section from Bagnotar is totally residual deposit, whereas the sections from Mohar and chahla Bandi are predominantly composed of siliceous clastics with few beds .of residual deposits. The three topmost beds of Chahla Bandi section composed of coal and Bauxitic clay. The environment of deposition varies from continental, supratidal, upper shore phase and lower shore phase.
The section of Lockhart Limestone near Chahla Bandi is thin to medium bedded. The Lower contact of Lockhart is disconformable with Hangu Formation and upper contact of Lockhart Limestone with Patala Formation is sharp unconformable. This section is comprise of 14 microfacies and 5 facies ranging from mudstone, wackestone and packstone; have been defined on the basis of field observation and petrographic studies. The deposition of Lockhart Limestone took place in open marine shallow shelf conditions. Neomorphism of syndepositional micrite has taken place under various conditions during different phases of tectonic activity.
Key words: Sedimentology, lithostructural mapping, Hangu Formation, Lockhart limestone, Eocene, Hazara.

M/29. Mahmood, Z.H. & Khan, S., 1983. Stratigraphy of the Karakoram thrust between Chalt and Budlus village along Hunza River northern Pakistan. M.Sc. Thesis, University of Peshawar, 78p.

Key words: Stratigraphy, Chalt, Hunza River, Karakoram Thrust.

M/30. Majeed, A., 1976. A report on lithostructural mapping and geology of Chalt–Hini area, Hunza Valley. M.Sc. Thesis, Punjab University, Lahore, 120p.

Key words: Structure, mapping, Chalt, Hunza.

M/31. Majid, M., 1976. Mineralogy and petrology of the Shilman carbonatite complex, Khyber Agency, North West Frontier Province. NCE Geology University of Peshawar, Information Release 8, 52p.

A number of carbonatite bodies have been reported from the northwest frontier of Pakistan. The Shilman carbonatite occurs in Khyber Agency near the Afghan border. Because of abundance of apatite and interest in REE, this body has been paid attention. This is a preliminary report on the petrography of the body that is a few hundred meters wide and a kilometer long. The body is mostly calcitic carbonatite.
Key words: Mineralogy, petrology, carbonatite, Khyber, NWFP.

M/32. Majid, M., 1978. Minerals potential. In: Causes, effects and remedies of poppi cultivation in Swabi-Gadoon area. Vol. 1, Resource Base. Board of Economic Inquiry, NWFP, University of Peshawar, 389-404.

Key words: Mineral potential, poppy cultivation, Swabi.

M/33. Majid, M., 1979. Petrology of diorites from the "Kohistan sequence", Swat, Northern Pakistan. A genetic interpretation at plate scale. Geological Bulletin, University of Peshawar 11, 131-151.

Diorites and related rocks of calc-alkaline nature include by far the most dominant rocks of various composite plutons extensively distributed within the suture zone in the Kohistan Himalayas in northern Pakistan. The main Himalayan suture zone has been recently traced across Kohistan through the Districts of Hazara, Swat, Dir and Mohmand by Tahirkheli et al. (1979).
The development of the thick complex of various types of diorite, granodiorite, hypersthene gabbro and calc-alkaline volcanics (andesite-dacite-rhyolite) within the suture zone in Kohistan is unique because along the Tsang Po and Indus valley in the east, the suture zone is characterized by a belt of flysch and volcanics with some ophiolites

and "melanges" (Gansser, 1964, 1977) and to the west of Afghanistan it is marked by large "nappes" of typical ophiolitic rocks.
In a tectonic discussion of the Kohistan area it has been pointed out that igneous rocks within the "Kohistan Sequence" represent products of calc-alkaline activity, associated with the subduction of the floor of the former Tethyan Ocean under a marginal basin. The mineralogical and chemical constraints of the diorites and related rocks described in this paper form the Kalam area (between latitude 35º15′ to 35º52′ N and longitude 72º20′ to 72º27′E) favor the possibility of their derivation as a result of the active consumption of the oceanic crust dragged beneath the marginal basin while the concentrations of major and trace elements within the studied suite are strictly against the process of partial melting of sialic crustal material due to the increased geothermal gradients. This point has been discussed further in this paper.
Key words: Petrology, diorites, plate tectonics, Kohistan, Swat.

M/34. Majid, M., Danishwar, S. & Hamidullah, S., 1991. Petrographic and chemical variations in the rift-related basic dykes of the Malka area (lower Swat), NWFP, Pakistan. Geological Bulletin, University of Peshawar 24, 1-23.

This paper deals with the petrography, mineral chemistry and rock chemistry of dolerite dykes of Malka (Lower Swat). These dykes intrude Late Palaeozoic Utla granite and consist of variable amounts of plagioclase (An 53-59%), clinopyroxene (augite), ilmenite, hornblende, biotite, apatite, Altered varieties show amphibole (calcic), plagioclase (An 21-23), Fe-Ti Oxides, chlorite and epidote.
Clinopyroxene, amphibole (both primary & secondary) and plagioclase have been studied in detail. Chemical composition of these rocks exhibits transitional character between alkaline and sub-alkaline basaltic composition. Major oxides verses S. I. Indicate evolved composition for these rocks. Whereas CMAS model of O' Hara (1968) show the fractionation control of plagioclase and clinopyroxene. Compositions of these dolerite dykes indicate their association with rifting of the northern margin of Indo-Pak plate.
Key words: Petrography, geochemistry, rift-related basic dykes, Buner, Swat.

M/35. Majid, M., Karim, A., Sufyan, M. & Danishwar, S., 1992. Chemical variations within rift-related basic dykes in the Peshawar plain alkaline igneous and adjoining areas, N.W.F.P., Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.26.

Key words: Chemistry, basic dykes, Peshawar plain alkaline igneous rocks.

M/36. Majid, M. & Paracha, F.A., 1980. Calc-alkaline magmatism at destructive plate margin in Kohistan, northern Pakistan. Geological Bulletin, University of Peshawar 13, 109-120.

Four episodes of calc-alkaline igneous activity have been identified in the crust of a fossil island arc, 'the Kohistan Sequence', in the Kalam area, Swat. The sequence which includes a thick complex of pyroxene granulite, amphibolite, various types of diorites along with metasediments and associated volcanics is 10-15 km thick and is presumed to have developed, as a result of subduction of the primary Tethyan oceanic crust beneath an arc during the suturing of Indo-Pakistan and Eurasia.
The calc-alkaline rocks within the sequence are divisible into two distinct associations. One of these, characterized by iron- and alkali-rich differentiation on variation diagrams, is volcanic, (the Utror volcanic), consisting of andesite, dacite, rhyodacite and rhyolite. The second association includes rocks varying from hornblende biotite diorite to pyroxene-biotite diorite. Analyses of these rocks, unlike the volcanics, display an iron- and alkali-poor and Mg-rich variation trend. Chemically these rocks have been distinguished into low-silica diorite, normal diorite, high-K diorite and granodiorite (Majid, 1979). The former two types contain less K2O than the latter two.
Field evidences suggest that the volcanic phase follows plutonic activity within the province. Most of the first-order features of the studied suite are identical with the calc-alkaline rocks of the circum Pacific type. The petrochemical indices, which identify the Kohistan calc-alkaline rocks, reflect a pronounced episodicity in their evolution. The macro-episode of major significance defined in the proposed genetic scheme is synchronous with first major tectonic event, which is referred to as the subduction of the Tethyan ocean crust in the plate tectonic model of Kohistan.
Key words: Geochemistry, calc-alkaline magmatism, Swat.

M/37. Majid, M. & Shah, M.T., 1985. Mineralogy of the blueschist facies metagraywacke from the Shergarh Sar area, Allai Kohistan, N. Pakistan. Geological Bulletin, University of Peshawar 18, 41-52.

A new occurrence of the glaucophane bearing rock within the Indus suture zone is reported from the Shergarh Sar area in Allai Kohistan. Being composed mostly of quartz with small amount of white mica, glaucophane, chlorite and plagioclase etc. the rock is described as blueschist facies metagraywacke. Constituent minerals are analyzed with probe; and P-T conditions of metamorphism (about 7 kbars and 400-450ºC) are calculated. Petrographic and chemical constraints of the constituent minerals oppose any retrogression or oscillatory transition in metamorphic conditions as noted in the blueschist rocks form Ladakh, and Shangla section of Swat.
Key words: Mineralogy, blueschist, Indus suture, Allai Kohistan.

M/38. Majid, M., Shah, M.T., Latif, A., Aurangzeb, & Kamal, M., 1981. Major elements abundance in the Kalam lavas. Geological Bulletin, University of Peshawar 14, 45-62.

Andesite and sialic eruptives of calc-alkaline affinity in the Kalam volcanic zone constitute the upper part of the 'Kohistan sequence' developed in the western branch of the Himalayan syntaxis between 71^0 E and 75^0 E. The sequence is interpreted as a complete cross section of a mature island arc formed by subduction during Mesozoic in the southern part of the Neotethys and obducted onto the Indian plate in Upper Cretaceous time. The Kohistan sequence includes a thick complex of amphibolites, hypersthene gabbros, pyroxene diorites, hornblende diorites, granodiorites, metasediments and volcanic rocks.
The potential usefulness of the geochemical parameters of the extrusive rocks from the Kalam area, Swat as tectonic fingerprints and genetic indicators is discussed in this paper. There is a close correspondence between the available petrochemical indices of genetic significance of the studied suite to the calc-alkaline volcanics in western and southwestern Pacific regions, which substantiates earlier workers designation of an Island are environment in the Kohistan Himalaya during Mesozoic time.
Key words: Geochemistry, volcanics, Kalam, Swat, Kohistan.

M/39. Malik, A.R., 1987-88. Geotechnical study of slope stability problems along the Kohala-Muzaffarabad Road. M.Sc. Thesis, Punjab University, Lahore, 174p.

Two stratigraphic units i.e. Murree Formation (Miocene) and the Hazara Formation (Pre-Cambrian) exist along the Kohala-Muzaffarabad road. A major structural element (Jhelum Fault) extend full length of the area.
Kohala-Muzaffarabad road is an important link between Pakistan and Azad Kashmir. Unfortunately this strategic route is under constant threat due slope stability problems as a result of which huge landslides occur along this road from time to time. The present study is aimed at investigating and highlighting the causes of land sliding and proposing remedial measures. In order to achieve the above aims detailed geological mapping was carried out along the Kohala-Muzaffarabad road. Field measurements such as discontinuity survey, roughness profiles of joints, compressive strength and field density (Chapter VI) were determined. A large number of samples of soil and rocks were obtained and tests were carried out in laboratory (Chapter VI) for data to be used in the slope stability analysis.
On the basis of prevailing conditions of lithology, structural and nature of discontinuities and materials, a broad classification of the area is made as:
Stable zones.
Potentially unstable zones
Unstable zones.
Field sketches of a number of landslides were prepared and the relevant data of each slide as far as discontinuity were collected so as to identify and analyse each slide accordingly.
An attempt has been made, in this study, to suggest economical and feasible remedies for preventing landslides.
Key words: Geotechnical, slope stability, Azad Kashmir.

M/40. Malik, I.A., 1967-68. Geological report on Kuhai-Chinar Area (Lower Swat). M.Sc. Thesis, Punjab University, Lahore, 73p.

Martin et.al. (1962) made a geological reconnaissance map of the Lower Swat-Indus Valley Region. The author worked in part of Lower Swat and did a detailed geological mapping (Fig.-I). The Ambela granitic comp1ex of Martin et. al. includes both igneous and metamorphic rocks. The grade of metamorphism is however low.
The Field Report presents a gist of observations made during the field work as well as in the Laboratories. Field work is completed in about three months in two consecutive field sessions in 1967 and 1968. The laboratory work includes study of forty thin sections of different rock units, preparation of orientation diagrams from reading of joints and beddings, and optics of a mineral.
The object of this report is to give a comprehensive account of the geology of the area. This report includes the description of various rock units, with an emphasis on the petrogenesis. The long discussion has been summed a chronological sequence given in “Conclusions”.
Key words: Geology, Kuhai, Chinar, Lower Swat, NWFP.

M/41. Malik, I.A., 1983. Graywacky in the middle Siwalik. Geological Gazette 6, 11-13.

Key words: Graywacky, siwaliks, Salt Range.

M/42. Malik, I.A. & Naseem, M., 1970. Geological Report on Rabat Area, M.Sc. Thesis, Punjab University, Lahore.

Key words: Geology, petrography, Rabat, NWFP.

M/43. Malik, I.A. & Qureshi, S.A., 1983. A note on the Tredian Formation. Geological Gazette 6, 6-10.

This note describes in detail the lithostratigraphy of the Triassic Tredian Formation of the Trans Indus Salt range.
Key words: Stratigraphy, Tredian Formation, Triassic, Trans Indus Salt Range.

M/44. Malik, M.H., 1974. A study of landslide problem along the Murree-Abbottabad Road. Geological Survey of Pakistan, Geonews 4, 59-63.

Key words: Landslide, hazard, Murree-Abbottabad, Hazara.

M/45. Malik, M.H., 1978. Some engineering geological properties of the sediments from two borrow areas at the Simly Dam-site Simly, Pakistan. Geological Bulletin, University of Punjab 15, 15-24.

The Simly dam-site on the Soan river near Rawalpindi is located at coordinates 33º 43′ 45″ N and 73º 20′ 25″ E. The various geological units present in the area belong to the Siwalik system. More than two million cubic yards of only silt and clay are required to be used in the construction of this dam. Two borrow areas namely Simly Plain and the Tamair deposits were therefore investigated for this purpose.
Undisturbed samples from both the borrow areas tested and an attempt is made to compare their engineering geological properties. The results are presented in the form of diagrams of the representative samples to make this paper brief.
Key words: Engineering geology, sediments, Simly dam, Rawalpindi.

M/46. Malik, M.H. & Farooq, S., 1991. Effect of tectonic disturbance on the stability of slopes along roads in mountainous regions. Abstracts, 1st Postgraduate Training Course in Plate Tectonics, Punjab University, Lahore, p.14.

Key words: Tectonics, slope stability, Mountain ranges.

M/47. Malik, M.H. & Farooq, S., 1992-93. Effect of tectonic disturbance on the stability of slopes along roads in mountainous regions. Regional Postgraduate Training Course in Plate Tectonics, Punjab University, p.30.

Slopes in mountain regions are vulnerable to structural disturbance in general. These changes in stability of slopes are relate with the already existing structural elements as fractures in different lithologies along the Murree-Muzaffarabad Road and along the Karakorum Highway, reveal interesting relations with major structural features which are the results of movement of plates in the region. The proximity of major faults seems responsible for increased fracture frequency and instability of slopes along these roads. Statistical analysis of laboratory strength test data has been used for wedge failure in rook slopes. Surface roughness of joints and wall compressive strength along-with friction angle have also been used for analysis.
Key words: Tectonics, slope stability, mountain ranges.

M/48. Malik, M.H. & Rashid, S., 1997a. Some engineering geological properties of the Murree Formations at Lower Topa (Murree) Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.41.

Consult the following account.
Key words: Engineering geology, Murree Formation, Murree.

M/49. Malik, M.H. & Rashid, S., 1997b. Correlation of some engineering geological properties of the Murree Formation at lower Topa (Murree District), Pakistan. Geological Bulletin, University of Peshawar 30, 69-81.

Uniaxial Compressive Strength, Young's Modulus, Point Load Strength Index, Schmidt Rebound Hammer Number and Matrix (calcitic as well as clayey) are correlated for 90 samples (30 from each lithology of alternating sandstones, siltstones and claystones) to determine the effect of lithological boundaries and that of the cementing material. Correlation Coefficients of different combinations of Strength, Young's Modulus and Schimidt Hammer Rebound Number were determined. Similarly various combinations of mineral assemblages and matrix with clasts and lithological position of samples were tried and compared with strength. It is observed that strength is not only variable in each lithology but also changes with position of sample with reference to the upper or lower lithological boundaries. Laboratory tests on cores seem to be imperative for supplementing the field index tests on such detritus materials.
Key words: Engineering geology, Murree Formation, Murree.

M/50. Malik, M.H., Rashid, S. & Khan, M.S., 2000. Effect of biological contamination on the water quality in Wah Cantt. area, Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, 140-141.

Key words: Hydrology, water quality, biology, Wah..

M/51. Malik, M.I., 1983. Scheelite prospecting in northwest Chitral, North West Frontier Province. 2nd National Seminar on Development of Mineral Resources, Peshawar 1, 3p.

Key words: Scheelite, prospecting, Chitral.

M/52. Malik, M.S., 1967. Records of groundwater levels of Peshawar valley, West Pakistan. Basic data Release No. 12, Water and Soil Investigation Department Publication No. 52, Hydrogeology Directorate, WAPDA, North West Frontier Province, Peshawar.

Key words: Groundwater, Peshawar.

M/53. Malik, M.Y. (ed.), 1983. Technical Report on groundwater resources in Lachi Valley, Kohat District, North West Frontier Province, Report 3, Hydrogeology Directorate, WAPDA, North West Frontier Province, Peshawar, 37p.

Key words: Groundwater, Kohat.

M/54. Malik, R.H., 1973-74. Geology of Nauser area, Neelum valley, Muzaffarabad Azad Kashmir. M.Sc. Thesis, University of Peshawar, 28p.

Key words: Geology, Nauser area, Azad Kashmir.

M/55. Malik, R.H., 1986. A preliminary study of the graphite-bearing rocks, at Patlepani-Mohriwali area, Muzaffarabad, A.K. Geological Bulletin, University of Peshawar 19, 101-112.

Graphite at Patlepani-Mohriwali area, District Muzaffarabad (A. K.) occurs in a skarn formed due to an intrusion of pegmatite in recrystallised limestone of Salkhala Series of Pre-Cambrian age. Skarn formed at the upper contact of pegmatite, devoid of graphite, is barren skarn, whereas, at lower contact is fully mineralised with graphite. Mineralised skarn show a well defined zonation pattern from pegmatite to amphibole-pyroxene-graphite skarn to pyroxene-amphibole-graphite skarn to plagioclase-garnet-graphite skarn.
Graphite has an average concentration of 12% and occurs in skarn as concordent lenses, disseminated flakes, bands and is formed in two phases; organic carbon present in original impure limestone was converted into amorphous to semi crystalline graphite during regional metamorphism of area. During the subsequent process of skarnification, this amorphous to semi-crystalline graphite was fully crystallized and being mobile migrated into low-pressure zones of skarn.
Key words: Graphite, skarns, pegmatite, Muzaffarabad.
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M/56. Malik, R.H., 1994. Geology and resource potential of Kashmir ruby deposits, Distt. Muzaffarbad (AK), Pakistan. Azad Kashmir Mineral and Industrial Development Corporation, Muzaffarabad, 21p.

Fine crystals of gem quality ruby occur in marbles in Nangi Mali area of Azad Kashmir. The occurrence and grade of metamorphism are similar to those of the Hunza ruby. The geological aspects of the mineralization and economic potential of the deposit are described in detail in this paper.
Key words: Geology, gemstones, ruby, Azad Kashmir.

M/57. Malik, R.H., 1995. Geology and resource potential of Azad Kashmir ruby deposits. Proceedings, International Round Table Conference on Foreign Investment in Exploration and Mining in Pakistan, Islamabad, October 16-18, 1994, 153-171.

Consult the preceding abstract for further details.
Key words: Geology, gemstones, ruby, Azad Kashmir.

M/58. Malik, R.H., Schouppe, M., Fontan, D., Verkaeren, J., Martinotti, G., Ahmed, K.S. & Qureshi, S., 1996. Geology of the Neelum valley, District Muzaffarabad, Azad Kashmir, Pakistan. Geological Bulletin, University of Peshawar 29, 91-111.

The central and north-western parts of Neelum valley have been mapped, proposing a new lithostratigraphic division for the region. The area comprises two main tectonic units: the Lesser Himalayan Crystalline Unit (LHC) and the Higher Himalayan Crystalline (HLC), separated from each other by the Main Central Thrust (MCT). The two units are characterized by a similar stratigraphy and share a common low-grade metamorphic assemblage. They, however, differ in the intensity of the imprints of the Himalayan metamorphism. The lithostratigraphic units comprise, from base to top, Naril Group (Precambrian basement), the Kundalshahi Group (pre-Himalayan cover) and Surgun Group (an Upper Paleozoic to Mesozoic Himalayan metasedimentary cover comprising paragneisses, mica schists, marbles, amphibolites, calc-schists and impure quartzite). This lithostratigraphic sequence is intruded by a megacrystic granite, similar to that of Mansehra (Early Cambrian) and meta-doleritic dykes, correlated with the Permo-Carboniferous Panjal Trap volcanics. Geochemistry reveals an igneous granitic calc-alkaline origin for the Naril granulitic gneiss, whereas, the sediments of Kundalshahi Group are characterized by a high SiO2 and highly variable trace element contents except REE. In the Surgun Group two types of marbles have been distinguished on the basis of high CaO and Low MgO. The amphibolites in the Surgun Group as well as of Himalayan cover share the same igneous protolith and are basaltic in composition. Geothermobarometric studies indicate polyphase metamorphic evolution for the lithological units of the Neelum valley in the Tertiary Himalayan event. The P-T-t path suggests a prograde metamorphic evolution up to Upper Cretaceous-Eocene times, followed by a retrograde path, essentially of decompressive type. The final part of the path being accompanied by a decrease in temperature. The LHC tectonic unit and a southern portion of the HHC unit followed a different P-T trajectory, under greenschist-facies conditions. The 40Ar/39Ar determinations on muscovite and biotite from these low-grade rocks yield middle Oligocene cooling ages. Four phases of deformation have been distinguished. Isoclinal overturned to recumbent folds represent the D1 and D2 phases; contemporaneous with the regional Himalayan metamorphism, during upper Cretaceous to Miocene. The MCT developed after D2 phase of deformation generating the LHC and HHC nappes and the reversed metamorphic zonation of Neelum valley. The D3 structures comprise of open large megascopic flexural slip buckle folds trending NE-SW. The D4 deformation affects the Hazara Kashmir syntaxis.
Key words: Geology, Neelam Valley, Azad Kashmir.

M/59. Malik, T.M., 1986-88. Stratigraphic studies of area around Dhamtaur-Baghseri District, Abbottabad. M.Sc. Thesis, Punjab University, Lahore, 96p.

The present report is a geologica1 study of nearly 30 sq. miles Dhamtaur and Baghseri area in south eastern direction of Abbottabad. The study includes a geological map on 1:12500 (1cm-125m) and the stratigraphy of the area, from Pre-Cambrian to Upper Palaeocene (Thanetian). The geological history of the Hazara Trough and the environmental deposition of the formation is reviewed. Structurally, the area is very much complicated within which a generally complex folding and faulting predominates.
Key words: Stratigraphy, Abbottabad.

M/60. Malik, Z., Kamal, A., Malik, M. A. & Bodenhansen, J.W.A., 1988. Petroleum Potential and prospects in Pakistan. In: Raza, H.A. & Sheikh, A.M. (eds.) Petroleum for the Future. Hydrocarbon Development Institute of Pakistan, 71-100.

Key words: Hydrocarbon, Pakistan.

M/61. Malinconico, Jr. L.L., 1982. Structure of the Himalayan Suture Zone of Pakistan Interpreted from gravity and magnetic data. Unpublished Ph.D. dissertation, Dartmouth College Hanover, New Hampshire, 128p.

Two-dimensional analysis of gravity and magnetic data in northern Pakistan suggest that he Indian plate is being thrust under the Asian plate and that the major structures in this region dip towards the north.
In northern Pakistan the westward extension of the Indus Suture Zone bifurcates into two structural zones which surround a sequence of rocks interpreted as a wedge of island-arc terrain caught between the colliding Indian and Asian plates. The Main Mantle Thrust (MMT), the southern suture zone, represents the contact between the Indian plate to the south and the island-arc complex to the north. The Indian plate is composed of Paleozoic metasediments intruded by granites, while the southern portion of the island arc complex is composed primarily of mafic rocks.

These contrasting lithologies provide a strong density contrast for modeling of gravity data. The northern suture zone, the Main Karakoram Thrust (MKT), separates the island-arc from the Asian plate to the north. On the south side of the MKT are the meta-sedimentary, meta-volcanic rocks of the island-arc sequence while on the north side of the MKT are the meta-sedimentary rocks of the Asian plate. Thus there is not as strong apparent density contrast across the MKT as there is across the MMT. Close to 600 gravity and magnetic measurements were made along traverses that were approximately normal to the major structures in the area. The gravity data were reduced to terrian corrected Bouguer values and were then analyzed using two-dimensional modeling techniques.
The results of the modeling suggest that both the MMT and the MKT dip toward the north. The MMT at angles of 35 to 45 degrees while the MKT dips at around 20 degrees. The island arc appears to be 8 to 19 km thick with its southern edge tilted upward and eroded back to expose the lower layers of the sequence. The amphibolite layer which outcrops along the southern margin of the arc must extend at depth along the entire width of the arc. Total field magnetic anomalies along the same traverses do not reflect major structural trends, but correlate instead with bodies of ultramafic rock which appear to be localized along the suture lines. An ultramafic klippe is observed 25 km south of the present outcrop of the MMT and suggests that the island-arc terrain once extended farther to the south.
The Main Boundary Thrust is the youngest structural feature studied. It is the zone of current crustal shortening along which Indian crystalline terrain is being thrust southwards over recent sediments along a plane which is modeled as dipping less than 15 degrees to the north. When the present attitudes and presumed ages of the MMT, MKT, and MBT are taken into account the generalization can be made that the older a suture zone is, the steeper its presents dip. The suture margins of the island arc have been recently modified by recent uplift in the Nanga Parbat region. This has caused the suture zones in that area to steepen into near vertical attitudes. Modeling of gravity data a traverse that crosses the entire length of the suture zone in northern Pakistan suggests that the Indian plate be being thrust under the Asian plate. This thrusting is forcing sialic material to a maximum depth of 100 km.
A possible tectonic history for the area can be constructed. Approximately 40 my ago the Indian plate collided with an island arc that was growing due to the northward subduction of the Tethyan oceanic crust. The Collision caused the island-arc terrain to be obducted onto the Indian plate along a very shallow thrust (the MMT). While this was happening, the basin behind the arc began close. With the complete closing of the back-arc basin, the arc ran into the Asian plate and the Asian terrain was thrust over the arc (along the MKT). Continued northward migration of India steepend the MMT and MKT into their present attitudes, while crustal shortening was accommodated along shallow thrust (the MBT).
Key words: Structure, Himalayan suture zone, geophysics, gravity, MBT.

M/62. Malinconico, Jr. L.L., 1986. The structure of the Kohistan-Island Arc terrane in Northern Pakistan as inferred from gravity data. Tectonophysics 124, 297-307.

Modelling of gravity data taken across the Kohistan Island-Arc terrane in northern Pakistan can be used to constrain the shape and thickness of the Arc. Over 600 new gravity measurements were made across the Kohistan Island-Arc terrane in northern Pakistan. These data were taken along traverses normal to the structures bounding the Arc and were reduced to terrain-corrected Bouguer values. The reduced data were then modelled using standard two-dimensional modelling techniques. The southern margin of the Arc, the Main Mantle Thrust (MMT), dips to the north at approximately 45° and gradually flattens out at a depth of 7–9 km. The northern margin of the Arc, the Main Karakoram Thrust (MKT), also dips towards the north, but at a shallower initial angle (15°). From the models, the Arc terrane now appears to be around 7–9 km thick with the thicker sections occurring closer to the southern margin. The proposed model, in particular the angle of the MMT and the MKT, may have been significantly affected by the recent and rapid uplift that is occurring along the Nanga Parbat-Haramosh Massif.
Key words: Structure, gravity, Kohistan island arc, Himalaya.

M/63. Malinconico, Jr. L.L., 1989a. Crustal shortening in the west-Himalaya. Geological Bulletin, University of Peshawar 22, 55-64.

The main collision between the Indian and Asian lithospheric plates occurred during the late Eocene (40 million years ago) and continued closure at the rate of 5 cm/yr has resulted in approximately 2000 km of crustal shortening between the two plates (Molnar and Tapponnier, 1975; Molnar, 1984). In northern India it has been suggested that while some of the shortening is by underthrusting (Molnar and Tapponnier,1975) much may be the result of diffuse

deformation in China (Tapponnier, 1982). However, in northern Pakistan the problem is complicated because there is no Tibetan plateau analog and no evidence of strike-slip structures that could have removed significant amounts of crustal material. In order to place tighter constraints on tectonic models for the Indian-Asian collision in the western Himalaya it is important to be able to estimate the amount of crustal shortening that has occurred. Current estimates of 500 of 700 km of convergence in northwestern Pakistan (Butler, 1986), are calculated from balanced cross section methods. This is significantly less than the 2000 km required by closure models based on paleomagnetic data (Powell, 1979; Molnar and Tapponnier, 1975; Molnar, 1984). An important step in estimating the amount of shortening that has occurred is to determine the volume of crust that remains in the orogen. The crustal models based upon observed gravity profiles presented in this paper suggest that there may be enough crustal volume to account for between 550-1100 km of shortening. This is still significantly less than the 2000 km of closure that has presumably occurred. The balance of the closure might be accounted for by erosion and/or defused deformation or it might suggest that less than 2000 km of closure has occurred in the northwestern Himalaya.
Key words: Structure, tectonics, collision, crustal shortening, Himalaya.

M/64. Malinconico, Jr. L.L., 1989b. Crustal thickness estimates of the Western Himalayas. In: Malinconico, L.L. & Lillie, R.J. (eds.), Tectonics of the Western Himalayas. Geological Society of America, Special Papers 232, 237-242.

The main collision between the Indian and Asian lithospheric plates occurred during late Eocene time (40 to 50 m.y. ago). Continued northward migration of the Indian plate since that time at the rate of 5 cm/yr has resulted in approximately 2,000 km of closure between the two plates. In northern India it has been suggested that, while perhaps 500 to 1,000 km of the closure can be accounted for by crustal shortening, underthrusting, and thickening, the balance (1,000 + km) may be accounted for by eastward motion along strike-slip faults in China. However, in northern Pakistan, the problem is complicated because there is no Tibetan plateau analog and no evidence of strike-slip structures that could have removed significant amounts of crustal material.
In order to place tighter constraints on tectonic models for the Indian-Asian collision in the western Himalaya, it is important to be able to estimate the amount of crustal shortening that has occurred. Current estimates of 500 to 700 km of crustal shortening in northwestern Pakistan are calculated from balanced cross-section methods.
An important step in estimating the amount of shortening that has occurred is to determine the volume of crust that remains in the orogen. The crustal model based on observed gravity profiles presented in this chapter suggest that there may be enough crustal volume in the western Himalaya to accounted for between 570 and 1,140 km of shortening. This is still significantly less than the 2,000 km of closure that has possibly occurred. The balance of the closure might be accounted for by erosion and/or diffuse deformation, or it might suggest that less than 2,000 km of closure has occurred in the northwestern Himalaya. The crustal models also suggest that the style of underthrusting in the northwestern Himalaya may be significantly different than that proposed for the Himalaya of northern India. Here the underthrusting seems to be occurring at a very steep angle when compared to the shallow underthrusting proposed for northern India.
Key words: Structure, tectonics, crustal thickness, Himalaya.

M/65. Malinconico, Jr. L.L. & Adams, K., 1986. Lithospheric underthrusting in the western Himalaya inferred from gravity data. Geological Society of America Abstract with Programs 18, 679.

Key words: Tectonics, lithosphere, gravity, Himalaya.

M/66. Malinconico, Jr., L.L. Johnson, N.M., Offield, O.B. & Tahirkheli, R.A.K., 1986. Gravity and magnetic constraints on the structure of the suture zone in northern Pakistan. In: Huang, J. (ed.), Proceedings of the Symposium on Mesozoic and Cenozoic Geology. Geological Society of China, 60th Anniversary Volume. Geological Publication House, Beijing, 357-367.

Key words: Tectonics, suture zones, gravity surveys, Island arcs, Swat.

M/67. Malinconico, Jr. L.L. & Lillie, R.J. (eds.), 1989. Tectonics of the Western Himalayas. Geological Society of America, Special Paper 232, 320p.

This edited volume contains nineteen papers on various aspects of the geology of the western Himalaya. All the papers concerning northern Pakistan are annotated in appropriate places, following alphabetic order of the authorships.
Key words: Structure, tectonics, Himalaya.

M/68. Mallick, K.A. & Valiullah, M., 1972. Mineralogical study of the non-clay fraction, in the bauxite and the associated rocks of Azad Kashmir. Acta Mineralogica – Petrographica, Szeged XX/2, 271-286.

Bauxite and the associated rocks from seven different localities of Muzaffarabad and Kotli areas of Azad Kashmir have been investigated for their non-clay mineral correspondence. Rocks in contact with the bauxite are the fire clay at the base and Eocene shale at the top. The fire clay overlies the Muzaffarabad Formation of Permo-Carboniferous age. The bauxite and the fire clay correspond closely with each other in their mineralogica1 composition. No relationship could be found between the top of Muzaffarabad Formation and the bottom of the fire clay.
The study reveals similar provenance and cycle of deposition for the fire clay and the bauxite with some breaks and changes when the pisolites of the bauxite were being formed.
Key words: Economic geology, bauxite, Azad Kashmir.

M/69. Maluski, J. & Matte, P., 1984. Ages of alpine tectonometamorphic events in the northwestern Himalaya (northern Pakistan) by ^{39}Ar-^{40}Ar method. Tectonics 3, 1-18.

The main teconometamorphic alpine events which occurred, in the western part of the western Himalayan migration at south of the main suture, in northern Pakistan, are dated by the ^{39}Ar/^{40}Ar method. These events are as follows: (1) the blueschist metamorphism (80 ± 5 Ma) present in tectonic/ophiolititic mélanges along the suture (this event occurred during an early subduction or obduction stage) (2) the alpine barrovian metamorphism (50-30 Ma) developed in the sedimentary cover and orthogneisses of the Indian Plate during the postcollisional northward underthrusting of this plate below Asia, leucogranites (23 Ma) resulting from the melting of the Indian crust during the climax of the alpine metamorphism.
Key words: Tectonics, chronology, metamorphism, Himalaya.

M/70. Maluski, J. & Schaeffer, O.A., 1982. ^{39}Ar-^{40}Ar laser probe dating of terrestrial rocks. Earth and Planetary Science Letters 59, 21-27.

We have shown that for metamorphosed granites, as well as for metamorphosed sediments, it is possible to obtain a reliable K-Ar age from a sample as small as 0.2 μg. Samples with ages as young as 40 m.y. are easily studied. There is no reason to believe that the method could not be used for samples considerably younger. The main application of the laser will probably be for cases where the same mineral species has been formed during two distinct metamorphic events in the same rock. In this case, it is difficult, if not impossible, to make a mineral separate suitable for a ^{39} Ar- ^{40}Ar study. We have shown that in the case of an old granite the biotite in one sample distinctly shows thermal events at 1600 m.y. while it is primary cooling age is 2100 m.y. The thermal release study yields a good plateau age, roughly an average age of the two thermal events. Another interest of this method is demonstrated by argon dating of two different kinds of glaucophane, only one of these showing argon in excess.
Key words: Chronology, metamorphosed granite.

M/71. Manzoor, P., 1963. Geology of the Neelam area, Hazara. M.Sc. Thesis, Punjab University, Lahore, 30p.

Key words: Geology, structure, Neelum, Kashmir.

M/72. Maraini, F., 1959. Gasherbrum IV. Baltoro Karakorum. Ed. L. da Vinci, Bari.

Key words: Gasherbrum IV, Baltoro, Karakoram.

M/73. Maraini, F., 1963. Paropamiso. Spedizione romana all'Hindu Kush ed ascensione del Pico Saraghrar (7350 m). Ed. L. da Vinci, Bari.

This is the description of the Italian expedition to the eastern Hindu Kush. The expedition conquered the Saghrar (Tirich Mir) peak.
Key words: Italian Expedition, Tirich Mir, HinduKush.

M/74. Marcoux, J. & Aymon, B., 1995. Late Permian to late Triassic evolution of the Northern Indian continental margin. Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

During the late Permian, the north Indian margin is the seat of rifting processes. The rift geometry is characterized by a rim basin, a thick upper-plate volcanic extrusion on the shoulder (Panjal Trap) and a terrigenous intrarift shelf and slope. After the uppermost Permian break up the Northern part of India evolves as a passive margin.
Typical of the Permian rim basin is the Nammal Gorge section of the Salt Range. The lower part of the Wargal Formation (late Murgabian) consists of regressive shallow-water carbonate sequences. On the shoulder, the Kashmir area shows a great thickness (up to 1 km) of early, late Permian volcanic rocks: the Panjal Traps. At the Guryul Ravine-type section a marine, fossiliferous, mixed carbonate-terrigenous shelf (Zewan Formation) transgress the Panjal Traps. On the rift side of the shoulder, in the Phuktal section, the open marine Kuling sandstones occur, transgressing on partly tilted blocks. The same lithologies characterize the whole Tethys Himalaya in India and in Tibet. Although absent in the central Himalaya, the Permian Traps, named the Abor volcanics, form large accumulations in the eastern part.
On the Zanskar traverse, the terrigenous Kuling shelf passes oceanward to the flyschoid Lutchungse basin in the Markha Valley area. The Permian exotic blocks consist of open-marine fossiliferous brecciated limestones (the Lamayuru block) or limestones with lava intercalations as in the Spongtang area. The same limestones have been found west of Raskas lake in southwest Tibet.
During the early and middle Triassic, the north Indian margin is characterized by a well-developed slope and a deep, wide, structural shelf. The distal and deeper part found in the Lamayuw and Yamdrock Tso areas consists of shaly and silty deposits with common marly intercalations, often representing turbidity currents. The deep shelf invariably characterized by nodular, condensed mudstone/wackstones of the Tamba Kurkur Formation,, more shaly towards the top and cropping out in northwest Zanskar, Spiti, Kumaon, where it corresponds to the Kalapani Limestone, and Nepal. In Kashmir middle Triassic sediments, the inner-shelf, nodular limestones are richer in fine clastics, as in the Khreuh Formation. The Salt Range was mostly covered by shallow water carbonates, now dolomitized (Kingriali Formation).
In the late Triassic, the distal deeper-water sediments were found in Lamayuru, with large Dachstein-type olistoliths and in the Yamdrock Tso area with shaly and silty deposits with common, marly intercalations, often sedimented by turbidity currents. The most distal part is found in the exotics of the central Himalaya, the Kiogar Peaks, with typical shallow water Dachstein-type limestones. On the margin, the shallow shelf is characterized by fine well-sorted subarkoses and outcrops in northwest Zanskar, Spiti and Nepal. In Kumaon, the corresponding deposits are the Kuti shale. In Kashmir the inner-shelf limestones are very thick. The Salt Range area was emerged; but to the west, shallow-water Limestones are present in the Samana Suk Range where the lower part of the Samana beds are middle to late Triassic in age. To the northwest the carbonate platform (Kashala Formation) is now metamorphosed to the greenschist facies.
Key words: Permian, Triassic, evolution, stratigraphy, Panjal Traps.

M/75. Marks, P. & Ahmad, A., 1962. The Giumal sandstone transgression in the Hazara mountains, West Pakistan. Geological Bulletin, Punjab University 2, 54-55.

During the field season of 1960 and 1961, parties of the Geology department, Punjab University, collected a large number of ammonites from the Giumal sandstone formation at various localities in the Hazara mountains. These faunas proved to be of different stages of the Lower to Middle Cretaceous. Previously, Spath, (1930) had already described such faunas from the same formation. The Giumal Sandstone Formation overlies in all localities the Spiti Shale Formation, which, in turn, disconformably overlies the Oolitic limestones of the Triassic 9?) formation, whereas, however, the boundary between the Triassic (?) Formation and the Spiti Shale Formation is dated in all localities by an Upper Oxfordian Jurassic fauna, the faunae identified from the Giumal Sandstone Formation vary in different localities. The fauna in the eastern part of the area is Berriasian in age; that in the centre (localities 3 and 4) is Valaginian/Hauterivian; while that in the western part of the area is Middle to upper albian (Spath, 1930, 63-64). These later localities lie, generally, on the north-south line, which suggests that the change of the faunae takes place from east to west. As the thickness of the Giumal Sandstone Formation is rather small, varying from about 100 feet in the east to about 50 feet in the west, and the Formation only contains a single fauna in each locality, it follows that the Spiti Shale/Giumal Sandstone Formation boundary shows a marked time-0shift from east to west.
Key words: Stratigraphy, Giumal sandstone, Hazara.

M/76. Marks, P. & Ali, C.M., 1961. The geology of the Abbottabad area, with special reference to the infra-Trias. Geological Bulletin, Punjab University 1, 47-55.

The stratigraphy and structure of the Paleozoic and Lower Mesozoic formations in the environment of Abbottabad (Hazara District) are described. The authors criticize the age given by previous authors, and suggest that part of their Triassic system is in fact Jurassic. An attempt is made to reconstruct the palaeogeography and sedimentary environment of the Infra-Triassic Group.
Key words: Stratigraphy, structure, Paleozoic, Mesozoic, Abbottabad.

M/77. Marks, P. & Ali, C.M., 1962. The Abbottabad Formation: A new name for Middlemiss' Infra-Trias. Geological Bulletin, Punjab University 2, p.56.

The Abbottabad Formation was initially named by Middlemiss as the Infra-Trias. This paper describes the formation with its new name.
Key words: Stratigraphy, nomenclature, Abbottabad Formation.

M/78. Martin, N.R., 1962. Tectonic style in the Potwar, West Pakistan. Geological Bulletin, Punjab University 2, 39-50.

A brief description is given of detailed structural observations made on number of the faulted folds of the Potwar region of West Pakistan. An attempt is made to analyze the kinematics of these structures in terms of a number of phases, and to show the general style of the tectonics. The structural analysis of the region by some of the previous workers is discussed.
Key words: Structure, tectonics, Potwar.

M/79. Martin, N.R., Siddiqui, S.F.A. & King, B.H., 1962. A geological reconnaissance of the region between the Lower Swat and Indus rivers of Pakistan. Geological Bulletin, Punjab University 2, 1-13.

The present results of a rapid reconnaissance of the Lower Swat-Indus region are given. The map is based on the interpretation of aerial photographs and selected traverses, and on some detailed mapping in the Lower Swat area. Tentative suggestions are made for the correlation of the formations encountered, and the structure of the region. Stratigraphy and structure are accompanied by description of the granitic rocks and gneisses. The southern amphibolites belt of the Kohistan magmatic arc is named as the Upper Swat Hornblendic Group. The geological map also shows the lensoid serpentinized body of the Shangla-Alpurai area.
Key words: Geology, reconnaissance, Lower Swat, Indus river.

M/80. Marussi, A., 1955a. With the Italian expedition to Karakorum, K–2. Royal Geographical Society, Series B. No. 355.

Key words: Geography, geomorphology, Karakoram.

M/81. Marussi, A., 1955b. L'Esplorazione geofisca del Karakorum. L'Universo 25, 1-12.

Key words: Geophysics, exploration, Karakoram.

M/82. Marussi, A., 1955c. Osservazioni gravimetriche e geomagnetiche effectuate dalla spedizione italiana al Karakorum 1954. Bollitin Adriatica Sc. Nat. 47, 132-137.

Key words: Geophysics, gravimetry, geomagnetism, Italian Expedition, Karakoram.

M/83. Marussi, A., 1955d. Con la spedizione italiana al Karakorum K2. Publl. Royal Society Geogr. 355, 21p (Madrid).

Key words: Italian Expedition, Karakoram.

M/84. Marussi, A., 1956a. Gravimetric and magnetometric surveys performed by the Italian Karakorum expedition 1954. Geodesique, London, Bull., 41.

Key words: Magnetometery, gravimetry, Karakoram.

M/85. Marussi, A., 1956b. Expedicao Italiano as Karakorum-K2. Boletin de Sociedade Geography de Lisboa, Series 74 (7-9), 252-267.

Key words: Expedition, Karakoram.

M/86. Marussi, A., 1963a. Le anomalie della gravita lungo la catena del Karakorum-Hindu Kush. Rendiconti Acaddemy Nazionale de Lincei, Series 8, 35, 5.

Key words: Gravimetry, Karakoram, Hindukush.

M/87. Marussi, A., 1963b. Le anomalie della gravita lungo la catena del Karakorum Hindu Kush. Atti Accad. Naz. Lincei, Rec., 35, 198–210.

Key words: Gravimetry, Karakoram, Hindukush.

M/88. Marussi, A., 1964a. Italian expeditions to the Karakorum (K2) and Hindu Kush: I–Geophysics of the Karakorum. Scientific Reports II–Geophysics. E. J. Brill., Leiden.

Key words: Karakoram, Italian Expedition..

M/89. Marussi, A., 1964. Geophysics of the Karakoram, Italian Expeditions to the Karakoram (K2) and Hindu Kush (Prof. A. Desio leader), II-Geophysics, Volume 1, 242p. Brill, Leiden.

Key words: Geophysics, expedition, Karakoram, Hindukush.

M/90. Marussi, A., 1976a. Introductory report of Geophysics. In: Geotectonica dell zone orogenische del Kashmier Himalaya, Karakoram-Hindukush-Pamir. Accademie Nazionale de Lincei 21, 15-25.

Key words: Geophysics, Kashmir, Himalaya, Karakoram, Hindukush.

M/91. Marussi, A., 1976b. Gravity in the Karakorum: International Colloquium on the geotectonics of the Kashmier Himalaya-Karakorum-Hindu Kush-Pamir Orogenic Belt. Rend. Acc. Naz. Lincei, 131-137.

Key words: Gravity, geotectonics, Himalaya, Karakoram, Hindukush.

M/92. Marussi, A., 1978. Results of seismic sounding: gravity and crustal structure in the Kashmir Himalaya and the Karakorum – Hindu Kush region. Abstract International geodynamic conference, Kathmandu, March 26-29.

Generally speaking, geophysics fields show little correlation with geological fields in the region of the Pamir-Kun Lun-Karakoram-Himalaya-Hindu Kush syntaxis. The gravity field shows regular symmetric trends astride the Karakorum range, but west of the Chitral Line this trend is substituted by strong negative gravity anomalies. The zone of transition coincides with the area of the Hindu Kush intermediate earthquakes, is marked by the junction of the Chaman and Heart fault systems, and thus testifies deep seated phenomena. An even more striking lack of correlation is appearing if satellite gravity data are considered.

The deep seismic sounding operations performed in 1974 and 1975 between India, Italy, Pakistan and U.S.S.R. show a thickening of the crust under the Karakorum and a progressive deepening of the Moho discontinuity proceeding from the Indus platform towards North. The Nanga Parbat massif shows high velocity surface layers. A map of the lineaments of the systaxial zone has been drawn from Landsat imageries.

Key words: Seismology, crustal structure, Himalaya, Karakoram, HunduKush.

M/93. Marussi, A., 1980. Gravity, crustal tectonics and mantle structure in the central Asian syntaxis. Geological Bulletin, University of Peshawar 13, 23-27.

An attempt is made to interpret the gravity field in the zone of the Tien Shan-HiduKush-Kun Lun-Karakorum-Kashmir Himalaya syntaxis, considering the local features of the field generated by density anomalies in the lithosphere separated from the regional geoidal features generated by anomalous density distributions in the Mantle as obtained by satellite geodetic methods.

The local isostatic anomalies show a marked dichotomy astride of a line representing the prolongation of the Chaman Fault lineament. Remarkably, the nest of intermediate Hindu Kush earthquakes is to be found at the intersection between the same line with the Herat Fault lineament. Strong negative anomalies unrelated to either the topography or the geology prevail NW of such line, whereas SE of the line the field is characterized by stripes of alternating negative and positive anomalies all having the Himalayan trend.

Both the Himalayan and the Chaman Fault trends are to be recognized in the geoidal features of GEM 10. The Himalayan trend is here related to the upheaval of the geoid that accompanies all along the Alpine-Himalayan geosyncline, and the Chaman Fault trend to the geoidal downwarping that follows the northern continuation of the tensional zone of the Arabian Sea crossing the syntaxial zone and continuing in the Balkash-Baykal Rift Zone in Central Asia. A tentative hypothesis is made to interpret the relationship between mantle structure and the crustal tectonics by the mechanism of gravity sliding.

Key words: Gravity, crustal tectonics, mantle structure.

M/94. Marussi, A., 1980. Geoidal features and crustal structures in Central Asia. Qinghai-Xizang (Tibet) Plateau Symposium, Beijing.

Key words: Tectonics, structure, Central Asia.

M/95. Marussi, A., 1983a. Gravity anomalies and granites of the Karakoram. In: Shams, F.A. (ed.), Granites of Himalaya, Karakorum and Hindu Kush. Institute of Geology, Punjab University, Lahore, 389-392.

On the basis of gravity survey, it is shown that negative anomalies, over Karakorum and the Nanga Parbat – Haramosh orogens, are related to granite bodies while the positive anomalies are related to regional amphibolites, basic granulites and basalts. It is further shown that the Nanga Parbat – Haramosh tectonic event as a huge diaper is genetically related to the Karakorum axial batholith.
Key words: Gravity, granites, Karakoram.

M/96. Marussi, A., 1983b. The Pakistani-Italian Karakorum geophysical project in the frame of the Pamirs-Himalaya International Project. Bollettino di Geofisica Teorica de Applicata (Pamir-Himalaya Volume) 25, 137-141.

Key words: Geophysics, Pamir, Himalaya, Karakoram.

M/97. Marussi, A., 1983c. Geophysical trends and evolution of the Pamirs syntaxis and Karakorum. Bollettino di Geofisica Teorica de Applicata (Pamir-Himalaya Volume) 25, 443-465.

Key words: Geophysics, tectonics, Pamir, Himalaya, Karakoram.

M/98. Marwat, N.J., 1983. Geology of a part of the Shiwa-Shehbaz Garhi complex, District Mardan. M.Sc. Thesis, University of Peshawar, 56p.

Key words: Geology, granites, Shahbaz Garhi, Mardan.

M/99. Marwat, S.K., 1972. Chemical study of rocks and ore for chromium, iron and nickel and geology of Baraul valley, District Dir. M.Sc. Thesis, University of Peshawar, 20p.

Key words: Geochemistry, rre, chromium, iron, nickle, Baraul, Dir.

M/100. Marwat, W.A., 1985. A report on lithostratigraphic units of Jawaki area, Kohat. M.Sc. Thesis, University of Peshawar, 69p.

Key words: Stratigraphy, lithology, Kohat.

M/101. Mason, D., 1914. Examination of certain glacier snouts of Hunza and Nagar. Geological Survey of India. Records 6, 49–51.

Key words: Glaciology, Hunza, Nagar.

M/102. Mason, K., 1929a. The representation of glaciated regions on maps of the survey of India. Geological Survey of India, Professional Paper 25, 18p.

Key words: Glaciology, mapping, India.

M/103. Mason, K., 1929b. Indus floods and the Shyok glaciers. Himalayan Journal, 1, 10–29.

Key words: Indus floods, Shyok glaciers, Himalaya.

M/104. Mason, K., 1930. The glaciers of the Karakoram and neighborhood: Geological Survey of India, Records 63 (2), 214-278.

Key words: Glaciers, Karakoram.

M/105. Mason, K., 1931. Expedition notes: tours in the Gilgit Agency. Himalayan Journal, 3, 110-115.

These are the notes and letters sent by the political agent stationed at Gilgit during the subject years, (1928-1932) to the editor of the journal. These notes give the details of the snouts of the glaciers in the area and possible suggestions.
Key words: Expedition, Gilgit.

M/106. Mason, K., 1932. The Upper Shyok Glaciers. Alpine Journal, 44, 237-245.

Key words: Glaciers, Shyok..

M/107. Mason, K., 1932. The Karumbar Glacier. The Himalayan Journal 4, 182-183.

About 2nd March 1930 the local chief in the Karumbar valley went to see if the route in this valley was clear for a tour that Mr. Todd proposed to undertake. He found that the glacier above Bort had advanced a very long way in the past year, but that it was still about a hundred paces from the far bank. On the 22nd March, however, one of his men reported that the glacier had closed up and blocked the entire valley. The chief, doubtful of the accuracy of this report, again went up the valley to investigate and found that the glacier had actually advanced a hundred paces in three weeks. Mr. Todd visited the glacier on 20th October and found it stretching right across the main valley with its snout hard pressed against the high steep cliff of the far bank. He estimated the height of the snout to be between 120 and 150 feet, and its breadth from 250 to 300 yards. The width of the valley at the block is about 400 yards wide. 8ome local Wakhis had succeeded in crossing the glacier to visit their fields upstream, but it must have been a perilous passage owing to the formidable barrier of ugly pinnacles and crevasses. The main river was flowing underneath the ice close to the snout and was quite clear. The muddy waters of the glacier itself were issuing from it some 200 feet above the snout. In recent years floods have been caused by the bursting of the Karumbar ice-dam on two occasions, in July 1893 and in June 1905. Mr. Todd gives the following information concerning the latter, thereby supplementing the notes he gave in his letter published in the Himalayan Journal, vol. ii, p. 174. In the autumn of 1904 the Karumbar glacier made an advance similar to that of last spring, and eventually closed against the cliff on the far side in November and December 1904. It was inspected in April 1905 and reported to be about 120 feet high at the snout. A lake formed behind the barrier in the winter and spring of 1904-5, which was reported by locals to be stretching for a full day's march upstream, a statement which was probably exaggerated, unless the march is considered a laborious and difficult one. On the night of 17-18th June the imprisoned waters forced a channel underneath the glacier, and the ice-bridge above the tunnel gradually caved in. The resulting flood reached Gilgit about 8 a.m. where it carried away the one-pier bridge. It will be interesting to note whether a similar flood occurs next year. If we take the block dates as the winters of 1891-2, 1904-5 and 1929-30, the intervals between the times of maximum advance are approximately 13 and 25 years. It would be interesting to know whether there was a minor block about 1917, which would give us a fairly regular periodicity of about 13 years. We are still groping for the laws that govern glacier-movement and we hope that the future movements of this glacier will be recorded annually by the authorities at Gilgit.
Key words: Glaciers, Karumbar, Gilgit.

M/108. Mason, K., 1935. The study of the threatening glaciers. Geographical Journal 85, 24-41.

Key words: Glaciers, natural hazards, Gilgit.

M/109. Masood, H., 1976. An evidence of Maestrichtian rocks in Hazara. Geological Bulletin, Punjab University 13, 111-112.

In his first reference to the geology of Hazara Verchere, 1866-67, gave a rough description of the geology of Hazara without giving any reference to the occurrence of the Upper Cretaceous rocks in the area. Waagen and Wynne, 1872, in their succession of rocks mentioned a bedded limestone, without fossils apparently, possibly of Cretaceous age. Middlemiss, 1896, included the above referred thin bedded limestone as part of Tertiary rocks, as lowest bed of the Nummulitic Series. Latif, 1962, recorded the presence of microfossils of Upper Cretaceous age in the rock units referred above. Latif, 1970, identified more than 30 species of microfossils and dated the rocks as Upper Coniacian to Campanian, Upper Cretaceous. He further identified the rocks as Chanali Limestone and separated it from the overlying Tertiary formations. The microfossil studies carried by Latif, 1970, were based on a study of five samples from Changlagali section. It was found to be necessary to advance the studies by measuring various sections in Hazara and studying the relevant samples. The investigations have shown the presence of twenty seven microfossils in addition to those of Latif, 1970. These microfossils are newly recorded from Hazara.
Key words: Stratigraphy, palaeontology, Maestrichtian, Hazara.

M/110. Masood, H., 1989a. Samana Suk Formation, depositional and diagenetic history. Kashmir Journal of Geology 6 & 7, 157-162.

Samana Suk Formation exhibits an excellent example of what is called as oolite shoal in the literature. Many such examples exist in the geological record and their studies carried out. In this study we tried to interpret the depositional and diagenetic environments of the Jurassic Samana Suk Formation from Hazara, Pakistan.
Several lithofacies are differentiated on the basis of the presence of oolites, fossils and terrigenous content. They include pure micrite to a sandy facies which is classified in the sandstone category.
The diagenetic environment include cementation of the grains with coarse crystalline, bladed calcite which represent an early cement, and equigranular calcite cement representing a later phase. Dolomitization in the phratic zone has replaced all the textures including intraclasts and cements. Replacement of the oolites by the dolomite crystals is another phenomenon observed in the Samana Suk Formation which happened in the later stage of the diagenetic history.
Key words: Stratigraphy, Jurassic, Samana Suk Formation, Hazara.

M/111. Masood, H., 1989b. Hardground surfaces in Samana Suk Limestone. Kashmir Journal of Geology 6 & 7,185-on ward.

Hardgrounds are the surfaces of the beds which show evidence of hardening or lithification on the sea floor indicating syn-sedimentary cementation. Such hardgrounds have been recognized in Samana Suk Formation in different parts of Hazara where some work is being carried out on the depositional and diagenetic processes in this formation. The study of the hardground reveal that the formation have been deposited in intertidal environments with possible transgressions of sea and slow sedimentation where the sea floor was lithified before the overlying beds were deposited.
Key words: Stratigraphy, lithification, Jurassic, Samana Suk Formation, Hazara.

M/112. Master, J.M., 1962a. Limestone resources of West Pakistan. Proceedings, CENTO Symposium on Industrial Rocks and Minerals, Lahore, 189-198.

Key words: Limestone, industrial rocks, Pakistan.

M/113. Master, J.M., 1962b. Gypsum deposits of West Pakistan. Proceedings, CENTO Symposium on Industrial Rocks and Minerals, Lahore, 363-370.

Key words: Gypsum, industrial rocks, Pakistan.

M/114. Mateen, A., Ahmed, A., Butt, K.A., Qureshi, A.A., Zaidi, H.A. & Chaudhry, M.N., 1997. Igneous phosphate (apatite) deposits associated with carbonatite of NW Pakistan: Mineralogical features and possibility of ore beneficiation. Abstracts, National Symposium on Economic Geology of Pakistan, Islamabad, 1p.

The apatite mineral - group is characteristic of carbonatite that commonly form apatite - carbonate ore bodies within the carbonatite complexes. Such igneous phosphate ores of commercial interest occur in the carbonatites of Sillai Patti, (Malakand) and Loe -Shilman (Khyber Agency) in N.W.E.P. Pakistan. We carried out detailed mineralogical study in order to assess the possibility and appropriate conditions for the beneficiation of the apatite - carbonate ores that can be developed as a source for the supply of raw material for phosphate fertilizer and chemical industry. Both the Sillai Patti and Shilman carbonatites are characterized by marked mineralogical and textural variations. Based on the variations genetic and mineral - petrographic features and their associated rocks, we have classified the ore-type as apatite - carbonate - silicate ore. The bulk mineral compositions of the two deposits were evaluated by several independent methods including, large number of thin-sections study, large-volume of bulk samples and chemical analysis of representative samples within the entire limits of the carbonatite. The overall apatite contents are about 5 to 8% and 4 to 6% for Sillai Patti and Shilman deposits respectively The impurities consist of calcite and dolomite (about 80% of overall amount of carbonates - predominantly calcite), ferromagnesian silicates, iron oxide (mainly as magnetite) and other accessory heavy minerals including pyrochlore. A simple process flow - sheet is developed for the physical beneficiation which consists of crushing grinding and floating the apatite concentrates almost free from the gangue minerals. Experiments were conducted using apatite crushed ore 0.2 mm and deslimed on 0.045 mm. Relationships are discussed between quality of the apatite concentrate and the particle size and its intergrowth with coexisting minerals.
Key words: Phosphate, carbonatite, mineralogy, ore beneficiation.

M/115. Mateen, A., Ahmed, A., Chaudhry, M.N. & Ahmad, I., 2000. Geochemical and Sr-O isotope studies of Chakdara granite gneisses, North Malakand, NW Himalaya, Pakistan: Geotectonic implications. Abstracts, Third South Asia Geological Congress, Lahore, 7-8.

Key words: Geochemistry, isotopes, granite gneisses, Chakdara, Malakand.

M/116. Mateen, A., Baloch, I.H., Hussain, S.S. & Chaudhry, M.N., 1997. Mineralogical characteristics and industrial utilization of the Koga nepheline syenite deposit, Buner, Swat, Pakistan. Abstracts, National Symposium on Economic Geology of Pakistan, Islamabad, 2p.

Nepheline syenite rocks are among few industrial raw materials that can be used directly in the industry without much pre-treatment or processing. These rocks find numerous commercial applications, primarily in the manufacture of glass and ceramic wares. Because of its excellent glass and ceramic properties the Koga nepheline syenite can be considered as a suitable matrix for vitrification of high - level radioactive waste. We carried out detailed mineralogical study of the Koga nepheline syenite deposit occurring in Buner. Swat. One of us (Baloch 1994) performed electron microprobe analysis to determine the compositional variations in the different mafic and felsic mineral constituents found in these rocks. The primary aims of this study were to determine the initial mineralogy and chemistry for which the success of mineral separation can be evaluated in the industrial beneficiation of nepheline syenite and to assess the suitability for the nepheline based wasteform. The feldspathoidal rocks comprise of foyaites, sodalite - cancrinite fovaites. feldspathoidal syenite, garnet- bearing nepheline syenite, pulaskites and alkaline syenites occurring as intrusions, plugs, dykes and pegmatitic bodies within the Koga alkaline igneous complex. The important felsic modal mineralogy consist of nepheline (5 to 42 % close to ideal Na:K ratio of 3:1). K- feldspar (20 to 70% as microcline Or95 to Or100), soda - feldspar (2 to 10% as almost pure albite Ab98 to Ab100), Cancrinite and sodalite (up to 12% and 15% respectively in same sections). The iron bearing mafic mineral phases comprise of sodic clinopyroxene (2 to 3% as aegirine), Fe- rich black mica (1 to 4% as biotite - phlogopite -

Annite), iron ore (tip to 3% mainly as magnetite), garnet (up to 4% in same sections as andradite - mainly Mn - bearing melanite), sphene (up to 1%) and amphibole (rare). Apatite and zircon occur as accessory minerals. Mafic minerals texturally occur as aggregates, clots and intergrowth within the felsic major phases. For industrial utilization laboratory - scale feasibility study was carried to assess the merit of the Koga nepheline syenite deposit for the glass and ceramic industry and possible use in the vitrification of radioactive waste. A process flow- sheet based on magnetic separation of iron bearing mafic mineral phases is developed for the Koga deposit to meet the commercial product specification for the industry. Results of preliminary investigations for the utilization of the Koga nepheline syenites as ceramic matrix for vitrification plant for radioactive waste disposal are presented. A glass composed of 85% nepheline syenite and 15% lime offers the best compromise in respect of high resistance to attack by water of various Eh - pH conditions.
Key words: Mineralogy, Koga, Nepheline syenite, Buner.

M/117. Mateen, A. & Chaudhry, M.N., 1997a. Geochemical and isotopic systematic in the carbonatites, Buner Swat, NW Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.44.

Key words: Geochemistry, isotopes, carbonatite, Buner, Swat.

M/118. Mateen, A. & Chaudhry, M.N., 1997b. Cogenetic association of feldspathoidal syenites, syenites and quartz syenites: Evidence for magma contamination in the Koga alkaline-carbonatite complex, Lower Swat, Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.45.

Key words: Carbonatite, syenites, Koga, Buner.

M/119. Mateen, A., Chaudhry, M. N. & Tingu, C., 2000. Permo-Carboniferous Potassic-Rich Shoshanitic Alkaline Magmatism in the Koga-Bunerai area, Swat Himalaya, NW Pakistan. In: Abstract volume, 3rd South Asia Geological Congress (GEOSAS-III), Shams, F.A., Choudhry, M.N., Hassan, Mahmoodul, Kamran, M. & Rashid, S., (Eds.), Lahore (September 23-26, 2000), 5-6.

In this paper we document for the first time a distinct potassic-rich shoshonite alkaline magma series found within the Koga alkaline understand igneous complex in Buner area of Swat, NW Himalaya Pakistan. The dominant alkaline felsic plutons investigated were previously considered mostly syenitic, typically of sodic alkaline feldspathoidal syenite suites (Siddiqui et al. 1968). An entire spectrum of potassic alkaline subvolcanic rocks comprising felsic to mafic suites representing the Pangaean Permo-Carboniferous alkaline magmatism ($^{40}Ar/^{39}Ar$ age = 290+3 Ma) been identified. The rocks of this association consist of intrusions of nepheline bearing K - rich microsyenites (well exposed near Koga village) and dykes and sills of micro-monzogabbros, monzodiorite and shoshonite lamprophyres belonging to trachybasalt-latite magma series. These are Ti shoshonitic magmatic suites, mafic to intermediate in composition slightly Si02- undersaturated (SiO_2 = 46.2 to 61.3Wt%) moderately alumina (A1203=12.1 to 18.5wt%) and potassium (K_2O=2.82 to 7.9) possibly representing potassic equivalents of sodic transitional rocks. elements chemistry shows enrichment in large ion lithophile elements (LILE) and light rare earth elements (LREE) relative to high field strength element (HFSE) and heavy REE with fractionated chondrite-normalized pattern (La/Yb = 9.32 to 24.4). Trace element composition and initial $^{143}Nd/^{144}Nd$ ratio (positive ~:Nd:+2.3 to + 4.1) indicated metasomatized depleted lithospheric mantle source. (Mateen & Lan, unpublished work). The petrogenetic evolution of this magmatic series is interpreted in terms of late stage product of igneous activity similar possibly to Roman type potassic alkaline magmatism found away from mature volcanic arcs and/or observed along the east African Rift Valley System. The compositional variations in the magmatic series have been discussed in relation to the polybaric fractionation. Both the sodic and potassic alkaline rocks of the Koga igneous complex are discussed in relation to the spatial and temporal evolution of what is now the Himalayan orogen. This igneous activity associated with the Permo-Carboniferous, alkaline magmatism in the early stages of rifting of NE Gondwanaland.

Key words: Carbonatite, shoshonitic magmatism, Koga, Buner, Swat.

M/120. Mateen, A., Hussain, S.S., Chaudhry, M.N. & Dawood, H., 1995. Occurrence of carbonatites in higher Himalayan basement rocks of Pakistan. Abstracts, International Symposium on Himalayan Suture Zone of Pakistan. Pakistan Museum of Natural History, Islamabad, 16-17.

In the northern Pakistan carbonatites and related alkaline igneous rocks occur both in the metamorphosed belt of Lesser Himalayas as well as the Higher Himalayan crystalline slab. The carbonatite occurrence just south of the Suture zone in the Higher Himalaya exposed in Malakand Agency (Sillai Patti), Bajaur agency (Turghar-bagh-Andarai) and Swat (Jambil) have distinctly unique geochemical environment and have no apparent relationship with the typical rift-related alkaline silicate-carbonatite complexes of Koga, Loe-Shilman in the Lesser Himalaya. The Silai Patti carbonatites are characterized by predominant dolomite-Anderite carbonate mineralogy with silicate –rich components of pyroxene, amphibole and biotite (>75% biotite and amphibole at places) and relatively higher REE and PO_4 (Apatite) content.
Key words: Carbonatite, Himalaya.

M/121. Mateen, A., Majid, C.A., Hussain, M.A. & Butt, K.A., 1994. Characterization of uraninite from rare metal granitic pegmatite, Bagrian, Mansehra, Pakistan. Pakistan Journal of Geology 2 & 3, 80-84.

Amorphous uraninite is described from an extremely fractionated rare earth bearing zoned complex granitic pegmatite exposed in Bagarian area, Mansehra District, NWFP Pakistan. X- Ray diffraction study suggests a complete amorphous uraninite state. X-ray diffraction pattern shows two broad bands around 317"A and 274"A, and a possible indication of very broad band around 12"A. Carefully devitrified at annealing temperature of 1350°C yielded X-ray diffraction pattern of crystalline uraninnite with chemical phases in atomic proportions of UO, (97.15%), $ThSi0_4$ (1.51%) and ThO_2 (1.51%) and ThO: (1.1%).
Key words: Pegmatites, radioactive minerals, Mansehra

M/122. Mateen, A., Qureshi, A.A., Butt, A.A. & Chaudhry, M.N., 1995. Carbonatite related mineral resources with reference to carbonatite of NW Pakistan. Proceedings, Pakistan Academic of Sciences 32, 69-78.

Key words: Carbonatite, NWFP.

M/123. Mateen, A., Qureshi, A.A. & Chaudhry, M.N., 2001. Petrological and geochemical characteristics of the Tertiary lamphrophyre/ ultrapotassic rock from the Loe-Shilman carbonatite complex, Khyber Agency, N.W.F.P. Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.7.

Lamprophyritic dykes and minor magmatic intrusions of ultrapotassic rocks occur within the Loe-Shilman carbonatite complex, Khyber Agency, NWFP, Pakistan. The lamprophyre dykes yielded 40Ar-39Ar biotite plateau age of 32.8 ± 0.2 Ma and isochron age of 33.4 ± 0.6 Ma. Potassic-rich alkaline rock sequence includes carbonatitic lamprophyre, alkali lamprophyre, K-micromonzonites, K-syenites and pseudoleucite syenites. Petrographic and textural features clearly show that these rocks have a magmatic rather than metasomatic origin. Lamprophyre/ultrapotassic rocks are very heterogeneous in terms of grain size, mineralogy and modal proportions. Lamprophyres are composed essentially of amphibole, biotite, sphene ± K-feldspar ± calcite. Alkali feldspar dominates in the pseudoleucite syenites. All the rocks have strong incompatible element enrichment in multi-element spidergrams which lack Nb-Ta anomaly The rare earth element (REE) patterns are steep with fractionation ratios of (La/Yb)m range from 27 to 87 for lamprophyres and 16 to 38 for K-syenites and pseudoleucite syenites. The enrichment of LILE, Nb-Ta, Zr-Hf, LREE and high La/Yb ratios are consistent with a phlogopite-bearing garnet peridotite residual source. Association of lamprophyres and carbonatites in the collision zone NW Himalaya of

Pakistan demand their parental magmas derived from a heterogeneous sub-continental mantle. Lamprophyres/ultrapotassic rocks are suggested to be generated by partial melting in the mantle, modified by fractional crystallization, immiscibility and magma mixing at shallow levels. Their emplacement is related to the Tertiary extensional rifling environment.
Key words: Petrology, geochemistry, carbonatite, Loe Shilman, Khyber Agency.

M/124. Mateen, A., Qureshi, A.A. & Karim, T., 1993. Chemical characterization of carbonatites from Loe Shilman. All Pakistan Sci. Conf., Aitchison College, Lahore, 26–30th Dec. 1993.

Key words: Carbonatite, geochemistry, Loe Shilman.

M/125. Mateen, K. & Haq, N., 1992. Need for understanding of hydrodynamic framework of petroleum reservoirs in exploration strategies in Bannu/Kohat Province, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, 27.

Key words: Hydrocarbons, reservoir, exploration, Bannu, Kohat.

M/126. Matsumoto, Y., 1974. List of minerals from the Tirich Mir and adjacent regions, the Hindu Kush range, Pakistan. Geoscience Magazine 25, 65-76. Japanese with English summary.

Key words: Minerals, Tirich Mir, Hindu Kush.

M/127. Matsushita, S., 1956. Geology of the Karakorum. Kagaku. Science, 26(2) (in Japanese).

Key words: Geology, Karakoram.

M/128. Matsushita, S., 1965. Geological research in the Upper Swat and eastern Hindu Kush. In: Matsushita, S. & Huzita, K. (eds.), Geology of the Karakoram and Hindu Kush. Results of the Kyoto University Scientific Expedition to the Karakoram and Hindu Kush (1955) 7, 37-88.

This is an excellent geological river log, beginning at Kalam in Swat Kohistan and ending at Mastuj in Chitral. Traverse follows the course of the Ushu River up the Dadarili Pass. Then on, it follows the Ghizar River up to Gupis. This is followed by turning northwest along the course of the Yasin River to Nazbar. From then on, crossing the drainage divide, entry is made into upper reaches of the Yarkhun River for descent into Mastuj. The author used brunton and pace method to prepare simple topographic and geological sketch maps at 1:35,00 to 1: 50,000 scales for the entire route. In addition, field features were shown in a large number of neat hand sketches (totaling 75) and photographs (4). Descriptions of rocks, structures, and field relations of various rocks, especially of the granitic intrusions and their host rocks, are elaborated. A strong aspect of the paper is the description and sketches of the glaciers, morains, glacial terraces, stream deposits, talus, etc. In the Swat-Gupis section, much of the traverse is through the granite batholith (now called the Kohistan Batholith), and the author has distinguished a succession of plutons and dykes. In the Naz Bar valley, he records the following succession of rocks:

Terrace Deposits …………………………………………… Pleistocene
Glacial Deposits …………………………………………… Pleistocene
Granite. …………………………………………………… Tertiary
Yasin Group ………………………………………………. Lower Cretaceous
Darkot Group ……………………………………………… Permo-Carboniferous

The overall stratigraphic setup is given on page 84 of the paper in the following table.

Age	Eastern Hindu Kush	Upper Swāt
Pleistocene	8) Terrace deposits	8′) Terrace deposits
Tertiary	7) Granite of Ghizar river	
EarlCretaceousy	6) Yasin group of Yasin 5) Green series of Ghizar valley	
	4) Granite of Shunji Gol	4′) Granite in the vicinity of Kalām
Permian and Carboniferous	3) Darkot group of Darkot	? 3′) Kalam group in the vicinity of Kalām
Unknown		2) Gneissose granite of Ushū Gol
Unknown		1) Gneiss of Unshū Gol

Key words: Stratigraphy, structure, lithology, glacial deposits, Swat, Hindu Kush.

M/129. Matsushita, S. & Huzita, K., 1964. Geological structure of the western Karakorum and eastern Hindu Kush. 22nd International Geological Congress, New Delhi.

Summary of the work performed during the expedition can be seen in Matsushita & Huzita 1965c below
Key words: Tectonics, structure, Karakoram, Hindukush.

M/130. Matsushita, S. & Huzita, K. (eds.), 1965a. Geology of the Karakoram and Hindu Kush. Results of the Kyoto University Scientific Expedition Karakoram and Hindu Kush (1955) 7, 160p. Kyoto University, Japan.

Summary of the work performed during the expedition can be seen in Matsushita & Huzita 1965c below. An orthoclase-muscovite-quartz pegmatite cutting biotite gneiss near dassu on the right bank of Braldu river has been dated. It gives 27 and 30 ma Rb-Sr and 4 ma K-Ar whole rock dates.
Key words: Tectonics, structure, Karakoram, Hindukush.

M/131. Matsushita, S. & Huzita, K., 1965b. Geological map of the Westernmost Karakoram and Eastern Hindu Kush. In: Matsushita, S. & Huzita, K. (Eds), 1965. Geology of the Karakoram and Hindu Kush. Results of the Kyoto University Scientific Expedition to the Karakoram and Hindukush, 1955, Vol. VII (in pocket). Nippon Printing & Publishing Co., Ltd., Japan.

This is a geologic sketch map at 1: 50,000 scale along the major stream courses traversed by the Japanese expeditions of the mid fifties. It covers northernmost Swat, northeastern Chitral, Gilgit, and parts of the adjacent areas.
Key words: Geological map, Gilgit, Yasin, NE Hindukush, Western Karakoram.

M/132. Matsushita, S. & Huzita, K., 1965c. Summary of the results of the geological researches in the Expeditions 1956 and 1957. In: Matsushita, S & Huzita, K. (Eds.), Geology of the Karakoram and Hindukush. Results of the Kyoto University Scientific Expedition to the Karakoram and Hindukush, 1955, Vol. VII, 89-92. Nippon Printing & Publishing Co., Ltd., Japan.

This is a summary of the geological studies performed by the Japanese Expeditions to the Eastern Hindukush and Western Karakoram during 1955, 1956 and 1957. The various groups of rocks have zonal arrangement and appear in some cases to be separated by faults. One of these faults runs from the south of Mastuj, through the north of Yasin, Pakhor in Ishkuman, Chalt and Chogolungma Glacier north of Haramosh. This may be the trace of the now called MKT or Shyok suture. They also describe other structures, including the extension of the NP dome and the sytaxial bend between the Hindu Kush and Karakoram.

Division of geological sequence in the Western Karakoram and the Eastern Hindu Kush

Age \ Division of the Area	Eastern Hindu Kush and Upper Swāt	Syntaxial area	Western Karakoram	No. of division
Unknown; probably Tertiary	Granite of Ghizar valley	Granite of Gupis and Gakuch	Pegmatite dyke near Dusso	(6)
Early Cretaceous		Yasin group of Yasin		(5)
	Green Series of Ghizar river	Green Series of Gupis and Gakuch	Green and black phyllite of Tormik and Chalt	(4)
Unknown	Granite of Shunji Gol	Granite of Karambar	Granite of Baltoro	(3)
Perminan and Carboniferous	Darkot group of Mastuj	Darkot group of Darkot and Ishkuman	Calcareous rock and conglometrate of Chalt. Slate and limestone of Gasherbrum	(2)
Unknown	Gneiss of Upper Swāt	Injection gneiss of Gakuch	Injection gneiss and mica-shist of the Indus and Braldu	(1)

Key words: Stratigraphy, structures, Hindu Kush, Karakoram.

M/133. Matsushita, S. & Huzita, K., 1966. Geological researches in the western Karakoram. Geology of the Karakoram and Hindu Kush. Results of the Kyoto University Scientific Expedition to the Karakoram and Hindu Kush (1955), Additional Reports 8, 1-7.

This volume is the 7th of the series published since 1960. It comprises a Preface, Introduction, eight papers, References and a geological map of the western Karakoram and eastern Hindu Kush. Individual papers cover general geology, stratigraphy, paleontology, petrography, geochemistry, metamorphism geochronology, and are dealt with in appropriate places. The Introduction to the volume contains a brief history of geological investigations in the area.
Key words: Tectonics, structure, Karakoram, Hindukush.

M/134. Mattauer, M., 1986. Intracontinental subduction, crust mantle decollement and crustal-stacking wedge in the Himalayas and other collision belts. In: Coward, M.P. & Ries, A.C. (Eds.), Collision Tectonics. Geological Society of London, Special Publication 19, 37-50.

Key words: Tectonics, structure, collision, Himalaya.

M/135. Mattauer, M., Proust, F. & Tapponnier, P., 1977. Some new data on the India Eurasia convergence in the Pakistani Himalayas. Colloquium International. CNRS., Paris, 268, 209–220.

Key words: Plate tectonics, plate boundaries, India, Eurasia.

M/136. Matthew, W.D., 1929. Critical observations upon Siwalik mammals. American Museum of Natural History, Bulletin 56, 437-560.

During the winter of 1926-27 I spent six weeks at the Indian Museum in Calcutta and two months at the British Museum (Natural History) in London making a critical re-examination of the type collections of the Siwalik Fauna preserved in those two institutions. The object of this study was to check up in the light of modern palaeontological evidence the classic researches and descriptions of Falconer and Cautley and of Lydekker, and the admirable later work of Pilgrim, as a basis for researches and description of the collections obtained for the American Museum by Mr. Barnum Brown in 1921-1923. The expenses of making this study were defrayed from funds provided by Mrs. Henry Clay Frick, as a part of her gifts to the American Museum for Siwalik collecting, preparation and research work.
To the President and Trustees of the American Museum I desire to express my high appreciation of the opportunity and privilege of making this research, involving release from Museum duties over a period of several months. I am likewise deeply indebted to the friendly aid of Director Pascoe, Superintendent Pilgrim and others of the staff of the Geological Survey of India, to Doctor Bather and Mr. A. T. Hopwood and other good friends at the British Museum, who placed the collections wholly at my disposal for study and comparison, provided every facility for examining the specimens and referring to the published literature and the museum records, and aided and enlightened me upon various obscure points.
The accompanying series of notes and criticisms are by no means to be regarded as final conclusions. They represent principally an attempt to verify, revise and supplement the type descriptions with the aid of subsequent palaeontological knowledge, to point out doubtful or erroneous identifications or conclusions as to the affinities of certain types, and to reconsider the correlation of the Siwalik faunas with those of Europe and America. The views here expressed upon the affinities of various Siwalik mammals, and especially upon the faunal correlation, will call for a further and more careful criticism when the monographic researches upon Mr. Brown's collections have been completed. They represent the present personal viewpoint of the author, and no attempt is made at this stage to bring them into conformity with the conclusions of Professor Osborn based upon his .proboscidean researches, or those of Doctor Pilgrim based upon his extensive and detailed studies of the stratigraphy and faunas of the Siwalik region.
Key words: Palaeontology, siwaliks.

M/137. Mattson, L.E. & Gardner, J.S., 1989. Energy exchanges and the ablation rates on the debris-covered Rakhiot Glacier, Pakistan. Zeitschrift für Gletscherkunde, 25(1): 17-32.

Consult the following account for further details.
Key words: Glaciers, ablation, Rakhiot, Nanga Parbat.

M/138. Mattson, L.E., Gardner, J.S. & Young, G.J., 1993. Ablation on debris covered glaciers: an example from the Rakhiot Glacier, Punjab, Himalaya. In: Young, G.J., (ed.), Snow and Glacier Hydrology. International Symposium, Kathmandu, Nepal, 16-21 November 1992. Proceedings. International Association of Hydrological Sciences. IAHS/AISH Publication, 218, 289-296.

This paper reports on ablation research carried out on the Rakhiot Glacier, Punjab, Himalaya. Specifically, detailed measurements of ablation rates on debris covered and debris free surfaces allow specification of relationships between ablation and debris cover thickness. Direct ablation measurements indicate a sharp increase in ablation with debris cover thickness increasing from 0.0 to 10 mm followed by a decrease in ablation with debris cover thickness increasing beyond 10 mm. Field observations reveal a critical thickness of 30 mm indicating that at any greater debris thickness ablation is suppressed from that expected on debris-free ice. A comparison with previous research indicates similar hyperbolic trends in the relationship between debris cover thickness and ablation, however, the intensity of these trends differ with global location.
Key words: Glaciers, ablation, Rakhiot, Nanga Parbat, Himalaya.

M/139. Matzko, J.J. & Hassan, M., 1967. Mineralogy of iron stone from Chichali and Makarwal areas, Mianwali and Kohat Districts, West Pakistan. US Geological Survey/Geological Survey of Pakistan, (IR) PK-26, 18p.

Key words: Mineralogy, iron ore, Chichali, Makarwal, Mianwali, Karak.

M/140. Matzko, J.J., Hussain, F. & Hassan, M., 1970. Examination of selected radioactive samples from East and West Pakistan. US Geological Survey/Geological Survey of Pakistan, (IR) PK-57, 25p.

Key words: Radioactive minerals, East & West Pakistan.

M/141. Max, G.W., 1966. Copper, Lead, Zinc, Antimony and Arsenic in West Pakistan. US Geological Survey/Geological Survey of Pakistan Project Report, IR PK-4, 39p.

Key words: Minerals, copper, lead, zinc.

M/142. Mayewski, P.A., 1976a. Geotectonics of the orogenic zone of the Kashmir Himalaya, Karakorum, Hindu Kush, Pamir: Introductory report on Geophysics. Accad. Naz. dei Lincei, 21, 15–25.

Key words: Geotectonics, geophysics, Kashmir, Himalaya, Hindukush.

M/143. Mayewski, P.A., 1976b. Geotectonics of the orogenic zone of the Kashmir Himalaya, Karakorum, Hindu Kush, Pamir: Gravity in the Karakorum: Acad. Naz. die Lincei, 21, 132–137.

Key words: Geotectonics, gravity, Kashmir, Himalaya, Hindukush.

M/144. Mayewski, P.A. & Jeschke, P.A., 1979. Himalayan and Trans–Himalayan glacier fluctuations since AD 1812. Arctic and Alpine Res., 11, 267–287.

Historical records of the fluctuations of glaciers in the Himalayas and Trans-Himalayas date back to the early 19th century. Local and regional syntheses of 112 of these fluctuation records are presented in this study. The local syntheses deal with fluctuations of glaciers in Kanchenjunga-Everest, Garwhal, Lahaul-Spiti, Kolahoi, Nanga Parbat, Karakoram (north and south sides), Rakaposhi- Haramosh, Batura Mustagh, and Khunjerab- Ghujerab. Regional syntheses deal with the composite record and the differentiation of records by glacier type (longitudinal versus transverse) and regional setting (Himalayan versus Trans-Himalayan). In a gross regional sense Himalayan and Trans-Himalayan glaciers have been in a general state of retreat since AD 1850. Filtering of the fluctuation records with respect to glacier type and regional setting reveals that the period AD 1870 to 1940 was characterized by alternations in the dominancy of retreat, advance, and standstill regimes.
Key words: Glaciers, Himalaya, Karakoram.

M/145. Mayewski, P.A., Pregent, G.P., Jeschke, P.A. & Ahmad, N., 1980. Himalayan and trans–Himalayan glacier fluctuations and the South Asian monsoon record. Arctic and Alpine Res., 12, 171–182.

Termini fluctuations for glaciers in the Himalayas and Trans-Himalayas are examined for the period AD 1850 to 1960. This period can be characterized as one of general retreat. Differentiation by geographic subdivision, however, reveals that Himalayan glaciers (best exemplified in Lahaul-Spiti, Kolahoi, Nanga Parbat, and Garwhal) show consistent retreat throughout the period, while Trans-Himalayan glaciers (best exemplified on the north side of the Karakoram and in Batura Mustagh and Rakaposhi-Haramosh) deviate from this pattern by displaying a major period of advance from AD 1890 to 1910. Although no apparent relationship exists between the magnitude of termini advances and glacier lengths, termini retreat records are commonly characterized by short- to medium- length glaciers (< 30 km). Termini advances are, however, related to flow direction; advancing termini most commonly face east, southeast, northwest, and west. Glaciers characterized predominantly by retreat flow commonly, but not exclusively, east and south- east. Advances of Trans-Himalayan glaciers during the period AD 1890 to 1910 are

attributed to strengthened monsoon wind cur- rents and to secular variations in Indian rainfall. Such changes in the general atmospheric circulation, implied by climatic data, produce subsequent increases of moisture influx to the Asian land mass.
Key words: Glaciers, monsoon, Himalaya.

M/146. McDoughall, J.W., 1987. Kalabagh strike-slip fault zone, western Salt Range, Pakistan. Ph.D. Thesis, Oregon State University, Corvallis, 178p.

Key words: Structure, tectonics, Kalabagh, Molasse.

M/147. McDoughall, J.W., 1992. The Main Boundary Thrust and propagation of deformation into the foreland fold-thrust belt in northern Pakistan. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, p.54.

In the western Himalaya, the Main Boundary thrust (MBT) is the floor thrust for imbricate slices incorporating Precambrian and Phanerozoic rocks in the hill ranges that are emplaced over Cenozoic strata of the northern Kohat and Potwar plateaus. In the western Kala Chitta Range, north of the MBT and south of the Attock-Cherat Range, steep thrusts (some S-dipping) do not ramp up directly from the decollement thrust at the base of the MBT allochthon. Shallow contraction is manifest as pronounced thickening and tight folding in Mesozoic strata in the upper third of the allochthon with preferred decoupling in Jurassic rocks, particularly in a belt 0-6 km north of the MBT and west of the Indus River.
The MBT is folded and exposed in a deep re-entrant of Eocene Kuldana Formation parallel to and 2-4 km north of the front fault between Mazari Tang and the Indus River. South of the MBT in the northern Kohat Plateau area of the foreland fold-thrust belt, tight folds in early to middle Tertiary rocks, including synorogenic deposits of the Murree Fm., indicate preferential decoupling at the base of the Tertiary section and in underlying Mesozoic strata. These nearly symmetrical lift-off or box folds include the Panoba anticline and related structures, which indicate out-of sequence thrusting along the MBT that deformed the northern Kohat Plateau over (against) the back limb of the M thrust sheet to the south.
Dip displacements are tens of kilometers for major thrusts on either side of the MBT, for example (from S to N), the M thrust of the northern Kohar Plateau (29-32 km), the MET (estimated >40 kin), the Hissartang fault (~25 km), the Cherat fault (?>l0 1cm), and the Khairabad fault (~25 km). South of the MET to the Surghar Range there has been about 50% shortening across the foreland fold-thrust belt on a system of blind thrusts overlying a nearly flat 8-10 km deep basement. Net horizontal shortening increases north of the MBT. The section exposed by thrusting changes markedly in the Attock-Cherat Range, 6-30 km north of the MBT, where Precambrian rocks are exposed and Mesozoic rocks are absent in thrust slices of the N-dipping Khairabad, Cherat, and Hissartang faults.
West of the Indus River, present day low-angle decollement thrusting from the top of the basement projects to the surface 40-70 km south of the MBT and is most recently active in the northern Kalabagh fault zone. Thrusting along the MBT in the Kala Chitta Range at 2.1-1.9 Ma was followed by ongoing shallow regional N-S compression and thickening of the foreland fold-thrust belt allochthon. The MBT allochthon was deformed prior to its low angle emplacement over the northern Kohai and Potwar plateaus, and folded and eroded during or after this emplacement. The MBT thrust front may participate in its own later deformation, but not as an emergent low angle thrust through the Quaternary.
Key words: Structure, MBT, deformation, Indus River.

M/148. McDougall, J.W. & Hussain, A., 1991. Fold and thrust propagation in the Western Himalaya based on a balanced cross section of the Surghar Range and Kohat Plateau, Pakistan. Bull. American Association Petroleum Geologists, 75, 463-478.

Consult the preceding information.
Key words: Structure, Foreland, Himalaya, Surghar Range, Fold and thrust propagation.

M/149. McDougall, J.W., Hussain, A. & Yeats, R.S., 1993. The Main Boundary Thrust and the propagation of deformation into the foreland fold-and-thrust belt in Northern Pakistan near the Indus River. In: Treloar, P.J. & Searle, M.P. (Eds.), Himalayan Tectonic. Geological Society, London, Special Publication 74, 581-588.

The Main Boundary Thrust in northwestern Pakistan is a floor thrust along which a thrust system incorporating Precambrian and Phanerozoic rocks of the Kala Chitta and Attock-Cherat Ranges was emplaced over Cenozoic strata of the northern Kohat and Potwar Plateaus. The MBT and successive thrusts toward the foreland are interpreted as low angle to flat decollement thrusts at 8–10 km depths that bound thrust sheets with large lateral dimensions. Admissible cross sections indicate over 60 km of shortening along the largely pre-Palaeocene Khairabad, Cherat, and Hissartang thrusts within the MBT allochthon. In the toe of the MBT allochthon, contraction is manifest at the surface as tight folds in largely Mesozoic and lower Tertiary strata, decoupled in the upper third of the allochthon. Displacement of the MBT is estimated at over 40 km and south of the MBT, shortening is interpreted along blind thrusts accompanied by shallow (0–3 km deep) backthrusting. The MBT allochthon was deformed prior to its low angle displacement over the northern Kohat and Potwar Plateaus, and folded and eroded during or after its emplacement. The MBT thrust front may participate in its own later deformation, but not as an emergent low angle thrust through the Quaternary.
Key words: MBT, deformation, Foreland, Kalachitta, Attock-Cherat, Potwar.

M/150. McDougall, J.W. & Khan, S.H., 1990. Strike-slip faulting in a foreland fold-thrust belt: the Kalabagh fault and western Salt Range, Pakistan. Tectonics 9, 1061-1075.

The 120-km-long Kalabagh fault zone is formed by transpressive right-lateral strike-slip along the western Salt Range-Potwar Plateau allochthon in northern Pakistan. Lateral ramping from a decollement thrust along an Eocambrian evaporite layer produced NNW- to NW-trending folds and NE- to N-dipping thrust faults in a topographically emergent zone up to 10 km wide. Piercing points along the main Kalabagh fault indicate 12–14 km of middle to late Quaternary right-lateral offset. The older right-lateral Surghar fault displaced axes of frontal folds of the eastern Surghar Range by 4–5 km. Total displacement is reduced northward in the Kalabagh fault zone where north-dipping thrust faults splay to the west. Cumulative right-slip offset in the Kalabagh fault zone is comparable to displacement along the Salt Range frontal thrust, at a minimum average displacement rate of 7–10 mm/year near the Indus River since 2 Ma. In the basement, which dips 2–3° north along the Kalabagh fault, a NNW-trending discontinuous ridge beneath the lateral ramp is interpreted from residual gravity anomalies. The eastern flank of this basement ridge probably ramped allochthonous strata upward from a depth of over 5 km in the Kalabagh fault zone. Kalabagh faulting displaced and uplifted Holocene terrace deposits and shifted the course of the Indus River eastward. A high slip rate and associated seismicity indicate that the Kalabagh fault zone should be considered active and capable of earthquakes.
Key words: Structure, strike-slip faulting, Kalabagh Fault, Salt Range.

M/151. McGibbon, K.J. (ed.), 1982. Karakoram Expedition 1982: A scientific Expedition to the Hunza valley, northern Pakistan (74^{o}E, 36^{o}N). Newcastle University, Exploration Society. 88p.

Key words: Expedition, Hunza, Karakoram.

M/152. McGinnis, L.D., 1971. Gravity fields and tectonics in Hindu Kush. Journal of Geophysical Research 76(8), 1894-1904.

Gravity fields in Afghanistan are characterized by large, negative mean free-air anomalies in the eastern Hindu Kush and by essentially zero anomalies in the western Hindu Kush. Thus, the western Hindu Kush are in isostatic equilibrium, whereas the eastern Hindu Kush are associated with a large mass deficiency. A mechanism involving underthrusting of light continental crust into higher density mantle in the eastern Hindu Kush and Pamirs is consistent with regional seismicity and gravity fields. Positive free-air and Bouguer anomalies mark a belt of intrusives that occupy a region of northeast-striking fractures along the Chaman fault zone. This zone may represent the northwest border of the Indian subcontinental plate.

Key words: Gravity, geophysics, Hindukush.

M/153. Mcmahon, A.H., 1899. Notes on the fauna of Gilgit Agency. Journal of the Asiatic Society of Bengal 68, 105-109.

This, and the following two accounts, give details of the fauna of Gilgit Chitral and Swat areas. This data was collected by the author during his appointment in the area as political agent. He has given quite useful geological data as well.
Key words: Fauna, Gilgit.

M/154. Mcmahon, A.H., 1901a. Notes on the fauna of Chitral. Journal of the Asiatic Society of Bengal 70, 1-7.

Key words: Fauna, Chitral.

M/155. Mcmahon, A.H., 1901b. Notes on the fauna of Dir and Swat. Journal of the Asiatic Society of Bengal 70, 8-12.

Key words: Fauna, Dir, Swat.

M/156. McMahon, C.A., 1884. Microscopic structure of some Himalayan granites and gneissose granites. Geological Survey of India, Records 17, 53-73.

Key words: Structure, Himalaya, granite, gneisses.

M/157. McMahon, C.A., 1887. The Gneissose-Granite of the Himalayas. Geological magazine (Decade III), 4 (5), 212-220.

The cause, or causes, which result in the foliation of igneous rocks is a subject which at present occupies the attention of many geologists, and seems likely, in the near future, to lead to some discussion. In view of this, a short account of the foliated granite of the Himalayas may be of interest. It may be as well, however, to preface my remarks by saying that I believe that foliation may be produced in several distinct ways, and the explanation which I offer of the mode in which the foliation of the Himalayan granite has been brought about is only intended to apply to the case of that granite.
In the following pages I propose to give a brief summary only of some of the more important results worked out in detail in a series of papers published in the Records of the Geological Survey of India; and to add thereto a brief consideration of the question whether the foliation of the gneissose-granite of the Himalayas
Key words: Structure, Himalaya, granite, Gneisses.

M/158. McMahon, C.A., 1897. Notes on the age and structure of the gneissose-granite of the Himalaya with reference to Mr. Middlemiss's memoir on the Geology of Hazara. Geological Magazine (decade IV), 304-313 and 345-355.

I am indebted to Mr. C. S. Middlemiss, Superintendent of the Geological Survey of India, for a copy of his Memoir on the Geology of Hazara and the Black Mountain recently published. Mr. Middlemiss has embodied in his Memoir the results of an unfinished survey by Mr. A. B. Wynne, late of the Geological Survey of India, and by linking these with his own more recent work, has given us an interesting and valuable Memoir on the Geology of the Himalayan district of Hazara.
Key words: Chronology, structure, gneissose granites, Himalaya.

M/159. McMahon, C.A., 1900. Notes on the Geology of Gilgit. Quarterly Journal Geological Society, London, 56, 337-369.

My son, Capt. A. H. McMahon, C.S.I., C.I.E., Y.G.S., Political Agent, Malakand, when stationed at Gilgit, made field-observations and collected rock-specimens for me in the course of numerous traverses through the Gilgit area.
I have not had an opportunity of visiting the region covered by this paper; but I have seen much of the neighbouring Himalaya, and I have had the advantage of correspondence not only with my son, but also with Capt. J. R. Roberts, I.M.S., regarding the geology of Gilgit. I am greatly indebted to Capt. Roberts for much valuable information, for field-observations undertaken on my behalf, for careful drawings of sections, and for numerous additional specimens supplementing those sent by my son. I cannot overrate the obligations under which I am to him.
A sketch-map (see p. 344) has been prepared to accompany this paper, compiled mainly from the map of the Pamirs (1896) by H. Sharbau and the Right Hon. G. N.—now Lord—Curzon; and from the map of Astor and Gilgit (1883) by the Surveyor-General of India. The geology of the neighbouring parts of Kashmir has been described by Mr. R. Lydekker, Y.R.S., in vol. xxii (1883) of the Memoirs of the Geological Survey of India, and in papers published in the Records of the same Survey. The map published with the above-mentioned Memoir shows the geology of Kashmir as far as Astor, at which place this paper takes up the geology.
Key words: Geology, Gilgit.

M/160. McMahon, C.A., 1902. Fossil beds and associated rocks of Chitral. Geological Magazine 9, 3-8.

Key words: Palaeontology, fossils, Chitral.

M/161. McMahon, C.A. & Huddletone, W.H., 1902. Fossils from the Hindu Khoosh. Geological Magazine 9, 49-57.

The Himalayas, with the help of that singular replica of the more mountainous region known as the Salt Range, have afforded to the paleontologist, in one place or another, a fairly good series of the several Paleozoic horizons.
1. The First Paleozoic Horizon. – The Lowest Cambrian, or Neobolus-Fauna, perhaps the lowest recognized fauna in the world, is to be found in the Salt Range in immediate succession to the Salt series. This fauna was discovered by Warth, and has been elucidated in the Paleontologia Indica at considerable length. In the volume for 1899 there is a plate of these fossils, which are described as consisting of simple forms like Neobolus, or rather complicated ones like Pseudotheca.
The Carboniferous overlap in the Salt Range, noticed by Waagen and confirmed by subsequent observers, has had the effect of shutting out the rest of the infra-Carboniferous horizons from that range, so that we there obtain nothing between the lowest Cambrian and the Carboniferous beds. On the other hand, I cannot find that the Neobolus-fauna has been recognized in the Himalayas proper.
2. The Second Paleozoic Horizon.- This must be sought in the Himalayas alone without the valuable confirmatory evidence supplied by the Salt Range in the case of the Carboniferous fauna.
A very valuable find of fossils belonging to this horizon, which in the main may be regarded as of Lower Silurian (Ordovician) age, was made by General Strachey some forty years ago in Niti. These were described and figured by Salter in a memoir printed for private circulation, to which H. F. Blanford contributed. To give an idea of the importance of this find, Salter enumerated some sixty species, as follows: - Crustacea 8 species, Annelida 2, Cephalopoda 8, Gasteropoda 11, Lamellibranchiata 3, Brachiopoda 21, Bryozoa 3, Amorphozoa 2, Zoophyta 2. Referring to the Brachiopoda only, Leptana, Strophomena, and Orthis are perhaps the best represented genera, and the fauna was regarded as most resembling Caradoc. Many of these fossils are in a fairly good state of preservation. The types are to be seen at the British (Natural History) Museum.
Shortly afterwards Stoliezka wrote a memoir on the Paleozoic formations in Spiti. Here he came across a fossiliferous horizon which he called the Bhabeh-series, but the fossils were badly preserved. In this recapitulation Steliezka described his Bhabeh-series as probably of Lower Silurian age, consisting of sandstones, slates, and quartzites, containing Orthis and other genera not specifically determinable.
Subsequently it is believed that important additions have been made to the collections from this horizon in the Himalayas, but at present these matters are in reserve. The following extract from Mr. R. D. Oldham's Manual, published in 1893, bears upon this point. It occurs as a footnote. "A large number of fossils from General Strachey's

collections were described by Messrs. Salter and Blanford in 1865, and the collections which were made by Griesbaeh, which are still in the course of description, will doubtless add to their number. Until this fauna has been worked out and its relations fully determined, there does not appear to be any benefit in printing a nominal list of the species that have been described."

3. The Third Paleozoic Horizon. – Like the second horizon, this has no replica in the Salt Range. So far as anything is known about it, we are still indebted to Stoliezka. Referring to his experiences in Spiti, he thus speaks of the Muth-series: - "Above the true Silurian rocks there will be found a thickness of beds, of about 1,000 feet, distinguished by a different shade of a bluish colour; their age is left undecided. The fossils of this series occur in an arenaecous limestone, some of the beds being of a purer limestone of a dark colour. Specific determination is not easy owing to the bad state of preservation."

Two species of Cyathophyllum were recognized, whilst the Brachiopoda were represented by Strophomena and two species of Orthis. In his summary Stoliezka regarded the Muth-series as of Upper Silurian age, and he correlated, as already stated by General McMahon, the middle or fossiliferous division of that series with the Blaina-limestone.

4. The Fourth Paleozoic Horizon.- This may be focused under the general term of the Kuling-series. The fine collection of Carboniferous fossils sent by Colonel God win-Austen from Kashmir engaged the attention of Davidson many years ago. A considerable number of these specimens may yet be seen in the Museum of the Geological Society. This very abundant and characteristic fauna is receiving samples attention from the writers in the Paleontologia Indica, supplemented as it is by the high fossiliferous Productiv limestones of the Salt Range.

Key words: Palaeontology, fossils, Hindukush.

M/162. Meciani, P., 1961. Il Karakorum, Monografia storico-geografica. In: Monzino, G., Kanjut Sar. 214-260. A. Martello, Milano.

Key words: Geography, Karakoram.

M/163. Medlicott, H.B., 1868. Note on the analysis of three specimens of coal from the "hills about Murree". Geological Survey of India. Records 64, 117-118.

Key words: Hydrocarbons, coal, Murree.

M/164. Medlicott, H.B., 1868. Report on supposed coal of Murree and Kotlee. Geological Survey of India. Records, 64, 120-126.

Key words: Hydrocarbons, coal, Murree, Kotlee.

M/165. Medlicot, H.B., 1873. Sketch of the geology of the North West Frontier Province. Geological Survey of India, Record 6(1), 9-17.

Key words: Maps, geology, NWFP.

M/166. Medlicott, H. B., 1881. The Nahan-Siwalik unconformity in the north-western Himalaya. Geological Survey of India, Records, 14 (2), 169.

Key words: Structure, siwaliks, Himalaya.

M/167. Medlicot, H.B., 1884. Sketch of the geology of the upper Punjab. Calcutta 1883-84.

Key words: Geology, maps, Punjab.

M/168. Medlicot, H.B., 1889. Sketch of the geology of the Punjab. Punjab Gazettier, 22-79.

Key words: Geology, maps, Punjab.

M/169. Medlicott, H.B. & Blanford, W.T., 1879-1887. Manual of the Geology of India. Government of India Press, Calcutta. 817p.

This is compilation of all the available data, mainly from the British Geological Survey of India. The descriptions contain references to the GSI publications. This manual was edited and revised subsequently, and annotation can be seen under Oldham, 1893.
Key words: Books, geology of India.

M/170. Mehboob, M., Pervaiz, J. & Rahman, S., 1983. Petrography of Thor and Thurly mafic-ultramafic association in Chilas Complex, Northern Pakistan. M.Sc. Peshawar University.

The Chilas complex is principally made up of noritic rocks. In its eastern part near Chilas, there are many bodies of olivine-bearing mafic and ultramafic rocks. These range from dunite and peridotite to troctolite, gabbro and anorthosite. Such bodies in the vicinity of Thor Gah and Thurly Gah have been mapped and petrographically described.
Key words: Petrography, ultramafics, Chilas complex, Kohistan Island Arc.

M/171. Mehdi, S.E., 1982-84. Geotechnical studies of landslides along Karakoram Highway from Shetan Pari to Ali Abad. M.Sc. Thesis, Punjab University, Lahore, 122p.

This thesis is mainly composed of the study of about land sliding along Karakoram High Way from Shetan Pari to Aliabad. A brief description of other geological features are also included in the thesis. The geological map shows the different types of rooks 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 rooks. 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: Geotechnical, landslides, Aliabad, KKH.

M/172. Mehdi, S.S., 1979. Geology and economic aspects of the Malakand chromite deposits. Pakistan Mineral Development Corporation Report, 130p.

Key words: Geology, chromite, Malakand.

M/173. Mehdiratta, R.C., 1962. Geology of India, Pakistan and Burmah. 2nd edition. Atma Ram & Sons, Delhi.

This book provides information on Pakistan’s northern part also. Much, if not all, is based on the GSI publications.
Key words: Geology, India, Pakistan, Burmah.

M/174. Mehmood, T., 1999-2000. Geological mapping, stratigraphy, petroleum geology and tectonics of Kohat sub-basin, N.W.F.P., Pakistan with special emphasis on structure and sedimentology of Shadi Khel-Gumbat area District Kohat N.W.F.P., Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 95p.

The study area lies in the Kohat sub-basin of upper Indus Basin which constitutes the western part of the Himalayan fold-and-thrust belt and is bounded by Surghar Range in the south. Regionally Kohat plateau is underlain by sedimentary rocks ranging in age from Pre-Cambrian to Pliocene. Oldest rocks are exposed in the north while most of the middle and southern portions are covered by rocks of Rawalpindi and Siwalik groups. Deposition of the

sediments was interrupted several times, however, the major one with in the exposed sequence is between the Eocene and Miocene. The rocks, exposed in the area, are locally highly folded and faulted due to orogenic movements related to Himalayan uplift.
The objective of the project was to study the structural style, stratigraphy, petrography of different rock units and to evaluate the hydrocarbon potential of the area. Within the exposed rock units, shales of the Chichali and Patala Formations are the potential source rocks. Limestone of the Samana suk, Lockhart and Shekhan Formations are the potential reservoir rocks. Potential cap rocks of the Kohat plateau are shale/clay of Datta, Patala, Kuldana and Kohat Formations. Bahadurkhel salt and Jatta Gypsum may prove very effective cap rocks, especially in the southern portion of the study area. Structural analysis of different rock units shows that there are two deformational events i.e. D1and D2 which are related to F1 and F2 folding. F1 folds related to D1 are north vergent folds with NE-SW extension. F2 folds and structures are formed by northeast and southwest compression. D2 deformation phase change the fold axis and plunge of F1 fold. The F2 cross folds are mainly anticlines and synclines.
Key words: Mapping, stratigraphy, tectonics, structure, sedimentology, Kohat.

M/175. Meier, A., 1992. The geology of the Higher Himalaya in upper Kaghan valley, NE Pakistan (Buruwai-Jalkhad section—Aspects of Tectonics). Master Thesis, ETH Zurich.

Consult the following for further information.
Key words: Structure, tectonics, Kaghan valley, Himalaya.

M/176. Meier, A. & Wahrenberger, C., 1991. The stratigraphy of the Higher Himalaya at upper Kaghan Valley, NE-Pakistan. Abstract Volume, 6th Himalaya-Karakoram-Tibet workshop, Auris, France, 59.

As a part of the Himalayan research programme of the ETH we has the opportunity to do the fieldwork for our diploma thesis in summer 1990 in Pakistan. During the fieldwork a stratigraphic profile of a total measured length of about 1400-m was taken. The effect of deformation on the original bed thickness has not yet been considered.
Three major lithological groups can be defined: a group of metagranitoid rocks overlain by metapelites form a “basement” overlain by a series of metamorphic calcpelites, which have been interpreted as cover to this basement (Greco et al., 1989).
The stratigraphically lowermost group is represented by a leucocratic-mesocratic garnetiferous two mica-gneiss. A banding with dark mica dominated schist layers takes place at 10-cm scale.
The transitional contact with a stratigraphically overlying group of micaschists takes place within about 2 m. No angular discordance was observed. These rocks are garnet-two micas gneisses characterized by porphyroblastic feldspar and an abundance of biotite. The aluminium rich nature of these rocks and the preservation of sedimentary structures show that the original material was pelitic to semipelitic sediment. The group also comprises occasional quartzitic layers and rare marbles. The contact to the uppermost group is also transitional over a distance of about 15 to 20 m. this group consists mostly of metamorphic calcpelites which vary from pure marbles to garnet-micaschists together with more psammitic layers. At the top of the profile stromatolitic layers are associated with structures indicating synsedimentary extension. Amphibolites are present in all groups. These being interpreted associated with the Panjal Trap Basalts (Papritz and Rey, 1989). They are probably of both extrusive and intrusive origin.
Key words: Stratigraphy, Kaghan Valley, Himalaya.

M/177. Meier, A. & Wahrenberger, C., 1992. Metamorphism and tectonics in the higher Himalaya crystalline of upper Kaghan valley, NE Pakistan. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, 55.

Based on the field data from summer 1990 we summarize our observations and interpretations on the geology of Burawai-Jalkad Section in Upper Kaghan Valley as follows:
The rocks can be separated in three major stratigraphically successive groups: The lowermost group of metagranitoid rocks form a basement to a first cover of metapelites. These are overlain by a series of metamorphic calcpelites (second cover). The stratigraphic profile taken in the field confirms this succession, but must include at

smaller scale several duplications produced by the F1 folds. The geological map shows regional unconformities between all lithological groups.
Different metamorphic histories can be derived for basement and cover rocks. Second cover metapelites suggest two phases of metamorphism. A first phase (M1) being of staurolite-kyanite grade syn- to postkinematic to f1 and a second phase (M2) postkinematic to f2. Kyanite of the first phase is broken during f2 and re-crystallizes during M2. Peak metamorphic conditions are reached during M2 and are estimated to 600-650 0C and pressures between 6 and 9 kbars by petrographic grid. First cover rocks suggest a two-fold re-equilibration of an earlier metamorphic event. Euhedral clinopyroxene, which is later consumed by amphiboles, encloses symplectitic structures of diopsidic pyroxene with plagioclase. These symplectites as well as rutiles enclosed in titanite are preliminary regarded as indicators for a former eclogite facies event. Eclogites which formed under 650±50 Cº and 13-18 kbars are reported further to the north by Pognante and Spencer (1991). These observations, as well as the presence of migmatized rocks, suggest a decompressional path with rising temperatures. The dissolution of white mica indicates the beginning of high temperature metamorphic overprint in the basement.
The structural data analysis leads to a ductile deformation of rocks documented by a polyphase folding history. Three different folding phases can be distinguished: A first phase (f1) produces tight to isoclinal folds with axial planes strongly deformed as a result of later folding phases. The well-developed penetrative schistosity, made up by oriented platy and acicular minerals, is the most dominant microstructural feature. Bedding and schistosity planes are subparallel and are folded together with schistosity-bedding intersection lineations (interpreted as first phase fold axes) by the second deformation event (f2). The second phase folds show an open fold type. The axial planes strike NE-SW and the fold axes are gently plunging to the southwest. A third folding phase (f3) deflects the older structures. The superpositions of the folding phases result in interference patterns. The crenulation of penetrative schistosity with constantly oriented fold axes plunging to southwest could document a further deformation event.
Key words: Metamorphism, tectonics, Himalaya, Kaghan valley.

M/178. Meier, W., Heintz, M., Kretzschmar, D., Niedtfeld, B., Wagner, E., Wagner, R., Dr. Gerhard Weiß, Beheng, K., Dr. Anno Diemer, Holtmann, G., Jaeger, W., Michaelis, W., Obrocki, U. & Wasel, P., 1976. Eine expedition ins Hohe Lungma-Gletscherbecken. Kolner Karakorum-Expedition 1976. Prufer, Kasendorf.

On August 8, the Cologne started with two jeeps and two tractors through the Shigar-Valley by the end of the jeep track to Jouna. At the mouth of the river in the Braldu Basha River at Youno or Jouna they rented carriers and marched along the Braldu in northern direction until Dassu had to the base camp withdraw. Only on August 24, a new trial could be started, because of fresh snow but managed only to Camp 1. Now turns at the mouth of the Hoh River Lungma the Braldu River to the east. But the Germans followed the Hoh Lungma-River and camped in Tapsa (3700 m). Here she first had with the inhabitants negotiate for the permission for entering the Hoh Lungma-area. After the agreement it went to Hoh Lungma Glacier where on the "Bärenwiese" in 4150 m Height on August 11, the base camp was. About the lower plateau of the glacier Tsilbu (4500 m) we went up to the upper plateau, where in 4700 m camp 1 has been built. On August 15, a barrage increased from three climbers on the top Tsilbu-Glaciers to South Hikmul pass on and established in 5390 m camp 2. After there was once a weather burglary and Cologne the weather was consistently bad and so they decided to retreat. Hillside, the Germans had split into two groups working completely separately. The second group was on August 12 by Tapsa the orographic right side the lower Sosbun glacier until about 4200 m height. The following day erected it their base camp m on the upper Sosbun Glacier in 4440 height. After a rest day it continued on August 15 and was at the foot of Sosbun Brakk-west ridge stock 1 built in 4820 m height. In the following days, the climbers started the Climbing at West Ridge. In about 5000 m, they crossed a glacier, and laid on Gratfuß to a first material depot. Another depot was with rope Insurance (IV Degrees) created in 5250 m. Following were equipment and food up stock 1 made from base camp. On August 23, it was in complicated Ridge climbing above the second depot on. There had to a large intersection and an ice slope (V degree) to be overcome in 5350 m. Following was the explored route insured. Behind the intersection it went on 25 August. Next, the Cologne reached the actual rock body in 5400 m height. Smoothness Plates and mixed terrain (V-VI grade) were a real challenge. Of the highest point, which was achieved, was in about 5500 m altitude. Because of slumping Night rose the roped off a piece, but then had in 5300 m altitude a bivouac set up. Prolonged snowfall demoralsierte Cologne so much that they decided dismount.
TRANSLATED

Key words: Lungma Glacier, Karakoram.

M/179. Meiners, S., 1998. Preliminary results concerning historic to Post-Glacial glacier stages in the NW-Karakorum (Hispar Muztagh, Batura Muztagh, Rakaposhi Range). In: Stellrecht, I., Karakorum-Hindukush-Himalaya: Dynamics of Change (Culture Area Karakorum, Scientific Studies 4). Rudiger Koppe, Koln.

Key words: Glaciers, Batura, Hispar, Mustagh, Rakaposhi, Karakoram.

M/180. Meissner, C.R., 1966. Phosphatic rock in the Nizampur area of the Kala-Chitta Hill. MROP, USAID/Geological Survey of Pakistan 3, 5p.

Key words: Phosphatic rocks, Nizampur, Nowshera.

M/181. Meissner, C.R., Hussain, M., Rashid, M.A. & Sethi, U.B., 1964-65. Reconnaissance geologic map and cross sections of the Parachinar quadrangle, Pakistan. US Geological Survey, Geological Map Series PP 716F Plate 1. Scale 1:250,000.

Key word: Reconnaissance geology, structure, Parachinar.

M/182. Meissner, C.R., Hussain, M., Rashid, M.A. & Sethi, U.B., 1969. Geology of the Parachinar quadrangle, Pakistan. Geological Survey Pakistan and U.S. Geological Survey, Professional Paper 716-G, 20p.

The Parachinar quadrangle occupies approximately 3500 square miles along the western border of West Pakistan. The area consists mainly of sedimentary rocks that range in age from Jurassic to Pliocene. A total of 23 stratigraphic groups and formations, most of them having formally accepted names, have an aggregate stratigraphic thickness of more than 23,000 feet; more than 13000 feet is Late Tertiary in age. Sixteen stratigraphic sections provide much detailed information on the lithology and stratigraphic relations of the rock units. The work was correlated with that done in the Kohat quadrangle to the east and the Bannu quadrangle to the south. Of major stratigraphic importance is the juxtaposition of two distinct facies of Cretaceous rocks in the quadrangle, a shale facies on the west and a limestone facies on the east.
Key words: Stratigraphy, structure, Parachinar.

M/183. Meissner, C.R., Hussain, M., Rashid, M.A. & Sethi, U.B., 1975. Geology of the Parachinar quadrangle, Pakistan. US Geological Survey Professional Paper, 716F, 1-24. Reconnaissance geological map 1:250,000.

Key words: Stratigraphy, structure, Parachinar.

M/184. Meissner, C.R., Master, J.M., Rashid, M.A. & Hussain, M., 1968. Stratigraphy of the Kohat quadrangle, West Pakistan. US Geological Survey/Geological Survey of Pakistan, (IR) PK-20, 86p.

The Kohat quadrangle (Survey of Pakistan topographic sheet 38-O) consists of approximately 4,000 square miles. Sedimentary rocks in the area have a total stratigraphic thickness of more than 25,500 feet. The oldest rocks crop out in the northeastern and northwestern parts of the quadrangle, and are slate, slaty shale, and sandstone of Precambrian or early Paleozoic age. Jurassic, Cretaceous, Paleocene, Eocene, Miocene, and Pliocene sedimentary formations are found in the Kohat quadrangle. Pleistocene sedimentary rocks also may be present, but were not recognized.
The rock sequence of 21 formations, six of which are formally defined for the first time.

The Jurassic System consists mostly of limestone: two subdivisions have been recognized. The Lower half of the Cretaceous System is mostly marine sandstone, and the upper half is mostly marine limestone. The Paleocene Series, which includes three formations, consists mostly of carbonate rocks but also contains some sandstone and shale. Of the Eocene Series, only rocks of early Eocene age are present in the Kohat quadrangle, and they contain extensive deposits of gypsum, rock salt, marine limestone and shale. A relatively thin section of the Murree Formation of Miocene age unconformably overlies lower Eocene rocks. It, in turn, is overlain by more than 10,000 feet of strata.
Key words: Stratigraphy, mapping, Kohat.

M/185. Meissner, C.R., Master, J.M., Rashid, M.A. & Hussain, M., 1974. Stratigraphy of the Kohat quadrangle, Pakistan. US Geological Survey Professional Paper 716-D, 30p. Geological map 1:250,000.

Key words: Stratigraphy, structure, Kohat.

M/186. Meissner, C.R. & Rehman, H., 1973. Distribution, thickness and lithology of Paleocene rocks in Pakistan. US Geological Survey, Professional Paper 716-E, 6p.

Key words: Stratigraphy, lithology, Paleocene.

M/187. Meixner, H. & Paar, W., 1976. Ein vorkommen von vayrynenit-kristallen aus ‘Pakistan’. Z. Kristallen 143, 309-318.

Key words: Gems.

M/188. Meltzer, A., Sarker, G., Seeber, L. & Armbruster, J., 1998. Snap, crackle, pop! Seismicity and crustal structure at Nanga Parbat Pakistan Himalaya. Eos Transition American Geophysical Union 79 Supplements F909.

For details, consult the following two accounts.
Key words: Seismicity, structure, Nanga Parbat, Himalaya.

M/189. Meltzer, A., Seeber, L. & Armbruster, J., 1998. Seismicity and crustal structure at Nanga Parbat, Pakistan Himalaya. Geological Bulletin, University of Peshawar 31 (Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop), 128-129.

Nanga Parbat lies on the western end of the Himalayan Mountain chain in NE Pakistan. This >8 km high peak, sculpted from Indian crust, is the site of rapid uplift, denudation, and young (<1 Ma) igneous and metamorphic activity. Substantial reworking of the crust occurs today, although the initial collision between India and Asia occurred ~55 my ago. While the Indian basement gneisses that make up the Nanga Parbat massif were clearly involved in a major collisional event, they exhibit virtually no evidence for early Himalayan metamorphism. As part of a multidisciplinary study to understand the active tectonic processes at Nanga Parbat we deployed a dense seismic array to characterize active seismicity at the massif (fault geometry and kinematics) and determine crustal structure beneath the mountain. Extremely rapid exhumation, the presence of hot springs, young intrusive rocks, and young metamorphism all suggest an anomalous thermal structure lies beneath Nanga Parbat.
Our 60 station array consists of 10 broadband and 50 short period three component stations deployed in a 60 x 60 km area surrounding the massif. Station spacing varies from 1 to 6 km, and station elevations range from 1.0 to 4.3 km. The array recorded local and regional seismicity for a 4 month period (May-September, 1996). Primary source regions are the Hindu Kush, the Karakoram, the Himalayan and Hazara arcs, and local seismicity beneath the massif itself. The Hindu Kush events which originate 200-300 km northwest of Nanga Parbat, and at 200-300 km depth serve as a beam source to illuminate the structure beneath the massif.

In a four month time window we recorded over 1500 associated events, a combination of teleseismic, regional, and local earthquakes. Our initial focus has been on locating events and analyzing waveforms. Ultimately, we'll use the Hindu Kush events and additional regional events from a range of azimuths combined with local events to produce a tomographic image of velocity and attenuation structure beneath the massif.
Our array recorded a high level of microseismicity at Nanga Parbat, between 3 and 8 small magnitude events per day. Seismicity is somewhat distributed along strike beneath the massif but exhibits a sharp drop off in intensity both west and east of the main summit. The sharp cut off in seismicity to the west corresponds to the mapped trace of the Raikot fault. This young active structure juxtaposes Indian Pre-Cambrian gneisses against mafic rocks of the Kohistan Island arc captured during the collision of Indian and Asia and provides a mechanism to expose Indian plate rocks from beneath Asia. The adjacent Kohistan terrane is virtually aseismic. The sharp cut off in seismicity to the east is bound by the region of highest topography. In fact, the highest intensity of distributed seismicity is associated with the region of highest topography. Local seismicity beneath Nanga Parbat is restricted to very shallow depths (< 8 km bsl) providing constraints on the transition from brittle to ductile deformation. Hypocenters projected to a NW-SE cross section outline a prominent bow or antiformal shape. The cutoff of seismicity with depth is shallowest beneath the summit (5-km bsl) and deepens to 8 km to the NW and SE. This observation is consistent with petrologic and thermochronologic data indicating very high geothermal gradients (~60-100o/km) at Nanga Parbat. At these rates, rocks pass through the 450o isotherm by ~7 km depth which approaches the ductile regime for quartzofeldspathic rocks, especially in the presence of fluids and high strain rates.
Most of the local events have clean impulsive signals allowing high quality focal mechanisms to be determined. While we recorded some thrust and some right-lateral strike-slip focal mechanisms, much of the observed seismicity is from a set of shallow normal faults striking roughly parallel to the main massif and dipping south to southeast, back toward the summit.
While many of the igneous, metamorphic, and petrologic observations at Nanga Parbat could be explained by a young intrusive body at depth, complicated but prominent S wave arrivals at stations throughout the array rule out the possibility of a substantial magma body beneath Nanga Parbat. This observation holds for both Hindu Kush events with a relatively vertical ray path beneath the massif sampling the entire crust and local events, which travel through the shallow crust. However, we do see local travel time delays and anomalous waveforms suggesting small scale heterogeneity possibly related to small partial melt zones. We also see a large variation in waveform coda associated with propagation path (not site affects). While we see many clean impulsive arrivals, others appear more harmonic, not unlike signatures associated with geothermal systems and volcanoes, suggestive of magmatic or fluid injection at shallow depths. These events are intriguing given the evidence for recent igneous activity focused at the core of the massif and evidence from fluid inclusions indicating a dry steam phase associated a hydrothermal system below 3 km depth. Finally, on many of the local events we see evidence of shear wave splitting presumably due to anisotropy associated with the metamorphic or strain fabric of the rocks.
Key words: Seismicity, structure, Nanga Parbat, Himalaya.

M/190. Meltzer, A., Seeber, L., Sarker, G. & Armbruster, J., 1999. Seismic characterization of active metamorphism, Nanga Parbat, Pakistan Himalaya. Terra Nostra 99 Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 98-99.

Earthquakes recorded by a dense array of seismometers deployed around the Nanga Parbat massif in the Himalaya of Pakistan provide new insight into synorogenic metamorphism and deformational processes. Microseismicity distributed along strike beneath the massif exhibits a sharp drop-off to the east bound by the main summit massif. An abrupt cessation of seismicity with depth defines a shallow brittle-ductile transition at 5-8 km bsl. Low P and S wave velocity anomalies observed at the core of the massif extend to depth through the entire crust. At Nanga Parbat local seismicity and low seismic velocities are associated with the highest topography, youngest metamorphic and igneous ages, high geothermal gradients, and active crustal fluid flow suggesting a genetic link between these phenomena.
Most of the local events have clean impulsive signals allowing high-quality focal mechanisms to be determined. While have recorded some thrust and some right-lateral strike- slip focal mechanisms, much of the observed seismicity is from a set of shallow normal faults striking roughly parallel to the main massif and dipping south to southeast, back toward the summit. These extensional focal mechanisms are not associated with low-angle crustal-scale faults typically associated with tectonic denudation in orogenic belts. Instead, they fall along planes that are relatively high angle, limited in lateral extent, and restricted to the shallow portions of the crust (upper 5-8 km). These normal faults are consistent with extension above the doubly vergent thrust system which bounds the massif.

Some extensional events may also record hydrofracturing associated with the release of overpressured fluids at depth. We see a cluster of events associated with the Tato hot springs. These events, when relocated using a cross-correlation technique, locate within ± 50m of each other defining a tightly constrained fault plane that may serve as a pathway for circulation of meteoric water to and from the surface. A 3-D joint inversion for hypocenter location, Vp, and Vs shows that the velocity structure beneath the Nanga Parbat massif is anomalously low, up to 10%, over lateral distances of 20-40 km (11). In the shallow crust (<10-km depth) Vp ranges from 5.6-5.8 km/s and Vs from 3.3-3.5 km/s within the massif compared to velocities of Vp=6.0-6.4 km/s and Vs=3.5-3.6 km/s in adjacent regions. Analyzing arrivals at the stations deployed in valleys as subsets of small linear arrays yields similar velocity values confirming the robustness of these results. At greater depths (10-50 km) Vp ranges from 5.8-5.9 km/s and Vs from 3.5-3.6 km/s within the massif compared to velocities of Vp=6.2-6.5 km/s and Vs=3.6-3.8 km/s in the surrounding area. Both the P and S wave velocity anomalies are observed at the core of the massif and extend to depth through the entire crust. Low velocities imply hot rocks at depth in this region as the composition of the massif is monotonously homogeneous with respect to seismic wavelengths. The distribution of low velocities found at Nanga Parbat is consistent with the prediction of numerical models examining the evolution of the conductive geotherm during rapid advection of crustal rocks, which indicate that Nanga Parbat should resemble a “pillar of heat”. This result also suggests that the primary flow path ci material into the massif is from depth rather than along a shallow detachment. Finally, our initial inversions yield slightly low Vp/Vs ratios at several areas within the massif, which may reflect the presence of super-critical fluids in small regions of limited extent. While many of the igneous, metamorphic, and structural observations at Nanga Parbat could be explained by a young intrusive body at depth, prominent but complicated S wave arrivals at stations throughout the array rule out the possibility of a substantial magma body beneath Nanga Parbat. This observation holds for both Hindu Kush events with a relatively vertical ray path beneath the massif sampling the entire crust and local events, which travel more obliquely through the shallow crust.

The seismic data recorded at Nanga Parbat supports a model of strain induced metamorphism. Focal mechanisms, travel time and waveform anomalies, low Vp and Vs, and low Vp/Vs ratios are consistent with the model in which rapid and dramatic exhumation leads to pervasive reworking of continental crust. Dehydrated Indian gneisses are transported from depth toward the surface. As this material is brought to the surface advection of isotherms results in low P and S wave velocities throughout the crust and elevates the position of the brittle-ductile transition causing it to bow, convex upward beneath the massif. As dry gneisses then pass into the lower strain zone beneath the summit, they are brought into communication with surface waters. Fluids may be released due to shear failure at elevated fluid pressure or due to local hydrofracturing providing the source of some of the microseismicity recorded at Nanga Parbat.

Key words: Seismicity, metamorphism, Nanga Parbat, Himalaya.

M/191. Memon, A.R., 1966. Sedimentary petrography of Siwalik sediments exposed in Khaur, Dhok Pattan, and Soan syncline areas. M.Sc. Thesis, Sind University, Jamshoro.

Key words: Sedimentary petrography, siwaliks, Khaur, Dhok Pattan, Soan syncline.

M/192. Memon, M.A. & Tietze, Klaus–W., 1997. Depositional environments and diagenetic history of the Lumshiwal Formation, Miranwal Nala section, Surghar Range. Pakistan Journal of Hydrocarbon Research, 9, 3–14.

Key words: Depositional environments, Lumshiwal Formation, Surghar Range.

M/193. Menke, W. & Jacob, K.H., 1976. Seismicity patterns in Pakistan and northwestern India associated with continental collision. Seismological Society of America, Bulletin 66, 1695-1711.

Key words: Seismicity, continental collision, India, Pakistan.

M/194. Mensink, H., Mertmann, D. & Ahmad, S., 1986. Stratigraphical dates on the Triassic rocks of Landu Nala, Surghar Range. Geological Bulletin, Punjab University 21, 104-119.

The stratigraphy and micofacies of some of the Triassic rocks of Landu Nala are described. Within the pisolitic horizon on top of the Mianwali formation a few species of conodonts namely Gondolella timorensis, Neospathodus homeri and Ozardina tortills are recorded. Within the Kingriali succession some brachiopod species of Spiriferinoides and some pelecypods have also been identified. An Anisian and Carnian age is proposed on the basis of fossil contents.
Key words: Stratigraphy, Triassic, Surghar Range, Mianwali.

M/195. Mensink, H., Mertmann, D., Ahmad, S. & Shams, F.A., 1984. Facies of Jurassic rocks in the Surghar Range, Pakistan. Abstracts, First Pakistan Geological Congress, Lahore, 63-64.

The Jurassic sediments of the Surghar and Salt Range show a variety of microfacies-types. It is possible to distinguish 12 different rock facies. Furthermore, the sections contain many discontinuities. Both are interpreted. The sedimentary history can be divided into 5 subsequent phases between the Upper-Trias and Neocom.
Key words: Microfacies, Jurassic, Surghar, Trans-Indus Salt Range.

M/196. Mensink, H., Mertmann, D., Ahmad, S. & Shams, F.A., 1985. A microfacies reconnaissance of the Kingriali Formation of the Nammal Gorge and Gulakhel areas. Geological Bulletin Punjab University, 20, 1-10.

Microfacies-analysis of 60 thin sections based on 80 rock samples from two sections namely Nammal Gorge and Gulakhel belonging to the Kingriali-Formation is presented. Eleven types of microfacies have been differentiated and are described. Most of these are of dolosparitic nature, others are dolomicritic. Furthermore, calcitic onco-, 00- and bio-sparites are also encountered during the present investigation. Based on facies-analysis the rock sequence is subdivided into different facies units. Paleoenvironments are interpreted as shallow marine to interidal.
Key words: Microfacies, reconnaissance, Nammal Gorge, Salt Range.

M/197. Mensink, H., Merttmann, D., Ahmad, S. & Shams, F.A., 1991. Facies of Jurassic rocks in the Surghar Range, Pakistan. Acta Mineralogica Pakistanica, 5, 109-120.

Key words: Microfacies, Jurassic, Surghar Range, Trans Indus Salt Range.

M/198. Mercer, J.H., 1963. Glacier Variations in the Karakoram. Glaciological Notes 14, 19-33.

Key words: Glaciers, Karakoram.

M/199. Mercer, J.H., 1965. Glaciers of Karakoram. In: Field, W. (ed.), Mountain Glaciers of the Northern Hemisphere, 371-409. US Army Cold Regions Research & Engineering Lab., Hanover, NH.

Key words: Glaciers, Karakoram.

M/200. Mercer, J.H., 1975. Glaciers of the Karakoram. In: Inventory of World Glaciers. Field, W., (ed.), 377–407.

Key words: World Glaciers, Karakoram glaciers.

M/201. Merla, G., 1931. Fossili Antrocolitici del Caracorum. In: Relazioni Scientifiche della Spedizione Italiana de Filippi Nel'Himalaia, Caracorum e Turchestan Cinese (1913-1914), 2(5), 101-319. Zanichelli, Bologna.

Key words: Fossils, Karakoram, Chinese Turkestan.

M/202. Merla, G., 1934. Fossili triassici del Depsang. In: Relazioni Scientifiche della Spedizione Italiana de Filippi Nel'Himalaia, Caracorum e Turchestan Cinese (1913-1914), 2(9), 51-124. Zanichelli, Bologna.

Key words: Triassic fossils, Karakoram, Himalaya, Chinese Turkestan

M/203. Merla, G., 1936. Prime observazioni su alcuni fossili permici raccolti della spedizione. Appendix to: La Spedizione Geografica Italiana al Karakorum (1929). Arti Grafiche Bertarelli, Milano, 29-48.

Key words: Fossils, Italian Geographic Expedition, Karakoram.

M/204. Mertmann, D. & Ahmed, S., 1997a. Sedimentary sequence of the marine Permian rocks, Salt Range, Surghar Range, Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.46.

Key words: Sedimentary sequence, Permian, Surghar Range, Salt Range.

M/205. Mertmann, D. & Ahmed, S., 1997b. The drowning of the Jurassic carbonate platform in Pakistan in the context of a peri-Gondwanian event. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p47.

Key words: Jurassic, carbonate, Gondwana.

M/206. Mertmann, D. & Ahmed, S., 2000. Foraminiferal assemblages in Permian carbonates of the Salt Range and Trans Indus Ranges, Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, 21-22.

The marine Permian sediments (Amb-, Wargal- and Chhidru Formations) of the Salt Range and the Trans Indus Ranges yield an abundant fauna of foraminifera. Main groups include Fusulinina, Miliolina and Rotaliina. The fauna occur as benthic organisms setting under open marine to lagoonal conditions in a warm Tethyan sea (P.J.R.G., 1985). The foraminifera show strong palaeobiogeographic relations to other Tethyan carbonate plat- forms situated in today's Iran, Afghanistan, China and Asia (Jenny-Deshusses 1983, Lys 1988).
Fusulinaceans (Parafusulina (Monodiexodina) kattaensis (Schwager) and Codonofusiella laxa Douglass) are rare in the Amb Formation due to strong clastic input and an agitated coastal water. In the lower Wargal Formation and association comprises Neoschwagenina margaritae DEPRAT, Sphaerulina sp., Schubertella sp., Chusenella sp. and Reichelina sp. Therefore, a Murghabian age is evident. The occurrence of the Neoschwagerina- association is related to a major marine transgression together with a warm surface current along the northern margin of Gondwana. In the upper part of the Wargal Formation and in the Chhidru Formation, Nanlingella simplex Sheng & Chang, Reichelina sp., Nankinella sp. and Staffella sp. indicate a Djulfian age. Small foraminifera include a variety of long ranging species from Parathuramminidae, Earlandiidae, Nodosinellidae, Endothyridae, Lasiodiscidae, Hemigordiopsidae and Fischeridae. Others are more interesting Globivalvulina vonderschmitti REICHEL and Dagmarita chanakchiensis RIETLINGER indicate a Murghabian to Djulfian age. Both are present in the Wargal- and Chhidru Formation. Globivalvulina mira REITLINGER (Midian - Djulfian) occurs from the Upper Wargal onward. Colaniella ex grupo lepida WANG and Colaniella ex grupo minima WANG are restricted to the Upper Wargal and the Chhidru Formation. Stratigraphically confined to the Midian to Dorashamian, older forms are described only from the Pamir and Kaukasus. In the southern Peri-gondwanian areas they represent a Djulfian age, whereas the youngest forms are

known from China (Jenny-Deshusses et al., 1989). Within the Wargal Formation they are often distributed in a coral reef facies.
Key words: Carbonate, Permian, Trans Indus Range, Salt Range.

M/207. Mertmann, D. & Ahmed, S., 2000. Evolution of Tethyan carbonate plateform during the Upper Permian (Salt Range, Surghar Rang), Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, 22-23.

During the Permian, a large carbonate platform developed on Gondwana continental crust in front of the Indian Shield. The platform was influenced both by sea-level fluctuations and by repeated intervals of hinterland uplift associated with an increase in clastic terrigenous input. Sedimentary environments were mainly of the following types; deltaic and siliciclastic shelf and carbonate platform with a variety of reef mounds, bioclastic shoals and tidal flats. The sequence can be divided into depositional sequences and the system tract philosophy can be applied. Third-order cycles are represented by atleast 6 depositional sequences with internal shallowing- upward parasequences. Moreover, a superimposed cycle spans the whole Zaluch Group.
Key words: Carbonate, Permian, Tethyan, Salt Range.

M/208. Mertmann, D., Dragastan, O. & Ahmed, S., 1992. Depositional environments of Jurassic carbonate rock of the Salt Range, Surghar Range and Kala Chitta areas, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, p.28.

Key words: Depositional environments, Jurassic, carbonates, Salt Range, Surghar Range, Kala Chitta areas.

M/209. Mian, I., 1970a. The chromium-bearing minerals of the North West Frontier Province. Geological Bulletin, University of Peshawar 5, 131-134.

During the past few years, many interesting minerals have been reported from the N.W.F.P. Of these, the chromium-bearing minerals – emerald, mica, spinal and tourmaline – merit special attention because of the economic and / or academic importance. Gem quality emerald from Swat and Mohmand Agency is sold at high price and has attracted a lot of people during the past few years. All of the chromium-bearing minerals are closely associated with ultramafic rocks from which chromium was derived by various mechanisms. In this paper, the writer has tried to gather all the published data available on these occurrences, and has added some new information.
Key words: Minerals, gems, ultramafics, N.W.F.P.

M/210. Mian, I., 1970b. Building and decorate material of North West Frontier Province. National Seminar on Mineral Development, Lahore.

Key words: Building stones, decorative stone, NWFP.

M/211. Mian, I., 1987. The mineralogy and geochemistry of the carbonatite, syenites and fenites of North West Frontier Province, Pakistan. Ph.D. thesis, Leicester University.

Key words: Mineralogy, geochemistry, carbonatite, syenites, fenites, NWFP.

M/212. Mian, I., 1994. Sulphide occurrences in Shinkai area of North Waziristan Agency, FATA. Abstracts, Second SEGMITE International Conference on the Export Oriented Development of Mineral Resources and Mineral Based Industries, Karachi, 33-34.

Waziristan area representing a typical ophiolite environment with a diagnostic sequence of ocean floor ultramafics, sheeted dykes and pillow lava with subordinate deep marine sediments. The ophiolite sequence is intruded by plutonic rock (Diorite and granodiorite).
Copper occurrences in brecciated pillow lavas of the ophiolite have been recorded in a North-west trending belt. Various gossans have been identified along 100-kms, as linear belt and confined to the west central part of Waziristan area. Major occurrences are confined in Shinkai and Degan-Paikhel area, North Waziristan Agency and Spinkamar area of South Waziristan Agency, total of 15 prospects of various area extent have been studied for sub-surface behaviour of copper and related sulphide in Shinkai and Degan Paikhel area.
Primary sulphide mainly (pyrite, chalcopyrite and bornite are confined to the chloritized pillow breccia as stock work in the form of fractures, cavity fillings and fine disseminations. These sulphides are mostly associated with quartz, epidote, calcite and chlorite. The stock work zone is capped by a thin layer of secondary oxides including malachite, azurite, Limonite, itch limonite, jarosite geothite and hematite. Geochemical studies of 92 bore hole samples of about 12,462 meters strata at 1 meter interval are conducted for copper and related sulphides.
Multidisciplinary geophysical survey has been conducted in the Degan Paikhel through Geological survey of Pakistan in 1988. Induced polarization survey has been initiated at Shinkai area. Total of 1411' profiles at 50 meters and 100 meters electrode spacing have been conducted. Based on bore hole geochemical studies, petrography, induced polarization (IP) studies and subsurface alteration, it is suggested that the sulphide mineralization is of volcano genic massive sulphide type (VMS); formed at or near die submarine spreading center and later on subjected to uplift and exposure during collision of Indian mass with the Eurasian continental block.
Key words: Sulphide mineralization, ophiolites, ultramafics, North Waziristan.

M/213. Mian, I. & Afridi, M.I., 1996. Sulphide occurrences in Shinkai area of North Waziristan Agency, FATA. Proceedings, Second SEGMITE International Conference on Export Oriented Development of Mineral Resources and Mineral Based Industries, Karachi, 1994, p.77.

Key words: Sulphides, ophiolites, ultramafics, North Waziristan.

M/214. Mian, I. & Jabeen, N., 1990. Sodic pyroxenes and amphiboles from Koga syenites of Ambela Granitic complex, NWFP, Pakistan. Geological Bulletin, University of Peshawar 23, 67-85.

The Koga syenites are intruded and fenitized by at least two carbonatite intrusions having different Na/K ratios. The carbonatite with high Na/K ratio formed Na-fenites, while the low Na/K ratio produced K-fenites. Amongst the fenitic pyriboles, Na-pyroxene shows a trend from acmitic to diopsidic and /or hedenburgitic component in contrast to magmatic trend. The fenitic Na-amphibole occurs only in Na-fenitized rocks and shows a trend from magnesio-arfvedsonite to richterite, which is opposite to the magmatic subsolidus trend. The amphibole composition shows an increase in MgO ratio with increasing intensity of fenitization and suggests the crystallization of fenite amphibole under strong oxidation conditions.
Key words: Mineralogy, pyroxene, amphibole, Koga, Buner.

M/215. Mian, I. & Le Bas, M.J., 1986. Sodic amphibole in fenites from the Loe Shilman carbonatite complex, NW Pakistan. Mineralogical Magazine 50, 187-197.

The carbonatites at Loe Shilman, near Khyber in NW Pakistan, fenitize their country rocks to form a metasomatic zone *c*.100 m wide of alternate dark blue (mafic) and pale grey (felsic) banded fenites which grade into unfenitized bedded slates and phyllites. The Na-amphiboles in the banded fenites form a complete solid solution series between magnesio-arfvedsonite and magnesio-riebeckite which coexist with varying proportions of aegirine, albite, and K-feldspar, with or without phlogopite or biotite. The amphiboles show a gradual decrease in Na_2O, K_2O, Mg ratio [100Mg/(Mg + Fe^T + Mn)] and iron oxidation ratio, and an increase in total iron away from the carbonatite contact. The pleochroism correlates with the chemistry and distance from the carbonatite contact.
The Mg ratio decreases from 74 to 35 away from the carbonatite contact. The iron oxidation ratio [$100Fe^{3+}/(Fe^{3+} + Fe^{2+})$] decreases in the magnesio-arfvedsonite for the first 30 metres from the carbonatite contact, and then increases in the magnesio-riebeckite from 40 to 60 metres from the carbonatite contact. K relative to Na decreases away from

the contact in the amphibole, and the decrease in K causes an increase in vacancy in the *A* site. The main variation in the chemistry in this solid solution series is due to $(K, Na)_A+(Mg,Fe^{2+})_c \rightleftharpoons \square + (Fe^{3+})c$ substitution.
Key words: Mineralogy, amphibole, Loe Shilman.

M/216. Mian, I. & Le Bas, M.J., 1987. The biotite-phlogopite series in fenites from Loe Shilman carbonatite complex, NW Pakistan. Mineralogical Magazine 51, 397-408.

The Loe Shilman carbonatite sheet complex comprises an extensive amphibole sovite which is intruded by minor biotite sovite and amphibole ankeritic carbonatite. The carbonatites have fenitized the country rocks to form a metasomatic zone c. 100 m wide of alternating mafic and felsic mica-bearing banded fenites which grade into slates and phyllites. Phlogopite-rich micas occur nearest to the carbonatite contact. The biotites occur in K-feldspar + albite ± Na-amphibole ± aegirine and ± phengite fenites produced by the intrusion of the early amphibole sovite. Aegirine buffered the iron distribution and the biotites became more magnesian. Veins cross-cutting the fenites consist of biotite and/or Ba-bearing K-feldspar, and are interpreted to result from solutions emanating from the biotite sovite. The ankeritic carbonatite is responsible for the formation of phlogopite in the fenites in a c. 3 m wide zone adjacent to the carbonatite, and evidently are the result of fenitizing fluids rich in Mg. Chemical equations calculated to balance the reactions interpreted to have taken place in the fenites suggest that about 10% of the Al and Si in the protolith was mobilized and moved towards the carbonatites during fenitization, and that the fenitizing solutions were strongly alkaline and oxidizing.
Key words: Mineralogy, biotite, fenite, Loe Shilman, NWFP.

M/217. Mian, I. & Le Bas, M.J., 1988. Feldspar solid solution series in fenites from Loe Shilman carbonatite complex, NW Pakistan. Geological Bulletin, University of Peshawar 21, 71-83.

The carbonatite sheets at Loe Shilman in Khyber Agency, NW Pakistan, fenitize their country rocks to form a metasomatic zone, c. 100 metres wide, of alternate dark blue (mafic) and pale grey (felsic) banded fenites which grade into unfenitized slates and phyllites. The carbonatite sheets comprise a more extensive amphibole sovite which is intruded by biotite sovite in different parts of the complex. These sovites are in turn intruded by ankeritic carbonatite mainly along the southern contact with the country rocks.
Among the new minerals, formed as a result of three fenitizations (two sodic and one potassic), K-feldspar are formed as a result of contact thermal effect by the early amphibole sovite at the expense of phengite and argillaceous material. The more disordered K-feldspar, which were formed at high temperature (~7000C), in the inner zones 3, 4 and 5 are now readjusted to maximum-microcline to intermediate-microcline. While in zone 2 the more disordered relict K-feldspar escaped readjustment, and therefore, produces reverse zonation in contrast to the temperature gradient. The effect of biotite sovite is restricted to the thin veins composed of K-feldspar (Ba=1.4 wt %) and biotite. The samples SM93 and SM84, amongst the banded fenites, have been also metasomatized by the biotite sovite.
Albite, which coexists with other metasomatic minerals, formed first by the early amphibole sovite, was presumably more disordered towards the carbonatite contact. It is now readjusted to its present lowest structural state by the ankeritic carbonatite. The presence of relict disordered intermediate low-albite now shows reverse zonation in contrast to the temperature gradient. Both the solid solution series are well correlated with distance from the carbonatite igneous contact.
Key words: Mineralogy, feldspar, fenite, Loe Shilman, Khyber Agency.

M/218. Mian, I. & Le Bas, M.J., 1990. The geochemistry of the zoned fenites at the Loe Shilman carbonatite complex, NW Pakistan. Abstracts, 2nd Pakistan Geological Congress, University of Peshawar, 26-27.

The carbonatite at Loe Shilman in Khyber Agency, NW Pakistan, fenitize the country rocks to form a metasomatic zone c. l00m wide of alternate dark blue (mafic) and pale grey (felsic) banded fenite which grade into unfenitized thin bedded laminites (slates and phyllites).
The banded fenites are syenitic in composition which show gradual increase in Na from 2 to 13.7 (calculated into a standard cell of 100 anions) while Si and Al decreases from 37 to 33.7 and 11.7 to 0.8 respectively from the outer zone 1 to the inner zone 5.K, Mg and FeT remain approximately constant in the outer four zones and range between

3.5-4.3, 1.9-3.0 and 2.5-3.5 respectively while K decreases sharply from 6.0 to 1.5 and Mg and FeT increase sharply from 5 or less to 9 and 11 respectively in the innermost zone in contact with the carbonatite. The decreases and increases correlate well with the distance from the carbonatite contact.
Trace elements La, Nb, Zr and Zn are approximately constant in the outer four zones but increase sharply in the inner zone. However, Rb, Ba, Cr, Ni, Ga, and Y decrease gradually from the least fenitized laminites towards the carbonatites and decrease sharply in the inner zone. Similarly, the total REE increases towards the carbonatites an the LREE to HREE ratio remains constant in the outer zones an increases in the innermost zone in contact with the ankeritic dolomite carbonatites. A negative Eu anomaly is present in the least fenitized rock and is gradually diluted in the inner zones (1-4) and almost disappears in the inner zone 5. These gradual increases and decrease in major, trace and RE elements are due to the metasomatism as result of Na-fenitization fluids (from the early amphibole sovite) soaking through the low permeability slates and phyllites. The latter biotite sovite has superimposed K-metasomatism over the Na-metasomatism. However, an even later ankeritic dolomite carbonatite is responsible for the sharp increase and decrease of major, trace and RE elements in the inner zone as a result of a second Na-fenitization, this time by fluids rich in Mg and Fe.
Key words: Geochemistry, fenites, Loe Shilman, Khyber Agency.

M/219. McGibbon, K.J. (ed.), 1982. Karakoram Expedition 1982. A Scientific Expedition to the Hunza Valley, northern Pakistan (74ºE, 36ºN). Newcastle University Exploration Society, 88p.

This is a generalized account of the Hunza valley in central Karakoram. It deals with various aspects of the geography of the area.
Key words: Exploration, expedition, Hunza, Karakoram.

M/220. Middlemiss, C.S., 1890. Preliminary note on the coal seam of the Dore ravine, Hazara. Geological Survey of India, Records 23(2), 267-269.

As this account does not have an abstract, the first few pages of the account are presented here as an introduction.

It is usual in the Memoirs of the Geological Survey to begin the description of a country with some remarks on the surface features, physical geography, etc. if I seem to be departing from a good old rule here, it is for the reason that all particulars, such as cannot be gathered from an inspection of the map, will more consistently find a place in the following chapters, when I come to describe in detail the geology of each of the zones, or strike areas, into which I shall find it expedient to divide up the country. This seems the more desirable inasmuch as the very varied aspects of the country are so indissolubly connected with the geological components of the zones that the former would be bare and meaningless if presented without their structural raisons centre.
I may remark, however, that Hazara is a strip of generally mountainous country, bounded on the south by the Rawalpindi plateau, on the north by the little-known mountainous country belonging to a number of warlike, independent hill clans, on the west by the Indus river, and on the east by Kashmir, with the Jhelum river below Domel as the line of demarcation.

Structurally, and therefore geologically, it connects the Rawalpindi and Jhelum districts (which embrace the Salt-Range) with the territory of Kashmir; all of which have been geologically described in considerable detail by former members of the Geological Survey of India (see list of authors and works in the Introduction).
The table which follows shows the stratigraphical elements or formations which take part in the Geological Record of Hazara, arranged chronologically:—

Table of formations in Hazara {in descending order).
Historical Rocks.
VIII.—Murreebeds. . . Miocene .
VII.—Kuldana beds (passage). * ' I Tertiary '

VI.— Nummulitic series . Eocene

V.— Middle Cretaceous = Chalk Marl and U

Greensand = Cenomanian > Mesozoic
IV, — Jurassic ....•

III.— Triassic

II.— Inira-Triassic=Carboniferous or. Carbo. Paleozoic and pro-Permian(P) probably older.

I.— Slate series . Age unknown . . .)

Crystalline and Metamorphic Rocks.
b.^Tanol . . . Infra-Triassic in the main \

a. Crystalline schists. . Equivalents of I and II f

v Palaeozoic or above in the main, or older.

x. Intrusive gneissose-granite. . . . A

y. Intrusive dyke rocks /

From the above table the youngest Tertiary, or Siwalik formation, Pliocene, is absent, as it does not occur in Hazara, although it is well developed towards the south in the Rawalpindi plateau. From the Murree beds to the Jurassics the Geological Record in Hazara is fairly complete, save that Upper Cretaceous rocks (if represented) are not marked by any fossil zone; and that the Jurassics, if lithological identity with other parts of India is disallowed as evidence, cannot be subdivided more closely into life-zones. With the Trias comes a small, though consistent, stratigraphical break. The evidence for any trustworthy subdivision of the Trias is wanting, or very doubtful. At the base of the Trias there is another stratigraphical break, and it seems certain that all representatives of the great Carboniferous, or Carbo-Permian epoch, so well developed in Kashmir and the Salt-Range, are either completely absent in Hazara or are represented by the unfossiliferous Infra-Trias limestone (but see p. 29).
With the so-called Infra-Trias we enter on unfossiliferous rocks of unknown age; but a comparative study of other Indian regions gives us a possible clue to the age of its lowest member (see p. 19 et seq.). Below the Infra-Trias is a great stratigraphical break with total unconformability upon the great azoic Slate series beneath. The crystalline and metamorphic rocks exhibit a Himalayan facies as regards the crystalline schists and intrusive sills of gneissose-granite and the basic dyke rocks; but the great thickness of subaerial volcanic rocks of Palaeozoic age, exposed in Kashmir, are not known in Hazara.
Key words: Hydrocarbons, coal, Hazara.

M/221. Middlemiss, C.S., 1896. The Geology of Hazara and the Black Mountain. Geological Survey of India, Memoirs 26, 1-302.

This detailed and well illustrated publication presents the geology of the Hazara area together with notes on economic geology. The rocks have been divided as following:

VIII.-Murree beds VII.-Kuldana beds (passage) VI.-Nummulitic series	Miocene Eocene	TERTIARY
v.-Middle Cretaceous=Chalk Marl and U Greensand=Cenomanian IV.-Jurassic III.-Triassic		MESOZOIC
II.-Infra-Triassic=Carboniferous or Carbo-Permian (p) I.-Slate series Age unknown		PALEOZOIC AND PROBABLY OLDER.

CRYSTALLINE AND METAMORPHIC ROCKS.

b. "Tanol" a. Crystalline schists x. Intrusive gneissose-granite y. Intrusive dyke rocks	Infra-Triassic in the main Equivalent of I and II above in the main,	PALEOZOIC OR OLDER

Key words: Geology, Hazara.

M/222. Middlemiss, C.S., 1910. A revision of the Silurian-Trias sequence in Kashmir. Geological Survey of India, Records 40(3), 206-209.

Key words: Stratigraphy, Silurian, Triassic, Kashmir.

M/223. Middleton, D., 1984. Karakoram history, early exploration. In: Miller, K.J. (eds.)., The International Karakoram Project, Volume 2. Cambridge University Press.

The Karakoram is the most heavily glaciated area outside the Polar Regions and contains some of the world's highest peaks. It is also the most formidable of the parallel mountain ranges dividing the Indian subcontinent from Central Asia. Early exploration was directed to finding a way beyond the Karakoram to trading centers in Eastern Turkestan (now Sinkiang). Attention focused first on the route from Leh to Yarkand by the Karakoram Pass, later on the Gilgit road into Hunza (William Moorcroft 1765-1825). G.T. Vigne (1830-1878) was the first official among the pioneer who opened up the Karakoram, and the first official maps were made by the Survey of India operating in Kashmir between 1857 and 1864. T.G. Montgomerie (1830-1878) was the first to see K2 and H.H. Godwin-Austin (1834-1923) the first actually to put it on the map with its surrounding peaks. The explorations of George Hayward (d. 1870) and the Intelligence work of Francis Younghusband (1863-1942) helped to build up a general picture of the region, and so paved the way for private enterprise and the scientific exploration of the twentieth century. Lord Conway, T.G. Longstass, the Duke of the Abruzzi, Filippo De Filippi, the Duke of Spoleto, Giotto Danielli, Ardito Desio, Dr and Mrs Visser, Kenneth Mason and Eric Shipton were active in the Karakoram between 1908 and the outbreak of the Second World War.
Key words: Glaciation, geology, Karakoram.

M/224. Miehe, G., 1992. Recent climatic changes in the subhumid to arid regions of High Asia (Karakorum, Kunlun, Himalaya, Tibet) as indicated by vegetation features. In: Zheng, D., Zhang, Q. & Pan, Y. (eds.), Proceedings of International Symposium on the Karakorum and Kunlun Mountains, Kashi, June 1992., pp. 333-346. China Meteorological Press, Beijing.

In the context of environments changes in High Asia, indications of dessication are described. They refer to different periods and are caused by different climate changes. In southern Tibet, the plant relicas of tone of the younger Holocene phases of higher humidity (Kobrisia pygmacea age) have been widely destroyed by Himalaya-front, giving way to semiarid alpin steppe on stone pavements. A decrease of plant vigor at climatically sensitive vegetation borders (upper treeline, drought limit of forests, transition zone between alpine Cyperaceae mats and the free gelifluction belt, transition zone between humid alpine mats and alpine steppe) gives evidence of diminishing winter precipitation during the last 30 to 40 years in the Karakorum.
Key words: Vegetation history, climate change, Asia, Karakorum, Kunlun, Himalaya, Tibet.

M/225. Mikoshiba, M., Takahashi, Y., Takahashi, Y., Kausar, A.B., Khan, T. & Kubo, K., 1996a. Rb–Sr dating of the Chilas Igneous complex, Kohistan, northern Pakistan. Abstract volume 11th Himalaya–Karakoram–Tibet Workshop, Flagstaff, Arizona, U.S.A., p.102.

Key words: Rb-Sr dating, Chilas complex, Kohistan.

M/226. Mikoshiba, M., Takahashi, Y., Takahashi, Y., Kausar, A.B., Khan, T. & Kubo, K., 1996b. Rb–Sr dating of the Chilas Igneous complex, Kohistan, northern Pakistan: A short note. Geological Survey Pakistan. Proceedings Geoscience Colloquium, 14, 69–70.

The Chilas complex gives a Rb-Sr age of 112 ±24 ma. with an initial 87Sr/86Sr ratio of 0.70403 ±0.00006. the whole rock isochrones age of this main facies is concorded with the Ar-Ar and K-Ar age of hornblende around 80 ma which may date cooling through 500^0 C (Treloar et al., 1989)
Key words: Rb-Sr dating, Chilas complex, Kohistan.

M/227. Mikoshiba, M., Takahashi, Y., Takahashi, Y., Kausar, A.B., Khan, T. & Kubo, K., 1996c. Rb–Sr whole–rock age of Chilas gabbroic complex, Kohistan, northern Pakistan. Abstract volume Annual Meeting Geological Society of Japan, p.279.

For details, consult Mikoshiba et al. below.
Key words: Rb-Sr dating, Chilas complex, Kohistan.

M/228. Mikoshiba, M.U., Kausar, A.B., Khan, T., Takahashi, Y., Takahashi, Y., Kubo, K. & Shirahase, T., 1996. Petrochemical study on the gabbro norite, diorite and quartz diorite of the Chilas igneous complex, northern Pakistan. In: Kausar, A.B. & Yajima, J. (eds.), Geology, Geochemistry, Economic Geology and Rock Magnetism of the Kohistan Arc. Proceedings of Geoscience Colloquium (Geoscience Lab, GSP, Islamabad) 15, 137-155.

Many chemical analyses have been presented for various rocks of the Chilas complex. It is considered to have formed in an island arc setting during the Late Cretaceous. These analyses, and many more were included in a later publication by Takahashi et al, 2006, Asian Journal of Earth Sciences. For details, consult Mikoshiba et al. in the following.
Key words: Petrochemistry, gabbro norite, Chilas complex, Kohistan island arc.

M/229. Mikoshiba, M.U., Takahashi, Y., Kausar, A.B., Khan, T., Kubo, K. & Shirahase, T., 1999. Rb-Sr isotopic study of the Chilas igneous complex, Kohistan, northern Pakistan. In: Macfarlaine, A., Sorkhabi, R.B. & Quade, J. (eds.), Himalaya and Tibet: Mountain root to mountain tops. Geological Society of America, Special Papers 328, 47-57.

The Chilas Igneous Complex is one of the major geologic units in the Kohistan terrane of the Himalaya of northern Pakistan. The Kohistan terrane is regarded as a tilted island-arc sequence. The Chilas Complex is a 300-km-wide-long, 40-km-wide plutonic body that intrudes the Kamila Amphibolite. The Main facies rocks of the Chilas Complex consist of gabbronorite, diorite, and quartz diorite. Small bodies of ultramafic-mafic association composed mainly of peridotitic-gabbroic cumulates, and a layered gabbronorite body, are also present, probably as xenoliths. A few samples are considered to have been contaminated as a result of assimilation of xenolithic materials and country rocks: Excluding them, 14 whole-rock samples of the Main facies have an Rb-Sr age of 111 ± 24 Ma and an initial 87Sr/86Sr ratio of 0.70403 ± 0.00006. Gabbroic rocks from the ultramafic-mafic association, from the layered gabbronorite body, and from mafic dikes, have 87Sr/86Sr ratios between 0.7039 and 0.7044, interpreted to be close to the 87Sr/86Sr ratios at the time of their generation. The whole-rock isochron age for the Main facies is regarded as the age of intrusion. The initial 87Sr/86Sr ratio for the Main facies is within the range of typical arc magmas, suggesting that the igneous activity occurred within an island arc or orogenic belt close to a continental margin. The age of intrusion of the Chilas Complex is similar to that of the earliest magmatism in the Kohistan batholith and to the Cretaceous plutonism in Ladakh and Karakoram, indicating large-scale generation of subduction-related magmas in the western Himalayan region and Karakoram during the mid-Cretaceous.
Key words: Rb-Sr dating, isotopes, Chilas complex, Kohistan.

M/230. Mikoshiba, M.U., Takahashi, Y., Kubo, K., Kausar, A.B., Khan, T., Takahashi, Y. & Shirahase, T., 1998. Petrochemical characteristics of the eastern part of the Chilas Igneous Complex, Kohistan, northern Pakistan. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 129-131.

The Kohistan terrane of the western Himalaya, northern Pakistan, is regarded as an island-arc sequence sandwiched between the Asian and Indian continental crusts. Deep crustal members are now widely exposed in Kohistan, which makes it an ideal area to study the genesis and evolution of subduction-related crustal structures and rocks.
The Chilas Igneous Complex is one of the major geological unit in the Kohistan terrane, and it is exposed in a large area of 300 km long and 40 km wide. Most of the complex consists of generally homogeneous gabbronorite, pyroxene diorite and pyroxene quartz diorite. They can be called as the Main Facies, which was termed the gabbro-norite association by Khan et al. (1989). Rocks with layered structure are also found within the Chilas Complex, which often occur in km-scale masses. One gabbronorite mass is characterized by well-developed rhythmic layering. Some of the masses are abundant in peridotites associated with layered gabbroic rocks (UMA, ultramafic-mafic association), which are deduced to be crystal accumulates. These layered rocks are considered to be intruded by the Main Facies rocks.
The rocks of the Chilas Complex (the Main Facies) have a calc-alkaline nature. The UMA rocks have chemical compositions reflecting their cumulate characteristics. Here we present detailed geochemical data of the constituent rocks in the eastern part of the complex, to discuss the evolution and crystallization processes in the Chilas Complex.
The Main Facies rocks have continuous variation of chemical compositions. Their SiO2 content ranges from 49 to 60wt% in almost all samples. The concentrations of K_2O, Y, Zr, Th and rare earth elements (REE) are positively correlative with the SiO2 content, while the concentrations of Ga, Sr, Cr and Ni do not vary with SiO_2 content. The chondrite-normalized REE patterns of many of the rocks with SiO_2 content less than 52 wt.% have a positive Eu anomaly, while those of some rocks with SiO2 content more than 56 wt.% have a negative Eu anomaly. The light REE are enriched relative to the heavy REE, and the enrichment is clearer in the rocks with higher SiO2 content.
Samples from the layered gabbronorite mass have chemical compositions resembling with the Main Facies, although their compositions are scattered reflecting their modal variation. In the case of the UMA, major chemical compositions of ultramafic rocks support the petrographic observation implying that they consist mainly of olivine-clinopyroxene cumulates. Some of layered gabbroic rocks in a UMA indicate accumulation of plagioclase, having low REE contents with a clear positive Eu anomaly. Ultramafic rocks and layered gabbroic rocks from the UMA have low incompatible element concentrations.
The chemical composition of the Main Facies rocks support the idea that they solidified from a single evolving magma or from magmas having similar origin. Chemical compositions of a large part of the Main Facies may be similar to those of the magma(s), rather than the crystal cumulates, and they have characteristics of magmas relating to a subduction zone. A part of the Main Facies rocks with low SiO2 content, may have lost the residual liquid at the late stage of solidification, or may have been enriched in the early-formed crystals. Therefore, it is possible to explain the chemical variation in the Main Facies by a weak segregation of melt and early-formed crystals composed of plagioclase, orthopyroxene and clinopyroxene. The relatively low concentrations of Cr and Ni in the mafic rocks suggest the magma had more evolved characteristics than the primary magmas from mantle.
The rocks of the layered gabbronorite mass have petrographical and chemical characteristics which resemble those of the Main Facies, suggesting a common origin. In the case of the UMA, chemical composition of the layered gabbroic rocks and ultramafic rocks clearly have characteristics of cumulates, implying the separation of the melt and crystals were effective. Their chemical and petrographical characteristics suggest that they were crystallized from more primitive magma, probably at the earlier stage than the crystallization of the Main Facies rocks.
Key words: Petrochemistry, gabbro norite, Chilas complex, Kohistan island arc.

M/231. Mikoshiba, M.U., Takahashi, Y., Takahashi, Y., Kausar, A.B., Khan, T. & Kubo, K., 1996. Rb-Sr dating of the Chilas igneous complex, Kohistan, Northern Pakistan. Abstract volume, 11th Himalaya-Karakoram- Tibet Workshop, Flagstaff, Arizona (USA), 102.

The Chilas igneous complex is one of the major geological unit in the Kohistan terrane of the western Himalaya, northern Pakistan. The Kohistan terrane is regarded as a tilted island arc sequence, sandwiched between Asian and Indian continental crust (Coward et al., 1982).

The Chilas complex is a 300km long and 40km wide plutonic body (Khan et al., 1989). The rocks of the Chilas complex intrude into the Kamila amphibolite which is mainly located in the southern side. In the north, quartz diorite to tonalite of the Kohistan batholith intrude into the Chilas complex.
Most of the complex consist of generally massive gabbronorite, diorite and quartz diorite. They can be called as the main facies. There are also small masses of ultramafic-mafic association (UMA, Jan et al., 1984) in the complex. The rocks of the UMA are mainly composed of peridotite and gabbronorite, often showing layered structure. The rocks of the main facies intrudes into the UMA in several outcrops.
Rb-Sr isotopic study is applied to the Chilas complex. The analyzed samples are mostly collected from the eastern part. Gabbronorite and quartz diorite or the main facies are analyzed. In these samples, main constituent minerals are plagioclase, orthopyroxene and clinopyroxene, but small amounts of hornblende, biotite, quartz or K-feldspar are often associated with them, especially in quartz diorite. Gabbronorite of the UMA are also analyzed, in which hornblende, olivine or spinel are often associated
Ten whole-rock samples of the main facies give a Rb-Sr age of 8914 Ma with an initial 87Sr/86Sr ratio of 0.704004±0.00005. Their 87Rb/86Sr ratios are less than 0.65. Six whole-rock samples of the UMA have 87Sr/Sr86 ratios with the range of 0.7039-0.7044. Their 87Rb/86Sr ratios are less than 0.1
The whole-rock isochron age for the main facies is concordant with the Ar-Ar and K-Ar age of hornblende from the Chilas complex around 80 Ma which may date cooling through 500ºC (Treloar et al., 1989). This Rb-Sr age can be regarded as the intrusive age. The results of the Rb-Sr analysis indicates that a large amount of magma intruded in the Cretaceous time, which produced the thick mafic crust in the Kohistan. The initial 87Sr/86Sr ratio for the main facies is higher than the range in MORB, and it is within the typical range in the arc magma. The initial 87Sr/86Sr ratios in the rocks of the UMA are also deuced to be higher than the range in MORB.
Key words: Rb-Sr dating, isotopes, Chilas complex, Kohistan.

M/232. Milisenda, C.C., Bank, H. & Henni, A., 1995. Peridot aus Pakistan. Gemmlogie 44(2-3), 33-42.

In the watershed between Kohistan and Kaghan to the north of Naran, ultramafic rocks host high quality peridot crystals. This paper gives an account of the gemological characteristics of the gemstone, including physical properties.
Key words: Gemology, peridot, Pakistan.

M/233. Miller, D.J. & Christensen, N.L., 1994. Seismic signature and geochemistry of an island arc: A multidisciplinary study of the Kohistan accreted terrane, northern Pakistan. Journal of Geophysical Research 99, 11623-11642.

Systematic sampling and mapping in the Kohistan accreted arc terrane of northern Pakistan has provided a sample suite representing the lithologic diversity of the section from its base along the Main Mantle Thrust upward through several stacked intrusions and their metamorphosed equivalents into the Kohistan batholith. A new lithologic column for the terrane has been developed during the course of this study using geothermobarometry based on elemental exchange reactions calculated from electron microprobe analyses of mineral assemblages. The pressures calculated from the chemical analyses of various mineral assemblages are constrained by recently published activity-composition models and an internally consistent thermodynamic data base. Compressional and shear wave velocities and densities have been measured on samples that represent the diverse lithologies in this section and have been correlated with the new lithologic column. This data set has been augmented with published compositions and values for the uppermost part of the arc, not sampled in this study. Compressional wave velocities range from 4.3 km s^{-1} in supracrustal volcanogenic sediments to 7.5 km s^{-1} in lower crustal mafic cumulates. Underlying ultramafic rocks with velocities of 8.0 to 8.4 km s^{-1} define a sharp seismic Moho. The strong inflection in the velocity profile to greater than 8.0 km s^{-1} is due to the transition from plagioclase-bearing to plagioclase-free cumulate rocks in a continuous ultramafic-mafic intrusion. The base of the crust lies at least four kilometers below this transition. Correlation of these laboratory-measured values and the new lithologic column has allowed development of a velocity profile comparable to profiles developed through more conventional field seismic methods. Geochemical indices of fractionation exhibit a reasonable correlation with Compressional and shear wave velocities. An estimate of mean crustal *Vp* is remarkably similar to models for other cordilleran terranes at 6.7 plus or minus 0.05 km s^{-1}. An estimate of the bulk chemical composition of the Kohistan terrane does not compare favorably with most

published assessments of bulk continental crustal chemical composition, but is significantly more mafic than the latter. The striking resemblance of our reconstructed velocity profile to models generated from field seismic studies not only addresses the veracity of these models, but suggests that the Kohistan arc is a superbly well-preserved analog for other arc terranes.
Key words: Seismology, geochemistry, oceanic crust, Kohistan island arc, Himalaya.

M/234. Miller, D.J., Loucks, R.R. & Ashraf, M., 1991. Platinum-group elements mineralization in the Jijal layered ultramafic-mafic Complex, Pakistan Himalaya. Economic Geology 86, 1093-1102.

Notable enrichments of gold and platinum-group elements (PGE) have been found during the course of our petrochemical enrichment within the Jijal Complex, Northwest Frontier Province, Pakistan. To our knowledge, the only prior documented report of PGE minerals in Pakistan is by Ahmed and Bevan (1981), who described Ir-Ru-Os-Ni-Fe alloy in one sample of serpentinized chromitite from the Sakhakot Qila ophiolite (also called the Dargai complex), ca. 50 km northeast of Peshawar. The chromite deposits were described by Ahmed (1984). Page et al. (1979) reported whole-rock assays pf Pt, Pd, and Rh totaling 5 to 25 ppb in six samples of dunite, harzburgite, and chromitite from the Dargai Complex. They also assayed 30 samples from the Zhob valley ophiolite near Quetta, reporting up to 375 ppb Pt + Pd + Rh in a gabbro sample and <3 to 81 ppb in the other 29 samples, which are mostly chromitites.
Key words: PGE, chromite, Jijal complex, Kohistan island arc.

M/235. Miller, K., 1982. Continents in Collision. International Karakoram Project. George Phillip & Son Ltd. London, 212p.

Key words: Continents, collision, MMT, MKT, Karakoram.

M/236. Miller, K.J., (ed.), 1984. International Karakoram Project. Cambridge University, Press. Cambridge, U.K., vol. 1, 406p., & vol. 2, 642p.

This is a compilation of papers resulting from the Royal Geographic Society International Karakoram Project, 1981. Individual papers are presented in this volume of ours.
Key words: Geography, geophysics, geology, Karakoram.

M/237. Mirza, A.R., 1981-83. Geology of Paras-Bela-Jared Area central Kaghan Valley. M.Sc. Thesis, Punjab University, Lahore, 148p.

This report covers a comprehensive study of a part of central Kaghan Valley. The principal emphasis has been on detailed lithostructural mapping of the area of the scale 1:8333. The rocks range in age from Pre-Cambrian Salkhallas to Miocene Murrees. Stratigraphically, the geology is in many ways different from that in the Abbottabad-Murree-Tarbela-Attock area further south. Part of the Mesozoic and part of the Tertiary sequence is missing in the project area. Furthermore, the equivalents of Panjal Trap and associated limestone are not found in the above mentioned area southwards. Structurally except for some folding in the blocks and nearly all contacts are faulted. The succession in the area is overturned. A fairly detailed account of the stratigraphy is being given and the report also includes a detailed account of the petrography of all the units based on extensive sampling. Tectonically the area is very interesting and the Panjal Traps appear to represent Ophiolites while the agglomerate slates appear to indicate volcano-sedimentary material with island arc affinities. There is, thus some evidence of a Paleozoic subduction zone in this area. Numerous photographs and sketches have also been included to illustrate the geology of the area.
Key words: Geology, structure, Kaghan valley.

M/238. Mirza, K., 1994-96. Geology of Dubran Area, District Haripur with special reference to palynology, micropalaeontology and biostratigraphy of some Paleocene-Eocene rocks. M.Sc. Thesis, Punjab University, Lahore, 219p.

Geological mapping of some 64 sq. Km area around Dubran in District Haripur has been carried out at the scale 1: 12500. The geomorphology, stratigraphy, structure, palynology and micropaleontology 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 green schist facies. Numerous faults, high angle, reverse and normal have now disrupted the sequence. High angle north dipping Nathia Gali 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: Palynology, micropalaeontology, biostratigraphy, Paleocene, Eocene, Haripur, Hazara.

M/239. Mirza, M.A., 1971a. Magnetic survey over the magnetite deposit of Dammer Nisar area, Chitral. Geological Survey of Pakistan, Information Release 42(1).

Key words: Magnetite, magnetic survey, Dammer Nisar, Chitral.

M/240. Mirza, M.A., 1971b. Magnetic survey near Ghazanosar, Swat State, West Pakistan. Geological Survey of Pakistan, Information Release 42(2).

Key words: Magnetic survey, Swat.

M/241. Mirza, M.A., 1980. A preliminary report on the interpretation of seismograms observed at Tarbela-Network of seismic stations. Geological Survey of Pakistan, Information Release 120, 12p.

A deep seismic sounding profile was observed in northern Pakistan in August 1975 under a programme of joint Pak-Italian Karakorum Geophysical Project. Two charges of 1600 kg and 2000 kg were detonated at Astore and Lawrencepur on August 15 at 0300 and 0400 GMT. On August 20 detonation of two more charges of 2400 kg and 2000 kg was repeated at Astore and Lawrencepur. The Russian seismologists followed a similar programme of explosion seismology and blasted charges of 10 tons at Karakul on August 15 and 20, and of 20 tons on the same dates at a site 30 km northeast of Zorkul. The observation timings of these blasts were 0100 and 0200 GMT respectively (Table I).
The detonation at Astore, Lawrencepur, Karakul and northeast of Zorkul for deep seismic studies along a profile joining Astore - Ishkuman and Astore- Lawrencepur was also recorded by seismic stations at Terbela (Fig. I) which were preinformed and alerted to receive the signals. The present report describes the results of seismograms observed at these stations, on 15th and 20th August 1975.
Key words: Seismicity, Tarbela.

M/242. Mirza, M.A., 1983. Seismic risk evaluation in Pakistan. Geological Survey of Pakistan, Records 56, 6p.

Key words: Seismic risk evaluation.

M/243. Mirza, M.A., 1984. Gravity survey in pyrite bearing area near Reshian. Geological Survey Pakistan. Pakistan. Information Release 221.

Key words: Gravity survey, pyrite, Reshian, Azad Kashmir.

M/244. Mirza, M.A., 1988. Seismic risk map of northern Pakistan. Geological Survey Pakistan. Seismic Risk Series Sheet No. 2.

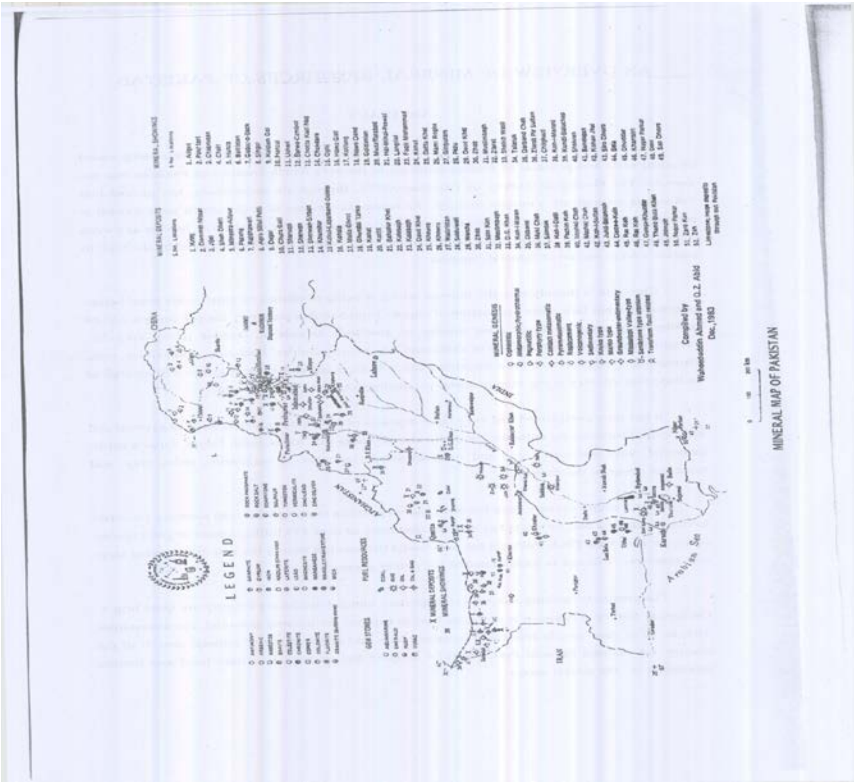
Key words: Seismic risk, mapping.

M/245. Mirza, M.A. 1995. Magnetic polarity stratigraphy of Soan Formation (Plio- Pleistocene), Mujahid village, Rawalpindi district, Punjab, Pakistan. Abstract volume, International seminar and field work on quaternary stratigraphy of the North – Eastern part of the Indian subcontinent Dhaka. 9-12 December, 1995. (IGCP – 347, Quaternary stratigraphic correlation of the Ganges – Brahmaputra sediments and of the Indian subcontinent. P.11.)

The Mujahid section is the type locality of Soan Formation (Plio-Pleistocene) of the Siwalik Group in Pakistan. The section is located on the road from Galijagir to Sihal, about half a kilometer short of Mujahad village, Rawalpindi District, Punjab Pakistan. It lies to the north of Soan River. The section is comprised of an alternation of pale-pinkish, orange-brown, grey silt shale and sand. The sand is greenish grey, fine, medium grained, having 1.5 to 3 meter thick beds of conglomerate. The conglomerate is dark grey, coarse, densely packed, containing rounded pebbles and boulders of grey limestone with the size of 5-25 cm. The formation possesses a thickness of 300 to 400 metres. Horizontally stratified magnetic zones have been studied for establishing the magnetic stratigraphy of the formation. Within 400 metres of the stratigraphic section, eleven magnetic polarity zones are identified. These zones represent the time from the upper Gauss Epoch (2.3 my.) through the Olduvai Event in Matuyama Epoch (1.6.m.y.) as determined from sedimentation rate of about 0.5 m/1000 years. The Gauss-Matuyarna correspond to the Pliocene-Pleistocene chronology of the Soan Formation in general as indicated by the lithological and faunal correlation.
Key words: Magnetic polarity, stratigraphy, Soan River, Rawalpindi.

M/246. Mirza, M.A., 1997. An overview of mineral resources of Pakistan. Geological Survey of Pakistan, Information Release 644.

In 1947, when Pakistan came into existence only 6 mineral commodities were being mined on small scale and potential of finding minerals in the area which constituted Pakistan was not known. The Geological Survey of Pakistan (GSP) , through its endeavours, has proved that Pakistan is geologically a unique country . Its landmass consists of rocks which were formed at oceanic centers, continental and oceanic island arcs, deep oceanic to shallow marine and even continental sediments . These rocks, as elsewhere in the world, have been proved by the GSP to contain a large variety of mineral deposits.
Chromite is the only metallic mineral which is being produced on small scale since before independence but large scale production of copper from Saindak porphyry copper deposit will be starting very soon and large scale mining of zinc/lead deposit of Duddar is not very far.
Favourable areas of mineralization of aluminum, chromium, copper, lead-zinc, gold, silver, iron, platinum and tungsten have been identified and it is expected that soon Pakistan will emerge as an important country on the map of metal producing countries of the world.
It has now been proved that very large deposits of industrial minerals such as gypsum and anhydride, limestone and dolomite, building stones, rocks salt, silica sand, barite, fuller's earth, industrial clays and soap stone and medium sized resources of magnesite, china clay, and bentonite occur in the country.
Only a couple of years back Pakistan had no position on the global map showing countries having substantial coal resources but with the discovery of over 175 billion tonnes of good quality lignite in Thar Coal Field, Pakistan has achieved 11th position among the countries having large coal reserves. The coal is found suitable for power generation. The prospect of making Pakistan an important mineral producing country are quite bright.
Geological Survey if Pakistan is doing its best to explore the mineral potential and disseminate data, so as to make people interested in exploration and exploitation of mineral wealth of the country. A National Mineral Policy will be adopted during 1995 to attract local and foreign investment in the mineral sector.



Key words: Mineral resources.

M/247. Mirza, M.A., Babar, M.Z., Farah, A. & Ali, K.S.A., 1988. Seismic risk map of Northern Pakistan. Geological Survey of Pakistan, Geological Map Series, Scale 1:1,000,000.

Key words: Mapping, seismic map.

M/248. Mirza, M.A. & Farah, A., 1984. Recent crustal deformation and seismicity in Pakistan. Abstracts, 1st Pakistan Geological Congress, Lahore, p.63.

Key words: Crustal deformation, seismicity.

M/249. Mirza, M.A., Jamiluddin, S. & Ahmad, M., 1983. Accomplishment report of the Geological Survey of Pakistan (1978-1983). Geological Survey of Pakistan, Record 62, 42p.

Key words: Geological Survey of Pakistan.

M/250. Mirza, M.A., Jamiluddin, S., Ahmad, M., Javed, N. & Haq, I., 1984. Status of geological mapping in Pakistan. Geological Survey of Pakistan, Information Release 220, 51p.

Key words: Mapping, geology, Pakistan.

M/251. Misch, P., 1935a. Arbeit und vorla u figz Ergebnisse des Geologen. In: Finsterwolder, Forschung am Nanga Parbat. Sonderveroff Geog. Gesselschaft, Hannover, 91-130.

Key words: Nanga Parbat.

M/252. Misch, P., 1935b. Nanga Parbat. Geologische Rundschau 26, 156-158.

Key words: Nanga Parbat.

M/253. Misch, P., 1936a. Ein junger gefalteter sandstein im nordwest-Hamalaya und sein gefuge. Festschift zum 60, Geburtstag won Hans Stille, Enke, Stuttgart, 259-276.

Key words: Structure, sandstone, Himalaya.

M/254. Misch, P., 1936b. Einiges zur metamorphose des Nanga Parbat. Geologische Rundschau 27, 79-81.

Key words: Metamorphism, Nanga Parbat, Himalaya.

M/255. Misch, P., 1949. Metasomatic granitization of batholithic dimensions. Part 1: Synkinematic granitization in Nanga Parbat area, Northwest Himalayas. American Journal of Science 247, 209-245.

In the Nanga Parbat area (Northwest Himalayas) a thick group of presumably pre-Cambrian argillites with thin calcareous and basic bands is overlaid by Cretaceous-Eocene volcanics, and both are bordered by extensive Eocene norite masses. These rocks have undergone regional metamorphism during Early Tertiary orogeny. Synkinematic metamorphism of the argillites progresses from slates and phyllites through mica schists, biotite-paragneisses, kyanite-schists and –paragneisses to sillimanite-paragneisses. The metamorphic zones in the argillites are matched by those in the calcareous bands.

Synkinematic granitization of the potash-predominant variety begins within the kyanite zone with microperthite-porphyroblast-schists passing to potash-rich augen gneisses of granitic appearance which contain relict kyanite in their groundmass. Lit-par-lit replacement—as against mechanical injection—along active foliation planes makes banded gneisses. In the interior of the Nanga Parbat massif, franitization becomes more complete, and coarse-grained granitic gneiss forms. Here only small quantities of argillite altered to sillimanite-schist have escaped transformation into granitic rock. The calcareous bands are not granitized, and are preserved as conformable intercalations in the gneissose granite which has replaced the argillites. Metamorphism and granitization progress both along and across the strike of the altered sediments. There is complete structural continuity from the weakly metamorphosed sedimentary areas to the intensely granitized region. Also the type of tectonic deformation is the same throughout these areas, and is that characteristic of the deformation of solid rocks during orogenic metamorphism. The granitized body as mapped measures 25 by 60 miles.

The chemical nature of the granitizing agent is discussed. The metamorphic isograds (approximately vertical in this region) are shown to be independent of depth, and a function of differential introduction of heat from below. It is stressed that degree of metamorphism and granitization are systematically linked and convection of heat by the granitizing solutions is held responsible for high grade regional metamorphisms in the upper part of the crust.

Key words: Himalaya, Nanga Parbat, granitization, metasomatism.

M/256. Misch, P., 1950. Late Cenozoic diastrophism in Himalayan system. Geological Society of America Bulletin, Abstract 61, p.1487.

Key words: Diastrophism, Cenozoic, Himalaya.

M/257. Misch, P., 1964. Stable association wollastonite-anorthite, and other calc-silicate assemblages in amphibolite-facies crystalline schists of Nanga Parbat, Northwest Himalayas. Beitrage zur Mineraloge und Petrographie 10, 315-356.

Progressive regional metamorphism and granitization of a dominantly pelitic sequence was essentially isobaric and proceeded on a level of rather high P within the field of amphibolite facies. The transition from kyanite to sillimanite zone does not coincide with the boundary between medium and high-grade rocks but is displaced toward higher T. Many of the Al-Si-rich high-grade rocks carry stable muscovite. Staurolite, andalusite, and cordierite are characteristically absent. Green hornblende occurs throughout the high-grade zone in rocks of appropriate composition.

Calcareous intercalations permit recognition of three distinct zones of high-grade metamorphism. They, and the reaction defining their boundaries, are:

a) "Wollastonite-anorthite zone"; highest attained.

$Ca_3Al_2Si_3O_{12} + SiO_2 = 2\ CaSiO_3 + CaAl_2Si_2O_8$ "Wollastonite-grissykarute zibe"

b) $CaCo_3 + SiO_2 = CaSiO_3 + CO_2\uparrow$ "Calcite-quartz-grossularite (bytownite) zone"

(lower limit defined by lower limit of bytownite).

Reaction (b) is sensitive to PCO_4. It is suggested that most of the rocks, especially those with excess silica, were open systems for CO_2, so that PCO_4 « P_{total}. Locally, as in some tight marbles, CO_2 was retained, and the wollastonite reaction was arrested or altogether prevented, in zone (2) and even in zone (1). Reaction (a), involving no gas phase, is dependent only on P, T. Under the prevailing high pressures, the temperatures required to make reaction (a) proceed to the right, must have been rather high.

Quartz-excess and calcite-excess, diopside-bearing assemblages of the three zones are described. Associate K-feldspar is orthoclase with very small — 2V. Metamorphism of argillaceous dolomitic limestones illustrates the principle of preferential decarbonation of Mg. Assemblages include (omitting dominant calcite): forsterite-spinel-phlogopite, found only in zone (1); phlogopite-diopside-(tremolite); diopside-(tremolite)-orthoclase; diopside-(tremolite)-anorthite-(orthoclase); diopside-wollastonite-grossularite (zone 2); diopside-grossularite-quartz (zone 3).

Relations of mineral assemblages found in the three calc-silicate zones to bulk compositions are discussed. Boundary layers between diopsidic calc-silicate rocks and associated politic schists are described. As a rule, a thin band of para- amphibolite is developed at the contact, characterized by the garnet-free assemblages, green hornblende-anorthite (bytowrite)-quartz. In adjacent, partly almandine-bearing biotite-quartz-plagioclase schists, plagioclase ranges from sodic andesine to bytowrite. Widespread reverse zoning of this plagioclase is attributed to slow, short-range (a few centimeters) diffusion of anorthite-building substance from the adjacent Ca-richer rock into the schist. Locally, the amphibolite band is lacking, and diopside and biotite mingle in the boundary layer. Although this local association recalls pyroxene hornfels facies, nearby rocks have amphibolite facies mineralogy.

Part of the diopsidic calc-silicate rocks of zone (1) show incipient retrogression under conditions of zone (2) or (3) , the pair, wollastonite-anorthite (bytownite), being "parasitically" replaced by grossularite. Retrogression below the limits of zone (3) locally displays the assemblage, zoisite-labradorite-grossularite. Calcic scapolite found in some of the high-grade calc-silicate rocks is retrogressive, replacing anorthite (bytownite).

Calc-silicate mica schists of higher-medium grade carry mutually stable calcic scapolite, andesine and zoisite, associated with calcite, quartz, local epidote, biotite, muscovite, and garnet. Much of their plagioclase is zoned. Reverse followed by normal zoning is interpreted as a record of the thermal history of metamorphism. Associated non-calcareous mica schists, commonly with almandine and kyanite, carry more sodic plagioclase which is unzoned. Garnet amphibolites of this zone have andesine plus zoisite or epidote, and some contain diopside.

Physical conditions of the metamorphism of the high-grade calc-silicate rocks are discussed further, in the light of available experimental data.

Key words: Nanga Parbat, Himalaya, Metamorphism.

M/258. Miyata, T., 1988. An Introduction to gem mines of Pakistan. (Japanese with English abstract). Journal of the Gemmological Society of Japan 13, 31-42.

Pakistan has 4 main mining areas in its territory. In Hunza valley, specimen- and gem-quality crystals of corundum occur in bed of marble. This area is not in operating at present. However, small, intensely coloured emerald crystals occur in dolomitic talc schist in the Swat valley. So many kinds of gemstones, aquamarine, topaz (F-type), tourmaline, zircon, quartz, are found from the pegmatite in Shingus-Dusso areas. Katlang area is the only place in the world to produce natural pink topaz.

Key words: Gems, Hunza.

M/259. Mohiuddin, M., 1972. Report on mineral in North Waziristan, Dera Ismail Khan Division, North West Frontier Province. Pakistan Chrome Mines Limited, Report, 7p.

Key words: Minerals, DI Khan, North Waziristan, NWFP.

M/260. Mohmand, A., 1971. Geology and mineralogy of Swat Hornblendic Complex in Charbagh-Khawaza Khela area, Swat. M.Sc. Thesis. Punjab University, Lahore, 78p.

Key words: Mapping, hornblendic complex, Swat.

M/261. Mohmand, A.K. & Tariq, M., 1982-83. Petrographic comparison of Khunjerab-Wakhan-Tirichmir, Karakoram and Kohistan-Ladakh granitic belts in Northern Pakistan. M.Sc. Thesis, University of Peshawar, 128p.

Key words: Petrography, granitic belt, Khunjerab-Wakhan-Tirichmir, Kohistan-Ladakh.

M/262. Mohmand, A.R.K., 1976. A field report on the geology and mineralogy of Hamoi valley area, Matta, Swat. M.Sc. Thesis. Punjab University, Lahore, 78p.

Key words: Petrology, petrography, Swat.

M/263. Mohsin, S.I., Hasan, S. & Latif, F., 1991. Export potential of Pakistani granites. Proceedings, First SEGMITE Symposium, Peshawar, 1-7.

The paper gives a brief account of the occurrence of granitic rocks in Pakistan, including those of the Himalayan region. Comparatively greater information is given on the Nagar parkar granites.
Key words: Granite, Nagar Parkar, Himalaya.

M/264. Mohsin, S.I., Qadri, M.U. & Ansari, I.A., 1979. Geology and evaluation of marble and travertine deposits of Pakistan. The Geologist, 4, 1–8.

Key words: Marble deposits, travertine, Pakistan

M/265. Mohsin, S.I., Qadri, M.U. & Hissamuddin, S., 1983. Technological characteristics of the Peshawar marbles, Pakistan. Acta Universitis Carolinae Geologica 4, 311–322.

White and gray coloured crystalline limestone and pink fossiliferous dense limestone are extensively quarried in Peshawar Division for dimension stone. The deposits belong to a reef belt which developed at the northern margin of Indo – Pakistan landmass during Silurian-Devonian. They are metamorphosed and dolomitized to varying degrees. White crystalline limestones are calcite marble of thigh purity comparable to world class marbles. Dolomite marbles are of inferior quality however they constitute only a small part of the deposits. A number of physical tests prove the soundness of the Peshawar marbles in confirmation to the ASTM standards.
Key words: Marble deposits, Peshawar, Nowshera, Swabi, Mulagori.

M/266. Moin-ud-Din, 1998-99. Geological mapping of Muzaffarabad-Chattar Kalas area with special emphasis on slope instability analaysis and Hazards evaluation of Dulai area Muzaffarabad (A.K.). M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 95p.

Key words: Hazards, slope stability, mapping, Muzaffarabad, Hazara.

M/267. Molloy, P.D., 1979. Conodont faunas from northwest Pakistan. M.Sc. dissertation, Macquarie University, Sydney, Australia, 283p

Key words: Palaeontology, conodonts, NW Pakistan.

M/268. Molloy, P.D., Khan, F., Khan, A.A., Simpson, A., Mawson, R. & Talent, J.A., 1999. Conodont correlations between Pakistan and eastern Australia for the latest Silurian to earliest Devonian interval. IGCP 421 Meeting, North Gondwana Biogeography, Bioevent Patterns in relation to Crustal Dynamics, Peshawar, Pakistan, 19–20.

Key words: Palaeontology, conodonts, Silurian, Devonian, Pakistan, Australia.

M/269. Molloy, P.D., Talent, J.A. & Mawson, R., 1997. Late Devonian-Tournaisian conodonts from the eastern Khyber region, north-west Pakistan. Rivista Italiana di paleontologiae e stratigrafia 103, 123-148.

Conodonts (62 species and subspecies) from acid-leaching of 226 samples from four sections through the Ali Masjid Formation west of Misri Khel in the former South Khyber Agency, north-west Pakistan, are documented by illustrations and distributional data. These indicate that most of this unit, at least in that area, spans the interval Middle *crepida* Zone (low in the Famennian) to at least Early *crenulata* Zone (mid-Tournaisian), though a fauna from low in one of the sections produced conodonts indicative of the Late *falsiovalis* Zone (early Frasnian). Two major hiatuses are inferred: between the Late *falsiovalis* and Middle *crepida* zones, and between the Late *expansa* and Early *duplicata* zones. Coherence of the conodont biostratigraphy accords with lithologic alignments between the sections.
Key words: Palaeontology, conodonts, Devonian, Khyber Agency, NWFP.

M/270. Molnar, P., 1988. A review of geophysical constraints on the deep structure of the Tibetan plateau, the Himalaya and the Karakoram and their tectonic implications. Philosophical Transaction, Royal Society London, Special Publication A–326, 33–88.

The Tibetan Plateau, the Himalaya and the Karakoram are the most spectacular consequences of the collision of the Indian subcontinent with the rest of Eurasia in Cainozoic time. Accordingly, the deep structures beneath them provide constraints on both the tectonic history of the region and on the dynamic processes that have created these structures. The dispersion of seismic surface waves requires that the crust beneath Tibet be thick: nowhere less than 50 km, at least 65 km, in most areas, but less than 80 km in all areas that have been studied. Wide-angle reflections of P-waves from explosive sources in southern Tibet corroborate the existence of a thick crust but also imply the existence of marked lateral variations in that thickness, or in the velocity structure of the crust. Thus isostatic compensation occurs largely by an Airy-type mechanism, unlike that, for instance, of the Basin and Range Province of western North America where a hot upper mantle buoys up a thin crust.
The P-wave and S-wave velocities in the uppermost mantle of most of Tibet are relatively high and typical of those of Precambrian shields and stable platforms: V, = 8.1 km s-' or higher, and V, % 4.7 km s-'. Travel times and waveforms of S-waves passing through the uppermost mantle of much of Tibet, however, require a much lower average velocity in the uppermost mantle than that of the Indian, or other, shields. They indicate a thick low-velocity zone in the upper mantle beneath Tibet, reminiscent of tectonically active regions. These data rule out a shield structure beneath northern Tibet and suggest that if such a structure does underlie part of the plateau, it does so only beneath the southern part. Lateral variations in the upper-mantle structure of Tibet are apparent from differences in travel times of S-waves from earthquakes in different parts of Tibet, in the attenuation of short-period phases, Pn and Sn that propagate through the uppermost mantle of Tibet and in surface-wave dispersion for different paths. The notably lower velocities and the greater attenuation in the mantle of north-central Tibet than elsewhere imply higher temperatures there and are consistent with the occurrence of active and young volcanism in roughly the same area.

Surface-wave dispersion across north-central Tibet also requires a thinner crust in that area than in most of the plateau. Consequently the relatively uniform height of the plateau implies that isostatic compensation in the north-central part of Tibet occurs partly because the density of the relatively hot material in the upper mantle is lower than that elsewhere beneath Tibet, the mechanism envisioned by Pratt. Several seismological studies provide evidence consistent with a continuity of the Indian Shield, and its cold thick lithosphere, beneath the Himalaya. Fault-plane solutions and focal depths of the majority of moderate earthquakes in the Himalaya are consistent with their occurring on the top surface of the gently flexed, intact Indian plate that has underthrust the Lesser Himalaya roughly 80-100 km or more.

P-waves from explosions in southern Tibet and recorded in Nepal can be interpreted as wide-angle reflections from this fault zone. P-wave delays across the Tarbela network in Pakistan from distant earthquakes indicate a gentle dip of the Moho beneath the array without pronounced later variations in upper-mantle structure. High Pn and Sn velocities beneath the Himalaya and normal to early S-wave arrival times from Himalayan earthquakes recorded at teleseismic distances are consistent with Himalaya being underlain by the same structure that underlies India.

Results from explosion seismology indicate an increase in crustal thickness from the Indo-Gangetic Plain across the Himalaya to southern Tibet, but Hirn, Ltpine, Sapin and their co-workers inferred that the depth of the Moho does not increase smoothly northward, as it would if the Indian Shield had been underthrust coherently beneath the Himalaya. They interpreted wide-angle reflections as evidence for steps in the Moho displaced from one another on southward-dipping faults. Although 1 cannot disprove this interpretation, I think that one can recognize a sequence of signals on their wide-angle reflection profiles that could be wide-angle reflections from a northward-dipping Moho.

Gravity anomalies across the Himalaya show that both the Indo-Gangetic Plain and the Himalaya are not in local isostatic equilibrium. A mass deficit beneath the plain is apparently caused by the flexure of the Indian Shield and by the low density of the sedimentary rock in the basin formed by the flexure. The mass excess in the Himalaya seems to be partly supported by the strength of the Indian plate, for which the flexural rigidity is particularly large. An increase in the Bouguer gravity gradient from about 1 mGal km-' (1 mGal = cm sCZ) over the Indo-Gangetic Plain to 2 mGal km-' over the Himalaya implies a marked steepening of the Moho, and therefore a greater flexure of the Indian plate, beneath the Himalaya. This implies a northward decrease in the flexural rigidity of the part of the Indian plate underlying the range. Nevertheless, calculations of deflections of elastic plates with different flexural rigidities and flexed by the weight of the Himalaya show larger deflections and yield more negative gravity anomalies than are observed. Thus, some other force, besides the flexural strength of the plate, must contribute to the support of the range. A bending moment applied to the end of the Indian plate could flex the plate up beneath the range and provide the needed support. The source of this moment might be gravity acting on the mantle portion of the subducting Indian continental lithosphere with much or all of the crust detached from it.

Seismological studies of the Karakoram are consistent with its being underlain by particularly cold material in the upper mantle. Intermediate-depth earthquakes occur between depths of 70 and 100 km but apparently do not define a zone of subducted oceanic lithosphere. Rayleigh-wave phase velocities are particularly high for paths across this area and imply high shear wave velocities in the upper mantle. Isostatic gravity anomalies indicate a marked low of 70 mGal over the Karakoram, which could result from a slightly thickened crust pulled down by the sinking of cold material beneath it. Geophysical constraints on the structure of Tibet, the Himalaya and the Karakoram are consistent with a dynamic uppermost mantle that includes first, the plunging of cold material into the asthenosphere beneath southern Tibet and the Karakoram, as the Indian plate slides beneath the Himalaya, and second, an upwelling of hot material beneath north-central Tibet. The structure is too poorly resolved to require such dynamic flow, but the existence for both a hot uppermost mantle beneath north-central Tibet and a relatively cold uppermost mantle beneath southern Tibet and the Karakoram seem to be required.

Key words: Tectonics, geophysics, Tibetan Plateau, Karakoram.

M/271. Monir, M., 1973. Geological mapping of Chalt area, Gilgit Agency with special emphasis on engineering geological problems of reservoir of Chalt dam site. M.Sc. Thesis, Punjab University, Lahore, 99p.

Key words: Mapping, structure, engineering geology, reservoir, damsite, Gilgit.

M/272. Monachese, G.L., 1993. Indagini mineralogico petrografiche sui materiali di rivestimento degli stupa della velle dello Swat (Pakistan), relazione ai litotipi impiegati. Thesis, University of Bari, 98p.

This is the mineralogic and petrographic investigations of the coatings used in the stupas in Swat valley. A relationship of the results with the rock types used is also given.
Key words: Mineralogy, petrography, stupa, Swat.

M/273. MonaLisa, & Khawaja, A.A. 2001. Seismic zonation based upon peak ground acceleration (PGA) values of a part of Northern Pakistan. Ten years of paleoseismicity in the ILP: progress and prospects, 17-21 December, 2001, Kaikowa, NewZealand.

A part of Northern Pakistan bounded by Lat: 32^0-35^0 30' N and Long: 69^O 45'-75' - 15' E has been divided into 360 grids of 0.15^0 X 0.15^0 size for carrying out seismic zonation. Instrumental data of Mb > 4.5 have been used. It comprises of 3197 events that occurred during the period April 1905 to April 1998. Peak ground accelerations (PGA) have been determined for the mid points of each grid applying the attenuation equation of the Public Works Research Institute of Japan (1990) for the return period of 100 years. These PGA values have been calculated using ERISA-P software. Contour map has been prepared for this return period and is discussed taking into consideration the geology of the region.
A number of distinct zones are observable in the PGA map of 100 years return period. In our area of interest (excluding Afghanistan), the highest PGA values correspond to the tectonically active hinterland zone of NW Himalayan fold and thrust belt. Besides containing localities like Dasu, Chilas and Mansehra, the important strategic link between Pakistan and China - the Karakorum highway also passes through this zone.
Another zone having high PGA values corresponds with the South Waziristan region and the Kurram Fault passes through the area. The other closure corresponding to the areas of Islamabad, Rawalpindi, Wah, Taxila, Tarbela have comparatively lower PGA values. According to our map the safest areas (with low PGA values) are in the Salt Range, Bannu and Peshawar Basins.
Key words: Seismology, PGA, North Pakistan.

M/274. MonaLisa, Khawaja, A.A., Ghazi, G.R. & Jadoon, I.A.K., 1997. Nature of faults and focal mechanism solutions of part of Northern Pakistan. Geological Bulletin, University of Peshawar 30, 143-151.

The area extending southwards from the MMT to Kohat/Potwar plateau in Northern Pakistan is considered to be one of the most seismically active region in the world. 13 earthquake events recorded during 1984-1995 from this area have been investigated for focal mechanism solution. Solution shows strike-slip faulting with a majority (eight) indicating a left lateral sense of motion. They mostly confirm the trend and behavior of the exposed faults with exception of one, which might be related with a blind fault.
Three right lateral strike-slip focal mechanism solution, one associated with the Thakot fault and other with the Kalabagh fault, support the active character of these faults or represent their buried offshoots. Two E-W trending right lateral focal mechanism solutions are considered to represent left lateral sheer at the western boundary of Indo-Pakistan Plate.
The P and T-axis orientation indicate NE-SW direction of compression for area located north of MBT, whereas in Kohat and Potwar area mixed trend of both NE-SW and NW-SE compressive directions are obtained suggesting more complexity. In this active zone of convergence i.e., thrusting dominated region, a kinematic change due to oblique collision is inferred.
Key words: Structure, faults, focal mechanism, Kohat-Potwar plateau, Kalabagh fault.

M/275. MonaLisa, Khawaja, A.A., Ghazi, G.R., Qureshi, S.N. & Boustani, M., 2000. Seismic risk analysis of Islamabad and its adjoining areas. Abstracts, Third South Asia Geological Congress, Lahore, p.51.

Earthquakes of Mb > 4.5 that occurred during the period from 1905 to April 1998 have been used to determine Peak Ground Acceleration (PGA) of an area of 200 Km radius around Islamabad. Midpoint of 1248 grids (0.065 x 0.065) established for this purpose were considered as sites and the PWRI attenuation equation used for the calculation at these midpoints. Raster maps for return periods of 50, 100 and 200 years have been prepared and seismic risk evaluation of the whole area undertake.

Key words: Seismicity, seismic risk, PGA, Peshawar.

M/276. MonaLisa, Khawaja, A.A. & Qureshi, S.N., 2001. Seismic zonation and peak ground acceleration of Peshawar and adjoining areas. Abstracts, 4th Pakistan Geological Congress, Islamabad, 70-71.

An area of 200 km radius around Peshawar has been divided into 360 grids of 0.150 X 0.15c' size for carrying out seismic zonation of the area. Instrumental data of Mb >4.5 have been used. It comprises of 3197 events that occurred during the period April 1905 to April 1998. Peak ground accelerations (PGA) have been determined for the mid points of each grid applying the attenuation equation of the Public Works Research Institute of Japan (1990) for the return periods of 50, 100 and 200 years. ERISA-P software has been used for calculating the PGA values. Contour maps have been prepared for these different return periods and are discussed taking into consideration the geology of the region. A number of distinct zones are observable in the PGA map of 50 years return period. The high PGA value zones in the northwestern quadrant of the map cover the area of Afghanistan. In our area of interest (excluding Afghanistan), the highest PGA values correspond to the tectonically active area i.e., hinterland zone of NW Himalayan Fold- and- Thrust Belt. Besides containing localities like Drosh, Chilas and Mansehra, which are highly populated areas, the important strategic link i.e. the Karakoram Highway also passes through this zone. Another zone having PGA values ranging from 70 gals (O.07g) to 290 gals (2.9g) corresponds with the Kalabagh fault thereby indicating the active nature of this fault. As such it is recommended that construction in this area should take into consideration the active nature of the faults. The other closures corresponding to the areas of Islamabad, Rawalpindi, Wah, Taxila, Tarbela have PGA values ranging upto a maximum of 0.08 g and may still be considered as hazardous area. According to our map the safest areas (with low PGA values ranging from 0.02g to 0.06g) are Peshawar, Swat, Bannu, Thal and Mardan.

Key words: Seismicity, seismic zonation, PGA, Peshawar.

M/277. Mononobe, S., Hirayama, J. & Karim, T., 1992. A preliminary report on the reserves of Kumhar magnesite mine, Hazara area. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad 3, 11-22.

Deals with economic geology of the deposit including reserve estimates (6.2 m tons) and chemical analyses (MgO > 45 wt%).

Key words: Magnesite, Hazara.

M/278. Mononobe, S., Karim, T. & Khan, I.H., 1992. A preliminary report on a short visit to mineral deposits around Abbottabad, Hazara area. Proceedings of Geoscience Colloquium, Geoscience Lab, GSP, Islamabad 3, 5-10.

Gives basic information on the mineral deposits of the area. The small-sized deposits include barite, soapstone, kaolin, scheelite and sericite, and the relatively large-sized deposits include phosphorite, gypsum and hematite.

Key words: Mineral deposits, Hazara.

M/279. Montgomerie, T.G., 1857. Memorandum on the Nanga Parbat and other snowy mountains of the Himalayan Range adjacent to Kashmir. Journal of the Asiatic Society of Bengal 26, 266-174.

Key words: Snow, Nanga Parbat, Himalaya.

M/280. Montgomerie, T.G., 1860. Memorandum on the Great Flood of the River Indus which reached Attock on the 10th August. Journal of the Asiatic Society of Bengal 29, 128-135.

"At 5 A. M. on the 10th August, 1858, the Indus at Attok was very low. At 7 A. m. it had risen 10 feet. By 0.30 p. M. it had risen 50 feet, and it continued to rise till it stood 90 feet higher than it did in the morning. The Cabul River continued to flow upwards for ten hours." — Extract from the proceedings of the Asiatic Society for September 1858, Journal Vol. XXVII. p. 366.
The flood destroyed a large amount of property in British territory both above and below Attok; and the back water (on the Cabul river) destroyed the greater part of the private property in the cantonment of Naoshera.
After the subsidence of the water, numerous reports were current near Attok, viz.: that the river was still blocked up and that another similar flood might soon be expected. These reports were generally given out on the authority of the inhabitants far up the river, who had sent down word to say that the water was still dammed up. Such a sudden flood or cataclysm on such a gigantic scale, at all times an important and interesting subject of enquiry, was rendered still more so to me by the above mentioned circumstances. Being at the time of the flood in the territories of the Maharajah Rumbhir Singh. I was in a favorable position for making enquiries in the Upper Valley of the Indus as far as the Maharajah's territories and influence extended, and I consequently made all the enquiries that I could.
On applying to the Wazeer Punnoo, the governor of Kashmir, he told me that had any damage been done in the Maharajah's territories by a flood on the Indus, he would certainly have heard of it, but up to that time he had received no report on the subject. However I begged him to write to all the Maharajah's officials (on the Indus and on its tributaries)* to enquire whether any extraordinary flood had been noticed. The answers were all in the negative except that from Boonjee, (the Maharajah's most northerly fort and cantonment on the Gilgit frontier) the report was as follows, viz. :—
"That a great flood (bura sailab) was noticed by the sepoys at Boonjee on the 27th day of "Sawan Mahina," "derh pahar din gaiya" when it first arrived. Shortly afterwards the sepoys saw a mass of timbers floating down the stream, which they recognised as belonging to the gateway of the Numbul fort." The Nfimbul fort is said to have been on the Gilgit river below the point where the Naggar River joins the Gilgit river.
I understand "the 27th day of Sawan Mahina, derh pahar din gaiya" to mean the 11th day of August about 9 or 10 in the morning. Although this is the day after the flood was noticed at Attok, it is in my opinion sufficiently near the date to make it highly probable that it was the same flood that was noticed at Attok.
At a frontier outpost of the Maharajah's (where no one goes that has sense enough to make interest to keep away), a mistake of two or three days in the date would be no wonderful thing considering the general indifference of natives on the subject of dates and the numerous doubts as to when their months begin.
I am therefore of opinion that the flood (sailab) noticed at Boonjee was the same that passed Attok on the 10th of August, and for reasons given hereafter 1 am of opinion that the sepoys' date at Boonjee should have been the 25th of Sawan or the 9th of August about 9 or 10 a. ft. The Trigonometrical height of Skardo the capital of Little Thibet situated on the river Indus has been ascertained to be about 7700f feet above the sea and that of the G. T. Station eighteen miles above Attok has been found to be about 1050J feet above the sea, thus shewing a difference of height between the two places of about 6650 feet. The distance between Skardo and the above G. T. Station by the course of the river Indus is approximately about three hundred and ten miles, and consequently there is an average fall in the bed of the Indus between those places of about 21 feet per mile.
Similarly the height of Baramoola where the Jhelum river leaves the Kashmir valley is about 4930* feet, that of the river two miles below Jhelum is about 750 feet above the sea, shewing a difference in height between the two places of about 4180 feet. The distance by the course of the river Jhelum between those two places is about one hundred and ninety-four miles giving an average fall in the bed of the Jhelum of a little over 21 t 5 q- feet per mile. Consequently we may assume that the Indus and Jhelum rivers flow at (very nearly) the same average rate between the respective places mentioned. With the assistance of Lieut. MelvilleJ I measured the rate of the Jhelum river at Naoshera, one march below Baramoola, in as slow a part of the stream, as there is between Baramoola and Jhelum, and I found the rate to be nearly 690 feet per minute, or about seven miles per hour. And Lieut. Melville quite agreed with me that we had taken a place where the rate§ was far below the average. The river Jhelum between the points mentioned has in general such rugged and precipitous banks that it was with difficulty that even the above measurement was made.
The distance from Boonjee to Attok may be taken approximately as about two hundred and twenty miles, and if the flood in question was the one noticed at Boonjee it traversed the distance between those two places between 10 o'clock in the morning of some day before the 10th of August and say 6 A. M. of the 10th August, that is the flood

must have taken either twenty-one hours or forty - five or sixty-nine &c. to traverse two hundred and twenty miles, that is, it must have passed Boonjee on 9th, 8th or 7th of August. Had the flood passed Boonjee on the 5th August, it would have taken forty- five hours and would have travelled at the rate of hardly five miles an hour, but it has been shewn above that the average rate of the Indus must be above seven miles an hour in ordinary times, and of course much greater during a flood, so it may, I think, be fairly concluded that the flood would take only about twenty-one hours in traversing the two hundred and twenty miles, and that it passed Boonjee on the 9th August, 185S, about 10 a. m. If so it travelled at the rate of ten and half miles per hour, by no means an improbable rate* as the Ganges when it issues from the hills opposite Hurdwar is stated by the Canal officers to flow in ordinary times at nine miles an hour, and its pace looks slow compared with that of the Jhelum below Baramoola.

As soon as I got the report from Boonjee I sent for further information but could only make out that the flood was understood to come from Naggar, an independent district which the Maharajah's people called a part of Yaghistan! quite inaccessible to ordinary messengers. Nothing would induce a man to go there; and the Wazeer said that when a present was offered, the man took the money, but only went a short distance and returned after a time with a made-up-story. Though repeated enquiries were made, nothing further was elicited.

Indeed beyond the fact that the flood had come from the Gilgit river, as reported by natives and as shewn by its carrying away the well known gateway of the Numbul Fort, nothing positive was known as to the cause of the flood or of the exact site of the place dammed up, though the Boonjee sepoys believed that it came from the Naggar valley which is drained by an Eastern tributary of the Gilgit river.

"Whether the flood in question came from Naggar or not, I feel quite certain that it did not come from above Skardo. At the time of the flood two of my assistants were working round Skardo, and another was working on the Shayok River within a month afterwards. I asked them to make particular enquiries, but they heard nothing of a large flood from any of the inhabitants of those parts. A table taken from the Philosophical transactions gives 4S0 feet in one minute or nearly five and a half miles an hour as the velocity of absolute torrents with an inclination of only 3 feet 1.27 inches per mile. The table gives no greater inclinations. Had the flood been generated on any of the tributaries of the Shayok I must have heard of it, as the damage done by the water on first escaping from the barrier or dam would have been very great in the Shayok valley itself.

No report was prevalent at Boonjee or elsewhere in the Maharajah's territories as to any river being still dammed up or as to the prospect of another flood. Should the river Indus or any of its tributaries be hereafter dammed up in any part of the Maharajah's territories, there would not be much difficulty in getting information from the Maharajah's officials, if proper measures were taken for collecting the same. If timely warning were given, I think that the water might be eased off, if the place was accessible and labour was available for the necessary blasting, mining and other operations. If, however, an obstruction should arise on the Gilgit River or any of its tributaries, there is, in the present political state of those valleys, no chance of getting timely warning or any accurate information, and if such was forthcoming, nothing could be done as to easing off the water unless the Engineer was accompanied by troops.

Key words: Floods, Indus River, Attock.

M/281. Montgomery, D.R., 1994. Valley incision and the uplift of mountain peaks. Journal of Geophysical Research 99, 913-921.

Simple end-member models describe the effect of isostatically compensated valley incision on the elevation of mountain peaks. These models allow calculation of the maximum portion of mountain peak elevations attributable to the development of observed relief and predict general downstream patterns of ridgetop uplift in response to erosion by fluvial processes. Analyses of topographic profiles across major drainages of the central Sierra Nevada and the Tibetan Plateau indicate that isostatically compensated valley incision could account for at most 5–10% of the present elevation of mountain peaks. In contrast, analyses of topographic profiles across the Himalaya show that as much as 20–30% of the present elevation of Himalayan peaks could be explained by isostatically compensated valley incision. The degree to which valley incision is compensated locally, however, depends on the flexural rigidity of the lithosphere, the size of the range, and its tectonic boundary conditions. These results show that while a tectonic control is required for late Cenozoic surface uplift of the Sierra Nevada, a significant portion of the elevation of Himalayan peaks may reflect late Cenozoic valley incision on the margin of the Tibetan Plateau.

Key words: Mountain peaks, Himalaya.

M/282. Moonen, J.J.M., Sondaar, P.Y. & Hussain, S.T., 1978. A comparison of larger fossil mammals in the stratotypes of the Chinji, Nagri and Dhok Pathan formations (Punjab, Pakistan). Koninklijke Nederlandse Akadamie van Wetenschappen, Proceedings, Series B, 81, 425-436.

Key words: Mammals, fossils, Chinji, Nagri, Dhok Pathan, Punjab.

M/283. Moorcroft, W. & Trebeck, G., 1841. Travels in the Himalayan Provinces of Hindustan and the Punjab; in Ladakh and Kashmir; in Peshawar, Kabul, Kunduz and Bokhara; from 1819 to 1825, 2 vols, 495 + 508 p. Oxford University Press, Oxford.

William Moorcroft was a veterinary surgeon in charge of the stables of the British East India Company and on the pretext of finding better breeds of horses made a pioneering journey from the heart of India up to the icy plateau of Central Asia. The other side of Moorcroft's efforts was that of a spy who looked to survey the probable friends and toes of India in the face of a Russian invasion. He started this journey from Kullu in the foothills of the Himalayan and it ended with his murder outside Kabul deep into Central Asia. During the course of his travels he stayed for 2 years in Ladakh and his account of this place is unmatched by later travelers. Moorcroft also wanted to open up the Central Asian markets to British good, and in his enthusiasm signed treaties in the name of the crown with local chiefs of the lawless tracts of Central Asia. In this book one finds details of almost everything that he saw, experienced and heard. The lands the people, the customs, the royalty, commercial potential, the flora and fauna, the river systems, the local religions. Moorcroft's account is not wanting in playing the role of being the eyes and ears in a foreign land. The journey took Moorcroft from the Punjab through to Bokhara via Ladakh, Kashmir, Peshawar, Kabul and Kunduz.
Key words: Travel, Ladakh, Kashmir, Bokhara, Himalaya.

M/284. Moosvi, A.T., Haque, S.M. & Mulsim, M., 1974. Geology of China clay deposits Shah Dheri (Swat), NWFP, Pakistan. Geological Survey of Pakistan, Record 26, 28p.

This report gives a detail geology of the china clay deposit at Shah Dheri, Swat. Reserves are estimated at 2980654 short tons. Mineralogical study shows that the commercial grade China clay is about 467217 short tons. This report contains a map and 10 figures.
Key words: China clay, mineralogy, Swat.

M/285. Morgan, M.E., 1992. Stable carbon isotope analysis of Miocene herbivores from the Siwaliks of northern Pakistan. American Journal of Physical Anthropology (Supplement 14), 127.

Key words: Palaeontology, herbivors, Miocene, isotopes, siwaliks.

M/286. Morris, C.J., 1928. Some valleys and glaciers in Hunza. The Geographical Journal 71, 513-531.

Key words: Glaciers, Hunza, Karakoram.

M/287. Morris, T.O., 1938. The Bain Boulder bed; a glacial episode in the Siwalik series of the Marwat Kundi Range and Sheikh Budin, NWFP, India. Quarterly Journal of the Geological Society of London 94, 385-421.

In October 1934, at the western end of the trans-Indus continuation of the Salt Range of North-West India, extensive outcrops of a deposit possessing all the characteristics of a typical boulder-clay were discovered in the middle of the strongly folded and faulted Siwalik series of the Marwat Kundi hills and on the northern slopes of Shekh Budin. The

boulder-clay was named the Bain Boulder-bed, after the frontier village nearest to its most conveniently accessible outcrop alongside the frontier road from Bannu to Tank, through the Bain pass.
The occurrence of a glacial deposit in this area and at such an horizon was totally unexpected. Successive studies of Siwalik faunas, made since Falconer's pioneer work, have raised progressively the age of the Siwalik series in terms of the European and American time-scales, but no dating later than Middle Pliocene had been suggested for the thick sandy formation in which the Bain Boulder-bed occurs; neither is there any record of evidence of glacial conditions during the deposition of the Siwalik series (Colbert 1935, p. 11). Prior to the discovery of the Bain Boulder-bed, the age of the formation enclosing it had been regarded as Upper Miocene, following Pilgrim (1913), or Middle Pliocene, following Matthew (1929). The nearest place to Shekh Budin at which fossils had been collected from the formation was the type locality of Pilgrim's Nagri fauna (1913, pp. 267, 318). That fauna lies in the lower portion of the Nagri outcrop cis-Indus, about 100 miles from Shekh Budin.
Key words: Glaciers, Bain pass, siwaliks, NWFP, India.

M/288. Mostler, H., 1980. Zur mikro fauna der unterkambriums in der Hazara Formation, Hazara, Pakistan. Annals Naturhistorisches Museum Wein 83, 245-247.

The acetic acid residue showed a microfauna proving that the Hazira-formation (Hazara, Pakistan), which lies transgressively on the paleo-relief of the Sirban-formation, belongs to the lowest part of the Cambrian (Tommotian). Therefore the Sirban-formation is of pre-Cambrian age and so all further stratigraphic speculations concerning the classification of this formation are without support. The microfauna corresponds with the fauna-association known from the trilobitelacking stage of China. Its point of effort lies in the Lapworthella tortuosa-subzone respectively Sachites-Zhijiinites-Turcutheca-assemblage-zone. In this study eight new species of the genus *Sachites* (Cambroscleritida) are described.
Key words: Palaeontology, Hazara Formation, Cambrian, Precambrian. Hazara.

M/289. Mott, P.G., 1950. Karakoram survey: A new map. The Geographical Journal No. CXVI, 1–3, 89–95.

Key words: Expedition, Karakoram.

M/290. Moudden, A., 1991. Petrology-Geochemistry des mafiques et ultramafiques grenues de l’arc volcanique obducte du Kohistan (NW Pakistan). Thesis, University of Montpellier, France.

Key words: Petrology, geochemistry, mafic-ultramafics, volcanics, Kohistan, Himalaya.

M/291. Mughal, M.A., 1981-83. Geology and petrology of Tangir valley (District Diamer) with special emphasis on the mineralogy/petrology of the intrusives. M.Sc. Thesis, Punjab University, Lahore, 147p.

Tangir covers 351 square kilometers area located between Kohistan in the South and Yasin in the North. According to plate tectonic concept it lies in between Indo-Pakistan and Eurasian plates comprising a part of Kohistan Island arc. The particular project area is mapped on a scale of 1:62500. In the thesis, an attempt is made to introduce the detailed Geology of the area. Bulk geological sequence of the area is consisted of Norite, Diorite, Amphibolite, Granodiorite and granite which is obducted on to the Paleozoic rocks of Indo-Pakistan plate in the South and subducted under the Eurasian plate towards the North. The Northern part of the area is in contact with Yasin Group which is volcanic. So Tangir area constitutes the lower sequence of Kohistan Complex.
Key words: Petrology, Tangir, Kohistan island arc.

M/292. Mughal, M.A., Sarhan, A.G., Gilmour, E.H. & Rahman, O., 1981. Carbonate petrography and microfacies of a portion of the Samana Suk Formation, Kohat range, Pakistan. Geological Bulletin, University of Peshawar 14, 73-84.

Five carbonate microfacies occur in a portion of the Jurassic Samana Suk Formation of the Kohat range, Pakistan. These microfacies are widespread over the area in the sections measured and indicate carbonate deposition in shoal environment in agitated water, restricted marine shoals and restricted marine shelf lagoons. The detailed petrographic study uncovered a duplication of section which had been caused by faulting and was previously unrecognized.
Key words: Carbonates, petrography, microfacies, Kohat range.

M/293. Mughal, M.Y., Baig, M.A.S. & Syed, S.A., 1997. Siwalik Group: A potential host for uranium. Abstracts, 3rd GEOSAS Workshop on Siwaliks of South Asia, Islamabad. Geological Survey of Pakistan, Records 109, p38.

Siwalik Group of rocks, Middle Miocene in age are exposed in part of AJK, Potwar, Bannu Basin and Sulaiman Range all along the foothills of NW and Western Himalayas. The Group basically comprises sand-shale interlayering with occasional development of conglomerates as channel lags or terrace deposits. The sand-shale ratio, their colour and horizontal distribution varies greatly within its four subdivisions i.e. Chinji, Nagri, Dhok Pathan and Soan formations. Uranium occurrences have been discovered over a major part of its exposures within Nagri and Dhok Pathan formations yet U-deposits could only be found in Bannu Basin and Sulaiman Range.
To develop a U-deposit three pre-requisites are essential i.e. U-source, U-mobilization, and U-precipitation and its stablisation. Due to widespread syn-deposition of volcanic ejects and feldspar the U-source is available indiginously. The movement of meteoric water, through the preamble strata, during diagenesis and upheaval mobilized the Uranium by leaching it from the volcanics as well as feldspars. The Siwalik rocks contain grey facies which is indicative of deposition in reduced environments. As a result reductants such as organic trash and pyrite were also deposited at more humid sites favourable for precipitation of U-from the solution.
The Himalayan Orogeny being still active imparted a very unstable character to the area with Siwalik rocks. Large scale thrusts and fold belts caused upheaval of strata due to which fluctuations of water table caused unstability for U-accumulation due to which the newly formed deposits in the uplifted blocks got mobilized. Areas still exist where upheaval movements were minimal as such chances of getting good quality U-deposits exist therein.
Key words: Radioactive minerals, Potwar, siwaliks.

M/294. Muhammad, J., 1990-93. Geology of Kumbar magnesite deposite near Sherwan, Abbottabad (N.W.F.P.). M.Sc. Thesis, University of Peshawar, 25p.

Key words: Magnesite, Abbottabad.

M/295. Muhammad, S., Kakakhel, M.A.G. & Nawaz, M., 1980. Swat China Clay. M.Sc. Thesis, University of Peshawar, 83p.

Key words: China clay, Swat.

M/296. Muir-Wood, H.M., 1930. The fossil fauna of Samana Range and some neighbouring areas; Part 3, The Brachiopoda. Geological Survey of India, Memoir 15(3), Palaeontologica Indica (New Series), 25-37.

Key words: Fossils, Samana Range, Hangu.

M/297. Muir-Wood, H.M., 1934. On the internal structure of some Mesozoic brachiopoda. Philosophical Transaction, Royal Society of London, B223, 511-567.

This is a discussion of modern methods of investigating the internal structure of fossil Brachiopod shells. The present paper show how a method of research hitherto but tentatively used by a few workers on the internal characters of Brachiopod shells has been elaborated and applied to certain Mesozoic genera of different families, and has resulted in establishing the relationship of the forms examined more satisfactorily than by methods and

classification of such numerous species of the Brachiopod families Rhynchonelliae, Terebratulidae, and Terebratellidae, as are found in Jurassic and Creyaxeous rocks. At the present time less than half of the Mesozoic Brachiopods are specifically determineable.
Key words: Brachipods, Mesozoic.

M/298. Muir-Wood, H.M., 1937. The Mesozoic Brachiopoda of the Attock district. Geological Survey of India, Memoirs 20(6), Palaeontologica Indica (New Series), 1-34.

Key words: Brachipods, Mesozoic, Attock.

M/299. Muir-Wood, R., 1980. Science goes to the Karakorum. New Scientist 88, 374-377.

This account is a fore-runner of the Royal Geographic Society international and multidisciplinary expedition to the Karakoram mountain range.
Key words: Karakoram.

M/300. Muir-Wood, R., 1981a. Islands at the top of mountains. New Scientist, 89, 274-277.

This is a simplified version of the geology of Kohistan, based on published data. It's a popular article, but gives a tectonic model for the development of Kohistan island arc in consequence of plates interaction since the late Cretaceous.
Key words: Island arcs.

M/301. Muir-Wood, R., 1981b. The moving mountains. New Scientist 89, 540-543.

This is a popular scientific article on geology and tectonics of the western Himalaya, Kohistan and central Karakoram mountain ranges. It describes their tectonic evolution, continental collision and geomorphology of the area.
Key words: Tectonics, Himalaya, Karakoram, Kohistan.

M/302. Muir-Wood, R., 1981c. Decay in the Karakorum. New Scientist, 89(1246), 414–417.

Key words: Karakoram.

M/303. Muir–Wood, R., 1981d. Highway to the top of the world. New Scientist, 91(1270), 656–658.

In the late seventies, the government of Pakistan with support from China opened up the Karakoram Highway. It traverses across some of the most fantastic scenary and highly rugged mountain terrain comprising from south to north, western Himalaya, Kohistan and Karakoram mountain ranges. The transect from Gilgit to Khunjerab provides access to a highly glaciated terrain with extreme relief at places.
Key words: Karakoram Highway, Himalaya, Karakoram.

M/304. Muir-Wood, R., 1984. A science of mountains. In: Miller, J.A. International Karakoram Project, Volume 2, Cambridge University Press.

This article considers the beginning of the science of mountains and the role of the International Karakoram Project (IKP) in the integration of several disciplines concerned with that science. The hope is expressed that the IKP may help stimulate more projects to further that integration towards a more unified approach to the study of earth sciences.
Key words: Mountain science, Karakoram.

M/305. Mujahid, W.K., 1982-84. Structural studies of Chinarkot-Galigada Area, District Mansehra. M.Sc. Thesis, Punjab University, Lahore, 87p.

The landforms bear a specific relationship with geological structure and climate which can be worked out by qualitative as well as quantitative analysis of the topographic map. The most predominant lithologies of the project area are garnet mica schists and Susalgali granite gneiss. The rocks of the project area have been classified into eight lithologic units for the sake of mapping purpose at a scale of 7 cm to a kilometer.
Mesoscopic deformational structures are well exhibited in the project area including both planar and linear structures. The rocks have been folded isoclinally and later being refolded into open folds. The area is traversed by a shear zone, the Chalundri fault and is divisible into two structural domains.
The area lies in the core zone of the regional synformal structure of the Mansehra Complex, which has experienced metamorphism in Barrovian style. The project area has been metamorphosed upto garnet grade with local contact metamorphic effects along the contacts of granites.
Key words: Structure, granite gneiss, schists, Mansehra.

M/306. Mujtaba, G., 1970-71. Geological mapping of Lawari Pass Area with special reference to engineering geological aspects. Institute of Geology, Punjab University, Lahore, (M.Sc. Thesis), 84p.

The aim of the project was to map the Lawari Pass area and to investigate about its engineering geological aspects. The area has never been geologically mapped before and no considerable work has been done there. The field work was carried out in the months of October and November, 1971. Field partner was Mohammad Ilyas. The area was again visited in September, 1972. Only the adits were examined during this. The thesis is divided into two parts. First part comprises of the introduction, physiography. Petrographic and structural studies. The second part relates to the engineering properties of rocks, tunnel and the location of a best route.
An area of about 40 square miles has been mapped. The area includes the following rock units:-
1. The granodiorite,
2. The granite,
3. The gneiss,
4. The quartz-amphibole schist,
5. The chlorite schist.

Their megascopic as well as microscopic features have been studied. A little description about their petrogenesis is also included. Regional geology has been summed up separately in Chapter-III.
Dikes and Vein are described in Chapter VII. A different chapter about the structural studies is written. Stereographic projections of the foliation and the joint planes for the major rock zones are produced.
The results of the engineering tests performed on almost all rock types have been discussed in Chapter VIII. The data is included in the appendix .Chapter IX is a summary of the data from subsurface explorations through drilling and aditing. Separate writing of Chapter X about tunnel and tunneling was considered necessary to get familiar about its theoretical aspects only related to the project. Prospecting for the construction of the proposed Lawuri pass tunnel has been discussed in detail in Chapter XI A few sketches have been drawn here.
Chapter XII discusses the location of best possible route. In addition, some measures have been suggested to keep the road clear of snow, throughout the year. The proposed location of the route is shown on Map 1.
Photographs show different features from the field area as well as the laboratory work. Conclusions have been drawn in the last chapter and also recommendations have been made.
The author has found a great shortage of the literature relating to the tunnels and the highway problems in the mountainous regions.
Key words: Engineering geology, Lowari Pass, Dir, Chitral.

M/307. Mujtaba, M., 1968. Field report of eastern Buner and Northern Chamla (Lower Swat Area). Institute of Geology, Punjab University, Lahore, (M.Sc. Thesis), 76p.

A detailed geologic and petrologic study of the eastern Buner and a part of northern Chamla was done with a special stress on granite complex. Granite rooks of the area is very complex mineralogically, compositionally as well as in field occurrence. The rock is composed of both granodiorite and granite but no sharp contact was found in the field to separate them. A third type of granite, known as Dumbukia Granite was noticed near the village Dumbakia, which is in the form of an oval body with a distinct weathering and gradational contact with the host granite. Due to this complexity of the granite, fifteen thin sections of the rocks were studied but the problem is still unsolved. Therefore, to solve the problem of the granite a very carefu1 study and detail matting must be carried out.
Metamorphic rocks of the area are also very complex. This complexity is due to thermal retrogressive and metasomatic metamorphisms which are superimposed on a previously regionally metamorphosed rocks. The highest grade of metamorphism in the area is found to be of staurolite and sillimanite grade of Amphibolite facies.
Basic dykes are very common in the area. There are younger than metamorphics but older than granite. These dykes are also metamorphosed along with the country rocks.
Dolerite dykes in granite have partly granitized. Three outcrops of iron-ore were noticed in the area. These ores, in the form of siderite and field evidences indicate that the ores are of magmatic in origin. A detail mapping must be done of these ores, in and outside the area so that it can be found weather these are economically useful or not.
Key words: Petrology, Buner, Swat.

M/308. Mujtaba, M. & Abbas, G., 2001.Diagenetic control on porosity development in Early Eocene carbonate reservoirs of Potwar Sub-Basin, Pakistan. Pakistan Journal of Hydrocarbon Development Research 12, 64-72.

Key words: Diagenesis, porosity, Eocene, carbonate reservoir, Potwar.

M/309. Muniam, A., 1983. Geology and petrography of sedimentary rocks from Jamal Khel, Dara Adam Khel, Kohat. M.Sc. Thesis, University of Peshawar, 70p.

Key words: Petrography, sedimentary rocks, Kohat.

M/310. Munir, A. & Khan, N., 1995. Structure and stratigraphy of a part of northern Kohat Plateau, south of Kohat City, N.W.F.P. M.Sc. Thesis, University of Peshawar, 54p.

Key words: Structure, stratigraphy, Kohat Plateau, Kohat.

M/311. Munir, M., 1973. Geological mapping of Chalt Area (Gilgit Agency). M.Sc. thesis. Institute of Geology, Punjab University, Lahore.

Key words: Mapping, geology, Chalt, Gilgit.

M/312. Munir, M.H., Baig, M.S. & Qureshi, M.A., 1997. Lower Tertiary litho-biostratigraphy of the Bagla-Kohala Bala area, Haripur Hazara (NWFP), Pakistan. Geological Bulletin, Punjab University 31 & 32, 153-160.

The Lower Tertiary shallow water marine sequence of Bagla-Kohala-Bala area overlies unconformably on the Late Cretaceous deep water marine Kawagarh Formation. The Lower Tertiary shaly, marly and limestone sequence of Lockhart Limestone, Patala Formation, Margala Hill Limestone, Chorgali Formation and Kuldana Formation yields rich foraminiferal assemblages. The study of four stratigraphic sections yield 19 age diagnostic benthonic larger foraminiferal species These foraminiferal species include Lockhartia tipperi, Lockhartia conditi, Assilina granulosa, Assilina subspinosa, Assilina laminosa, Daviesina khatiyahi, Miscellanea miscella, Miscellanea stampi, Nummulites atacicus, Nummulites boninesis, Nummulites globulus, Nummulites sp., Operculina canalifera, Operculina complanta, Operculina salsa, Operculina subsalsa, Dmiesina lunghami, Ranikothalia nuttalli and Bigenerina sp. The

analysis of these benthic foraminifers suggests that the deposition of the Lower Tertiary sequence occurred in an open sea upper slope to outer shelf shallow marine environment.
Key words: Litho-biostratigraphy, foraminifera, Tertiary, Haripur, Hazara.

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Key words: Lithostratigraphy, fluvial deposits, Pliocene, Pleistocene, Bhittani, Marwat Ranges.

M/314. Munthe, J., Hussain, S.T., Lukaes, J.R., West, R.M. & Shah, S.M.I., 1979. Neogene stratigraphy of the Daud Khel area, Mianwali District, Pakistan. Contributions in Biology and Geology 23, Milwaukee Public Museum Press, 1-18.

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Key words: Stratigraphy, structure, reef complex, Siluro-Devonian, Nowshera.

M/316. Mustafa, Y.M., Khan, M.H. & Muhammad, N., 1985. Geology of Jatta Ismail Khel and Takht area, Karak, N.W.F.P. M.Sc. Thesis, University of Peshawar, 86p.

Key words: Geology, Karak, NWFP.

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