R/1. Rab, A. & Qureshi, K.M., 1980. Petrography of Ambela Granite, Swat. M.Sc. Thesis, University of Peshawar, 45p.

Consult Rafiq (1987) for detailed description of the Ambela granite complex.
Key words: Petrography, granite, Ambela, Buner.

R/2. Rabbani, M.A., 1976. Geology of Kalaya and Ismail Zai, Tehsil of Orakzai Agency, North West Frontier Province, Pakistan. FATA DC, Records 1, 17p.

Consult the following account for further information,
Key words: Stratigraphy, Orakzai Agency.

R/3. Rabbani, M.A., 1978. Geology of Orakzai Agency, North West Frontier Province, Pakistan. FATA DC, Records 2, 1-47.

The stratigraphic sequence in the Orakzai Agency has been described in detail. The oldest rocks of the area comprise the Shinwari Formation (Fm) of Early Jurassic. These are followed by Samanasuk Fm (Middle Jurassic), Chichali Formation (Late Jurassic to Early Cretaceous), Lumshiwal Formation (Middle Cretaceous). Kawagarh Formation (Late Cretaceous), Hangu Formation (Paleocene), Lokhart Limestone (Paleocene), Patala Formation (Paleocene), Panoba Formation (Early Eocene), Sheikhan Formation (Early Eocene), Kuldana Formation (Early Eocene), and Murree Formation (Miocene).
Key words: Stratigraphy, Orakzai Agency.

R/4. Rabbani, R., 1983-85. Detail geological map of the Kohala Damsite. M.Sc. Thesis. Punjab University, Lahore, 90p.

The detailed geological map of the Kohala damsite No.1 and No.2 have been prepared. This field report consists of TWO Parts. Part 'A' deals with the General Geology of the Area. Introduction, Physiography, Stratigraphy, Structure, Tectonics and Economic Geology of the area has been discussed in this part. In Part 'B' various Engineering Geological Aspects have been discussed in detail. In this part, different factors of site investigation have been discussed. Recommendations and conclusions have been given at the end.
Key words: Mapping, damsite, Kohala.

R/5. Rabbi, F. & Khattak, N., 1983. Petrography and geochemistry of diorites and volcanics from Northern Dir. M.Sc. Thesis, University of Peshawar, 58p.

Diorites and quartz diorites are common in the Kohistan island arc. Those from northern Dir, commonly containing hornblende (with or without biotite) and variable amounts of quartz, are described in the work. Chemical analyses of selected samples are discussed from petrological point of view.
Key words: Petrography, geochemistry, diorite, volcanics, Dir.

R/6. Rabot, C., 1904. Explorations des glaciers du Karakorum. La Geographie 9, p.374.

Key words: Glaciers, exploration, Karakoram.

R/7. Raeburn, S.P. & Kerrick, D.M., 1995. Reconnaissance Lithological Mapping in the Karakoram Using Digital JERS-1 and Landsat-5 Satellite Data. Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

Kerrick and Caldeira (1993, 1994) hypothesized that the amount and advective flux of metamorphic CO2 arising from post-collisional metamorphism in the Himalaya orogenic belt may have been of sufficient to have enhanced

atmospheric CO2 contents and thus have contributed to early Cenozoic greenhouse warming. In reviewing uncertainties in their quantitative analysis of the amount of metamorphic CO2 generated at depth, they emphasized the need for improved estimates of the proportion of CO2 source rocks (carbonate protoliths) in the Himalayan-Karakoram orogenic belt. Accordingly, the primary purpose of our study was to further quantify the aerial abundance of carbonate-bearing and calc-silicate bearing lithologies. Because of the logistical difficulties in access and the limited lithologic mapping over the extensive area required for such estimates, satellite imagery was used to aid in such estimates. Using the Karakoram metamorphic complex as a case study, We have investigated the utility of remotely sensed visible and near infrared (VNIR) and short wavelength infrared (SWIR) digital satellite data for lithological discrimination in an area largely free of vegetative cover and bounded by the Hunza, Gilgit and Ishkuman rivers. A thematic map was compiled from two different data sets: Japanese JERS-1 SWIR data which has 4 spectral bands within the SWIR region, and a Thematic Mapper (TM) data which has 2 bands in the SWIR and 4 bands in the VNIR region. Limited JERS-1 data availability required acquisition of digital image data characterized by a low sun elevation angle and snow cover in high elevation areas, whereas acquired Landsat TM data had a higher sun elevation angle and less snow cover. Variation in the intensity of backscattered radiation as a result of topographical effects is a considerable problem in areas of high relief, and requires separate analysis of shaded and unshaded areas. Spectrally distinct units identified using band rationing and principal components analysis techniques were correlated with previously mapped regions in the Hunza valley (Searle, 1991) and extrapolated westward into the less well-mapped area between the Hasanabad glacier and the Karumbar valley. This study provides assessment the utility of digital satellite data in extending reconnaissance mapping to other inaccessible areas of high relief and limited vegetation in the Karakoram.
Key words: Reconnaissance, landsat imagery, carbonates, Hunza.

R/8. Rafiq, M., 1984. Extension of Skhakot-Qila ultramafic complex in Utman Khel, Mohmand Agency, NWFP, Pakistan. Geological Bulletin, University of Peshawar 17, 53-59.

The Utman Khel area in Mohmand Agency Contains bodies of ultramafic and mafic rocks covering an area more than one third of that of the Utman Khel mountains. The ultramafic rocks are emplaced as klippe over the metasediments of Paleozoic age. The central part of the complex generally consists of massive dunite, peridotite, and grades outward into massive to friable serpentinites. At several places, dunite, peridotite and serpentinite are altered to talc, carbonate and carbonate- quartz rock, particularly along shear zones. Steatite and blackwall-chlorite rock form small masses at the margins of the ultramafic rocks, adjacent to the contact with metasediments. Chromite occurs as podlike and lensoidal masses in 54 showings sporadically distributed over six different locations.
The characteristics displayed by the ultramafic rocks of the Utman Khel area are virtually similar to those displayed by the rocks of the Skhakot-Qila complex. Therefore it is appropriate to consider the ultramafic rocks of Utman Khel area as the extension of Skhakot-Qila complex.
Key words: Ultramafic, Utman Khel, Mohmand, Skhakot-Qila, Malakand.

R/9. Rafiq, M., 1987. Petrology and geochemistry of the Ambela granitic complex, N.W.F.P. Pakistan. Ph.D. Thesis, University of Peshawar, 272p.

The Ambela granitic complex is a middle to Late Paleozoic batholith consisting of oversaturated (70%), saturated (20%), undersaturated (5%) and basic (5%) igneous rocks. Petrographic study reveals three major divisions of the rocks: Group I includes granites and alkaline granites; Group II includes quartz syenites, alkali quartz syenites, syenites, alkali syenites and feldspathoidal syenites; and Group III consists of basic dykes. Chemical classification based on 166 major element analyses match the petrographic division and the rocks vary from peraluminous (partly metaluminous) to peralkaline in composition. Major, minor and trace element contents of these rock indicate a within plate (continental) origin.
Key words: Petrology, geochemistry, petrography, Ambela, Swat.

R/10. Rafiq, M., Ahmad, I. & Tahirkheli, T., 1983. A geological map of the surroundings of the Peshawar Plain. Geological Bulletin, University of Peshawar 16, 189.

This is an early attempt on presentation of the geology of the mountain area surroundings the Peshawar basin. Major structures in the area are also shown.

Key words: Mapping, Peshawar plain.

R/11. Rafiq, M. & Jan, M.Q., 1983. A discovery of emerald near Bucha, Mohmand Agency. Geological Bulletin, University of Peshawar 16, 188.

Light green beryl and emerald occur in talc-carbonate and carbonate-quartz rocks located about 200m north of Bucha village in eastern Mohmand Agency. The crystals reach up to 10×5mm in size, however, large crystals are translucent, fractured, and poor in quality. Transparent and clear crystals of light green beryl and emerald are less than 3mm in length and are, therefore, nor of a high commercial value.
Key words: Gems, emerald, Mohmand Agency.

R/12. Rafiq, M., & Jan, M.Q., 1984. Emerald and green beryl from Bucha, Mohmand Agency, NW Pakistan. 1st Pakistan Geological Congress, Lahore, p.21

Deep bluely-green emerald and light green beryl occur sporadically in talc-carbonate and carbonate-quartz rock's near Bucha (34o 241/2' N, 71o 36' E). The host rocks have formed along shear zones due to alteration of enclosing ultramafic rocks. However, the source of solutions for this metasomatic process and introduction of Be is not clear. The beryl and emerald have high iron, emerald also having higher MgO content and refractive indices than most of the described natural emeralds. The crystals are variable in clarity and reach up to 10 mm in length; however, gem quality crystals are less than 3 mm long.
Key words: Gemstones, emerald, beryl, Mohmand Agency.

R/13. Rafiq, M. & Jan, M.Q., 1985. Emerald and green beryl from Bucha, Mohmand Agency, NW Pakistan. Journal of Gemmology 19, 404-411.

Deep bluey green emerald and light green beryl occur sporadically in talc carbonate- quartz rocks near Bucha (34º 24.5' N, 71º 36' E). The host rocks have formed along shear zones due to the alteration of enclosing ultramafic rocks; however, the source of solutions responsible for this metasomatic process and introduction of Be is not clear. The beryl and emerald have high iron, the emerald also having higher MgO content and refractive indices than most natural emeralds. The crystals are variable in clarity and reach up to 10 mm in length; gem quality crystals, however, are less than 3 mm long.
Key words: Gems, emerald, beryl, Mohmand Agency.

R/14. Rafiq, M. & Jan, M.Q., 1987. Fibrolitic sillimanite in sheared rocks of the Ambela granitic complex, northwestern Pakistan. Geological Bulletin, University of Peshawar 20, 181-188.

Two-mica granites in the northeastern margin of the Ambela granitic complex underwent cataclastic deformation. The resulting shear zones acted as pathways for the migration of a water-rich fluid phase that also contained boron and some fluorine. This resulted in 1) formation of fibrolitic sillimanite and white mica at the expense of feldspars and biotite, especially along micro-shears, 2) bleaching of biotite and release of Fe and Ti oxides, and 3) crystallization of tourmaline and fluorite. Some recrystallization / neo-mineralization of feldspar, quartz and muscovite also occurred due to shearing.
Key words: Granites, shear zones, deformation, Sillimanite, Buner.

R/15. Rafiq, M. & Jan, M.Q., 1988. Petrography of the Ambela granitic complex, NW Pakistan. Geological Bulletin, University of Peshawar 21, 27-48.

The Ambela granitic complex occupies the southeastern part of the Buner subdivision of Swat. It is a composite batholith consisting of a variety of oversaturated (70 %), saturated (20 %), and undersaturated rocks (10 %). The batholith may have formed over a considerable length of time, spanning from middle to late Paleozoic. Petrographic studies (800 thin section) allow a three fold grouping of the rocks. Group I include granites, alkali granites and

microporphyrites; these appear to represent the early magmatic episode of the complex. Group II includes quartz syenites, alkali quartz syenites, syenites, feldspathoidal syenites, carbonatite, ijolite, lamprophyre, and associated pegmatites and fenites. Considerable metasomatic changes were associated with successive alkali rich intrusive phases of this group of rocks. Basic dykes (Group III), intruding both Group I and II rocks, represent the last magmatic episode and constitute about 5 % of the complex. This paper presents petrographic details of the various types of rocks in the complex.
Key words: Petrography, Ambela granitic complex, Buner.

R/16. Rafiq, M. & Jan, M.Q., 1989. Geochemistry and petrogenesis of the Ambela granitic complex, NW Pakistan. Geological Bulletin, University of Peshawar 22, 159-179.

The Ambela granitic complex comprises three groups of rocks. Group I, the product of the first magmatic episode, consists of granites and alkali granites which occupy ~70% of the 900 Km2 area of the batholith. Group II, following the granites sequentially, comprises quartz syenites, syenites, feldspathoidal syenites and related rocks. Following these, the area was invaded by dolerite dykes which occupy ~5% of the complex. These (Group III rocks) are not discussed in this paper. The granitic rocks range from dominantly peraluminous to metaluminous to mildly alkaline. These were derived from melts produced by crustal anataxis due to crustal thinning and rifting. Different degrees of partial melting and fractional crystallization led to variation the composition of these Group I rocks. With deepening of the zone of magma generation in the crust, the underlying mantle was activated, resulting in the influx of volatiles and alkalis. This led to the generation of magma batches which were successively more SiO2 undersaturated and alkaline, resulting in the production of Group II rocks. The Ambela batholith appears to have developed during a major phase of crustal thinning and rifting towards the end of Paleozoic.
Key words: Petrography, geochemistry, Ambela granitic complex, Buner.

R/17. Rafiq, M. & Jan, M.Q., 1990. Petrogenesis of basic dykes from the Ambela granitic complex, NW Pakistan. Abstracts, 2^{nd} Pakistan Geological Congress, University of Peshawar, p.45.

Basic dykes intrude the upper Paleozoic granites, alkali granites, syenites and associated rocks of the Ambela granitic complex. These dykes mostly have N 25-450E trend, constitute about 5% of the complex, and from 1 to 7m thick bodies that at places extend for hundreds of meters. Textural, modal and chemical composition criteria have been used to classify these dykes into (1) dolerites of varied assemblages, and (2) Lamprophyres. The dolerites generally display ophitic to subophitic texture and consist of plagioclase (An35-55), hornblende, pyroxene, epidote, ore (ilmanite and titaniferous magnetite), sphene, and rarely quartz, biotite, chlorite and apatite. The chemistry of the dolerite dykes is suggestive of continental tholeiitic affinity. The lamprophyres are restricted in occurrence and intrude the north-central part of the complex near Koga. Texturally these are panidiomorphic and are composed of amphibole, sphene, albite, apatite and ore. Field data and petrography suggest that these rocks represent the last episode of the alkaline magmatism in the complex.
Key words: Petrography, basic dykes, Ambela granitic complex, Buner.

R/18. Rafiq, M. & Jan, M.Q., 1991. Titanium content of a chloritoid-quartz-ilmenite band in ophiolitic melange near Prang Ghar, NW Pakistan. Geological Bulletin, University of Peshawar 24, 127-132.

Titanium is a valuable engineering metal and has many uses. In the greenstone of the Indus suture melange near Prang Ghar, a 200 m long and 1 to 3.5 m thick band consists essentially of chloritoid (31 to 59 vol. %), quartz (10 to 27%), and ilmenite + Fe-oxide (8 to 25%). The rocks contain very high Al_2O_3, total Fe_2O_3 and TiO_2, and low SiO_2, CaO, MgO and alkalies. The unusual composition may have formed from basaltic precursors of the greenstone by weathering (laterization) or alteration, followed by greenschist facies metamorphism. Chemical analyses of three samples, containing 5 to 10 wt. % TiO_2, warrant further investigation of the area.
Key words: Ophiolites, ultramafics, Indus Suture, Prang Ghar, Mohmand.

R/19. Rafiq, M., Khan, M.A. & Jan, M.Q., 1988. Myrmekite in the Ambela granitic complex, N. Pakistan: A product of deformation and replacement in the feldspar. Geological Bulletin, University of Peshawar 21, 159-165.

The Ambela Granitic Complex in N. Pakistan is locally intersected by strike-slip and thrust faults, which have resulted in the development of relatively, sheared granites. A characteristic feature of the deformed granites is the occurrence of myrmekite in the K-feldspar porphyroclasts, which is otherwise absent in the complex. A detailed petrographic study shows that the myrmekites are localised along those margins of the porphyroclasts which are mot strained and which are adjacent to the trails of secondary muscovite. A comparison with the established examples of strain-related myrmekites suggests that though the deformation may be important in the genesis of the Ambela myrmekite, there may be a greater role of metasomatic replacement accompanying deformation.
Key words: Myrmekite, petrography, Ambela granitic complex, Buner.

R/20. Rafiq, M., Khan, M.A., Jan, M.Q. & Ahmad, I., 1988. Petrography and geochemistry of the inclusions from the Ambela granitic complex, N. Pakistan. Geological Bulletin, University of Peshawar 21, 141-145.

Petrography of twelve and geochemistry of three selected samples are presented for the inclusions of the Ambela granitic complex. The inclusions are silicic to intermediate in composition with a metaluminous chemical character. Major element geochemistry is inconclusive with regards to their origin, but incompatable trace elements are in correspondence with the concentration of these elements in the host granites and syenites. A closer match, however, is with the acidic volcanics which now make a part of the country rocks but were probably the early phase of the Ambela granitic complex.
Key words: Petrography, enclaves, Ambela granitic complex, Buner.

R/21. Rafiq, M., Shah, A., Hamidullah, S. & Sayab, M., 1997a. Petrogenetic study of Late Paleozoic sub-volcanic rocks from Peshawar Plain, N.W. Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.50.

Please consult the following account for additional information.
Key words: Petrogenesis, Paleozoic, Peshawar Plain.

R/22. Rafiq, M., Shah, A., Hamidullah, S. & Sayab, M., 1997b. Classification and genesis of late Palaeozoic, volcanic rocks from Peshawar plain, North West Pakistan. Geological Bulletin, University of Peshawar 30, 251-271.

Acidic microporphyries and rhyolites of Late Paleozoic age are intimately associated with acidic plutonic rocks, i.e., the Ambela granitic complex of alkaline igneous province of Peshawar plain. Basic rocks occurring as flows are also associated with these acidic rocks. Field evidences including the association of metasedimentary sequence of Carboniferous age, i.e., Jaffar Kandao and Baroach Formation, provide constraints on the date of their emplacement. The microporphyries and rhyolites have a fine-grained texture with feldspars and quartz as phenocrysts. The rocks are classified as A-type, mildly alkaline and peraluminous on the basis of major and minor element chemistry. Tectono-magmatic discrimination diagrams, Zr and Ta concentration, Hf/Th and Hf/Ta ratios, and low Sr reveals that these rocks are of crustal origin and were emplaced in intra-cratonic rift environment. The Th, Hf and Ta concentrations indicate crustal contamination, and Eu anomaly shows soda metasomatism due to the intrusion of late magmatic fluids in these rocks.
Key words: Petrogenesis, Paleozoic, volcanic, Peshawar Plain.

R/23. Rafiq, M., Shah, M.T., & Ahmad, I., 1984. Note on tremolite zone from the extension of Skhakot-Qila ultramafic complex Utmankhel, Mohmand Agency. Geological Bulletin, University of Peshawar 17, 178-179.

Tremolite rock occurs along the northeast and northwest contact of the ultramafic complex, west of Jindai Khwar near Balola in Mohmand Agency Tremolite is mostly found in association -with actinolite, talc and chlorite along shear zones. Palegreen to green and fibrous to blady tremolite crystals vary from 3 to 1b.m in length. However, a greyish-green variety (about 2mm in length9 intermixed with $talc and chlorite is not uncommon. The blades are commonly broken, bent, and usually tailed out into finely fibrous bundles of ashtiform tremolite. It has large 2V with an extinct angle varying from 15^0 to 20^0, and *a* and P refractive indices of 1.60 and 1.61 respectively.
Tremolite mineral from the tremolite rocks was analysed for major oxides by wet chemical methods. These oxides were used for the calculation of mineral formula (Ca_{1-68} Na_{0-20}) (Mg_{4-58} Mn_{0-02} Fe_{0-21} Al_{0-30}) (Si_{7-83} Al_{0-16} O_{21}) (OH_2) on the basis of 23 oxygens; water was not included in the recalculation (Leake, 1978). The mineral was classified as tremolite. This analysis on comparison, has correlation with the tremolite from Feather River ultramafics (Ehrenberg, 1915) and also with tremolite from Ultimo, Italy (Pirani, 1951). Inspite of optical properties and chemical data, the presence of tremolite was also established by examination of X-Ray Diffractometer powder pattern. The powder pattern of charge contained 90% tremolite, the remainder being actinolite, talc, and chlorite. Field relationship of tremolite rock with the ultramafics suggests that it may probably be the product of secondary processes. However, more detailed work is required to ascertain the possible origin of this rock.
Key words: Ultramafics, tremolite, Skhakot-Qila, Mohmand Agency.

R/24. Rafiq, M., Shah, M.T., Rehman, M. & Ihsan, M., 1984. Petrochemistry of the rocks from Babaji area, a part of the Ambela granitic complex, Buner, Northern Pakistan. Geological Bulletin, University of Peshawar 17, 31-42.

Geological mapping covering 50 km^2 around Babaji in Buner, shows that the area comprises of syenites, quartz-syenites and granites. The rocks are distinguished on the basis of field and petrographic observations. Petrochemically (19 analyses) the Babaji rocks are comagmatic and have the characteristics of an extensional type of plutonic suite, associated with rifting. There is a close correlation of available chemical indices of the studied suite with similar rocks elsewhere in the world.
Key words: Petrology, geochemistry, Ambela granites, alkaline rocks, Buner.

R/25. Rafique, M., 1964-65. Geology and Petrology of Hakle-Mansehra Area. M.Sc. Thesis, Punjab University, Lahore, 170p.

The area mapped lies in the core of syntaxial bend and is designated as "Hakle Area" after the name of the locality. One geologic map is given with extensive readings of joints, foliation, lineation and general bedding.
The area consists of acid igneous rocks and regionally metamorphosed sediments. The acid rocks are Granites (classified as Mansehra and Hakle Granite) whereas the metamorphic include chlorite biotite schists, quartzites and garnet mica schists. A detailed study of Hakle Granite has been mad for the first time. From the systematic study of the rocks it is concluded that
Because of the chemical similarities (except Soda which is abundant in Granites) between the Granites and country rocks, a genetic relation can be traced. Again because of field observations and chemical and mineralogical similarities, Hakle Granite is traced to be a late differentiate of Mansehra Granite which underwent potash and boron metasomatism. The previous view of antipathic relationship between tourmaline and biotite of Hakle Granite is contradicted. Structurally the area is folded into anticlines and synclines, the granites occupying the cores of anticlines while metamorphic form the synclines. The space for granites was provided by marginal faults and stoping.
Key words: Petrology, structure, metasediments, granites, Mansehra.

R/26. Rafique, M., Ashraf, M., Din, A. & Faruqi, F.A., 1976. Evaluation of glass sand deposits of Pezu, Bannu District, NWFP, Pakistan. Geological Bulletin, University of Punjab 13, 87-92.

Eight different silica sand samples (of Jurassic age) collected from Pezu region was investigated for their grain size distribution, chemical analysis, and removal of Fe2O3 contents and melting behavior. It has been found that sand Nos. 9S and 10S from Chunda after water washing and grading are among the best sands of the country. Sand Nos.

1S (Nar Kasha Tangi), 5S and 6S Terkhobai Ster are the medium quality sands. Most of the iron oxide present in the sands in the form of heavy minerals is of para-magnetic nature and magnet treatment is unnecessary. Sand Nos. 9S and 10S exhibit a good melting behavior.
Key words: Glass, silica sand, Pezu, Bannu.

R/27. Rafique, M., Chaudhry, M.A. & Chaudhry, M.N., 1988a. Chemistry, mineralogy and utilization of Kotli Azad Kashmir dolomite for making colorless glass. Pakistan Journal of Scientific and Industrial Research 31, 449-454.

Five dolomite formations of Lateri, Sawar, Kamroti, Nikial and Tattapani of Kotli area of Azad Kashmir have been studied in detail for their use in the manufacture of colourless glass. It has been shown that raw samples due to high iron content (more than 0.1 %) are not suitable for colourless glass making. However, after beneficiation, the iron content is reduced to 0.058% and 0.08% which is acceptable for colourless glass making. Experimental glass meltings containing 3.2 % MgO with the beneficiated dolomite samples gave satisfactory results.
Key words: Mineralogy, chemistry, dolomite, glass, Azad Kashmir.

R/28. Rafique, M., Chaudhry, M.A. & Chaudhry, M.N., 1988b. Studies on economic potentials of nepheline syenite of Koga (Swat) for making colorless glass. Pakistan Journal of Scientific and Industrial Research 31, 663-668.

Six samples of Nepheline syenite collected from Koga area (Swat, NWF) have been investigated to find their suitability for the manufacture of colourless glass. This work involves geology, microscopic study, crushing grinding, grading, chemical analysis, magnet treatment and glass melting. The iron content in the raw samples varied in the range 0.87 to 2.7 %rendering them unsuitable for colourless glass making. After magnetic separation, Fe203 is reduced (0.06 %) to a level which is acceptable for colourless glass making. Two glass compositions containing Al_2O_3 1.5 % and 4.0 % suitable for container and fiber glass have been melted to produce colourless glass. The results are satisfactory.
Key words: Nepheline syenite, glass raw material, Swat.

R/29. Rafique, M., Chaudhry, M.N. & Ashraf, M., 1987. Beneficiation and evaluation of a part of the nepheline syenite deposit of Swat as a raw material for glass manufacture. Geological Bulletin, Punjab University 22, 116-124.

For further information, consult Rafique et al. (1988b)
Key words: Nepheline syenite, glass, raw material, Buner, Swat.

R/30. Rafique, M. & Farooqi, F.A., 1984. Evaluation of optical quality Hazara sand North West Frontier Province. Kashmir Journal of Geology 2, 103-108.

A representative sample of sand from Hazara District was procured for investigation for optical glass making point of view. It was found that after water washing and grading, the reduction of iron content (Fe_2O_3) was so significant that this sand was quit suitable for the manufacture of optical glass.
Key words: Glass sand, Hazara, NWFP

R/31. Rahimuddin, M., 1971. Report on geology and petrology of Taghma area, Swat district, M.Sc. Thesis, Punjab University, Lahore.

Taghma area occurs in the southern amphibolites belt of the Kohistan arc. In addition to amphibolites, ultramafic rocks, gabbros and diorites are described from this area.
Key words: Petrography, petrology, amphibolites, Swat.

R/32. Rahim, M.A., 1981-83. Geological mapping and hydrological investigation of Kalabagh Dam Site, Area. M.Sc. Thesis, Punjab University, Lahore, 109p.

Key words: Mapping, hydrology, engineering geology, damsite, Kalabagh.

R/33. Rahman, A., 1961. A gravity study of the granites in the Mansehra area, west Pakistan. Geological Bulletin, Punjab University 1, 15-20.

The results of a gravity survey of the granites and metamorphics near Mansehra are given. The residual gravity anomaly pattern does not, in general, follow very closely the geological structures, and the main mass of granite is thought to be in the form of a sheet. One very marked and circumscribed negative anomaly occurs over a small tourmaline granite intrusion for which a possible form has been calculated. To explain the anomaly a higher density contrast had to be assumed than that given by measurements of actual rock samples.
Key words: Geophysics, gravity, metamorphic, granite, Mansehra.

R/34. Rahman, A., 1964. A preliminary investigation by the self-potential method of a known galena deposit at Sobrah, Hazara District, West Pakistan. Geological Bulletin, Punjab University 4, 103-104.

Shams (1963) has given an account of lead mineralization in the Abbottabad Area, Hazara District. Self-potential survey has been carried out on one of the three galena occurrences which he has mentioned in this area; the Sobrah Lead deposit has been investigated to determine its possible extension and, hence, the feasibility of the economic exploitation of the mineral. In 1959, extraction of Lead was started at the Sobrah deposit, but the work was abandoned after a short time. Since then, no further attempt has been made to reconsider the possibility of mining at this site. Moreover, there exists no account of any Geophysical survey, before the mining was taken up. The only evidences of the deposit are the exposed galena-containing rocks in the nala, in the form of a thin vein, (Shams 1963). This Lead occurrence at Sobrah is an impregnation of Galena in a zone of fracture between the Hazara Slates and the Tanol Formation. To carry out the self-potential survey, an ABEM Self-potential equipment, with porous pots (copper in copper sulphate) was used. In view of the very rugged topography of the area, the gradient method was employed. The gradient of Self-potential was observed between two points, 30 ft. apart, along the profiles shown in figure 1. Because of the hindrance due to the cultivated fields, the lines of the profiles were run only along the accessible paths or along stream beds. The data thus collected was found to be insufficient for drawing the equipotential contours; therefore, only the ranges of the gradient of Self-potential were shown in the map (Fig. 1.). The gradient of Selfpotential in the range of 100 to 250 mV/30 ft. was taken as high, that in the range of 50 to 100 mV/30 ft. was considered as medium, while that lying below 50 mV/30 ft. was classified as low. The high and medium gradients were marked on the map, the low gradients were not taken into account.
The high Self-potential gradients were observed to exist between Station Nos. 37-38, 44-45, 100-101102, 136-138 and 138-139, and the medium SP gradients were found between Stations Nos. 38-39, 102-103, 103-104 and 147-148. The highest value of gradients (245 mV/30 ft.) was found between Stations No. 136-138 and 138-139. These values were rechecked for shorter electrode-spacings and at different times but were found to be consistent with a deviation of 20 mV/30 ft. A high S. P. gradient observed between stations Nos. 37-38 and 44-45 could be due to some deepseated ore body, as it shows a scattered type of anomaly. In the map (Fig. 1) the high gradients of S.P., shown on profile IV, lie on a band which also contains the mining pits. The extension of the band is in a direction N 45° W, which coincides with the strike of the ore body, exposed in the mining pits. In order to determine the extension of the ore body in the direction of the strike, two profiles, Nos. V and VI were run. All the S. P. gradient values found on these profiles were lower than 50 mV/30 ft., which probably shows that the galena deposit of Sobrah does not extend continuously beyond the profiles Nos. V and VI. It requires, however, more work to determine whether there are other galena deposits in the direction of the strike. Thus the Sobrah Galena Deposit has a limited extension in the direction of its, strike and does not call for a full-scale mining operation.
Key words: Geophysics, economic geology, lead deposits, galena, Abbottabad.

R/35. Rahman, A., 1990-92. Geological mapping of Nauseri-Muzaffarabad-Garhi Habibullah area and evaluation of landslide hazards on western limb of Hazara-Kashmir Syntaxis. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 55p.

The northwestern part of Muzaffarabad and western limb of Hazara-Kashmir syntaxis is the area of high landslide hazards. Steep slopes silty, sandy and clayey soils, heavy rainfalls, water seepages and under cutting of the river all contribute to the landsliding in the region. The instabi1ity of the area has been further increased by road widening and effect of Main Boundary Thrust (MBT), resulting in the form of major landslides such as, slumping, earthflows, rockfalls, sinkholes and combination of these. The active Lohar Gali landslide is investigated in detail because of its large size and proximity to roadways. Soil samples were collected to evaluate engineering properties of material involved in these failures. The investigated area is a limb of Hazara Kashmir Syntaxis of folded and faulted, low grade metamorphic rocks, which have been further deformed by the important Muzaffarabad fault and regionally significant Main Boundary Thrust (MBT).
In addition, a landslide map of the area was prepared by performing field work. All slope failures were classified according to their movement and state, of activity with varying water content (1.5-12.3%), liquid limit (16.1-39%), plastic limit (0-2.0%), shrinkage limit (14.5-28.8%), absorption (0.69-3.9%), compaction (114.5 lb/cu.ft), dry density at 13.55 optimum moisture content, specific gravity (2.51-3.2), slake durability (5.1-24%); grain size analysis and breaking characteristics. The results suggest that slope failure occur due to high swelling potential of soils, active faults and shear failures.
Key words: Mapping, landslides, hazards, Hazara-Kashmir syntaxis.

R/36. Rahman, A., 1992-93. Geological mapping and hydrogeological studies of Muzaffarabad area with special emphasis on pollution studies and waste disposal of Muzaffarabad city area. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 123p.

Key words: Mapping, pollution, waste disposal, hydrogeology, Muzaffarabad, Azad Kashmir.

R/37. Rahman, A.U., 1970. Geological report on Dunga Gali, Abbottabad. M.Sc. Thesis, Punjab University, Lahore, 83p.

A brief description of physiography of the area between Dunga Gali and Abbottabad is given with special reference to mass-wasting drainage, -its adjustment to structure, soils and terraces. The stratigraphy of rocks ranging in age from Paleozoic to Eocene is described. An attempt is made to reconstruct the environments of deposition of each formation. A description is given of s1tructural observations made on faults, folds and bedding planes. A brief description of tectonic behaviour of each formation is also described. The Author has discussed very briefly the type of forces and tectonic framework which could create present tectonic style; and also attempted to reconstruct the evolutionary stages of the Himalayan geosyncline during its life span.
Key words: Geology, physiography, Abbottabad.

R/38. Rahman, F., 1968a. The study of alkali metasomatism across a granite contact near Batrasi, Mansehra area, Hazara District, northern West Pakistan. 20th All Pakistan Science Conference, Dacca, p.G4.

Key words: Metasomatism, petrology, granites, Mansehra.

R/39. Rahman, F., 1968b. The study of geochemistry of the alteration products of the Susalgali granite gneiss, near Ahl, District Hazara. Abstracts, 20th All Pakistan Science Conference, Dacca.

For details consult the Rahman, F. 1972a.
Key words: Geochemistry, granite gneiss, alteration, Hazara.

R/40. Rahman, F., 1969. The geochemistry of granites and the associated rocks of the Mansehra area, Hazara District. Ph.D. Thesis, Punjab University, Lahore.

Key words: Geochemistry, petrology, granites, Mansehra, Hazara.

R/41. Rahman, F., 1972a. The study of geochemistry of the alteration products of the Susalgali granite gneiss, near Ahl, District Hazara, NWFP, Pakistan. Geological Bulletin, University of Punjab 9, 1-12.

On the Battal-Mansehra road and close to the Ahl rest house north of Abbottabad, Hazara district, there is a huge deposit of soft, friable, white-looking material. This has been repeatedly investigated, in the past, by many workers taking it as a deposit of kaolin clay; the reports have been both in favor as well as against this assumption. However, these reports were almost never based on detailed technical investigation, which had been the cause of widely variable conclusion.
The present paper has been written on the basis of chemical, microscopic, differential thermal and infrared spectrophotometric analyses and also on the basis of geochemical relationships, which exist between the soft, friable deposit and the immediately associated Susalgali granite gneiss. Moreover, it has been discovered that the deposit has got the same mineralogy and almost the same chemical composition as that of the surrounding granite gneiss and the deposit can not be other than but an alteration product of the surrounding rock.
Key words: Geochemistry, granite gneiss, alteration, Hazara.

R/42. Rahman, F., 1972b. The determination of gold by radiochemical and non-destructive neutron activation/radioactive analysis in some of the sulphide ore samples from Pakistan. Geological Bulletin, Punjab University 9, 37-42.

Four sulphide ore samples were selected from different localities in Pakistan, and were analysed by both radiochemical as well as by non-destructive neutron activation techniques. Only the results on gold are being presented in this paper. The nuclear reactor JEEP-II located at Kjeller (Norway), has been used as a source of neutrons. The samples were irradiated at a flux 1.5 X 1013 n/cm2/sec for one hour in case of radiochemical neutron activation experiment, and for half an hour in case of non-destructive neutron activation experiment. Following irradiation and "cooling" for two days, the respective samples were used directly for non-destructive analysis, whereas others were put to gold radiochemistry. 198Au, half life 2.697 days, has been assayed in both the experiments. A lithium-drifted germanium detector, Ge (Li), has been used, along with a 16 bit computer (NORD-I) with 4K memory, to measure the gold activity.
Key words: Sulphides, gold.

R/43. Rahman, F., 1975. Simultaneous estimation of eleven elements in sulphide ore samples from Pakistan. Norsk Geologisk Tidrskrift 55, 277-281.

Key words: Sulphide ore.

R/44. Rahman, F., 1978. Estimation of silver by radiochemical neutron activation method and study of its geochemical distributing in selected sulphide ore samples from Pakistan. Geological Bulletin, Punjab University 15, 7-14.

With the intention of studying distribution of silver metal in sulfide ore samples of different composition and different origin, a careful selection of four sulfide ore samples was made. Their silver metal content was estimated by employing radiochemical neutron activation technique. 100 - 200 mg of pulverised, homogenised ore samples were irradiated by thermal neutrons (at a flux of 1.5 x 10 13 n/cm2/sec) for 24 hours alongwith standard rock samples and synthetic standards for silver. These irradiated samples and standards were allowed to cool for three

weeks and then their silver content was separated and estimated by making radioactivity measurements of 110m Ag via 657.8 k e v. Finally geochemical relationship of silver with other coexisting metallogenic elements, under the then existing environments, was envisaged.
Key words: Geochemistry, sulphides, silver.

R/45. Rahman, F., 1980. A short note on landslide of Amluknar, Dir District, North West Frontier Province, Pakistan. Geological Survey of Pakistan, Information Release 123, 8p.

Key words: Landslides, hazards, Dir.

R/46. Rahman, F., Khan, A. & Din, W., 1983. Regional geology of the Karak District, North West Frontier Province. Geological Survey of Pakistan, Information Release 131, 25p.

Key words: Geology, mapping, stratigraphy, Karak, NWFP.

R/47. Rahman, H., 1962. Stratigraphic Code of Pakistan: 2nd edition. GSP, Memoir 4(1), 8p.

Key words: Stratigraphic code, Pakistan.

R/48. Rahman, H., 1963. Geology of petroleum in Pakistan. 5th World Petroleum Congress, Frankfurt, Section 1, Paper 31, PD-3, 653-683.

Key words: Geology, hydrocarbon, petroleum, Pakistan.

R/49. Rahman, H. & Dunkle, D.H., 1961. A review of fuel resources. Natural Resources 1(1), 43-46.

Key words: Hydrocarbon, fuel, Pakistan.

R/50. Rahman, H. & Dunkle, D.H., 1966. On marine fishes from the Eocene of West Pakistan. USGS/GSP, (IR) PK-30, 8p.

Preliminary announcement of the discovery of marine Eocene fishes from the Zinda Pir Anticline, Dera Ghazi Khan District, west Pakistan, is made with discussion of the stratigraphic setting of their occurrence in the foreshore basin of the Tethyan Geosyncline, summarization of conflicting opinion as to the lower or middle Eocene age of the horizon and the current and future importance of their systematic and ecologic implications relative to local and regional geologic interpretation.
Key words: Palaeontology, marine fish, Eocene.

R/51. Rahman, H., Khan, M.Y., Hussain, F. & Ahmad, H., 1966. Fuel Map of Pakistan.

Key words: Energy, fuel, maps.

R/52. Rahman, M.A., 1979. Geology, mineralogy and genesis of uranium mineralization in Mauji-Reshian areas, Azad Kashmir, Pakistan. M.Sc. Thesis, University of Aberdeen.

Key words: Mineralogy, uranium mineralization, Azad Kashmir.

R/53. Rahman, M.A., 1980a. Betafite in carbonatite from Khyber Agency, North West Frontier Province. Pakistan Journal of Scientific and Industrial Research 32, 5-8.

Key words: Betafite, carbonatite, Khyber agency.

R/54. Rahman, M.A., 1980b. Electron probe data on brannerite and xenotime from District Muzaffarabad, Azad Kashmir. Contributions to Geology of Pakistan 1, 45-52.

Uranium mineralization hosted in the graphite schists of the Salkhala Series at Mauji-Reshian area in District Muzaffarabad Azad Kashmir indicated the presence of two sub-microscopic size mineral phases. These mineral phases were analyzed by mean of the electron probe microanalysis and identified as brannerite essentially a uranium titanium oxide and xenotime yitrium phosphorous oxide with thorium. Chemical data by the EPM on these minerals is provided and the results are discussed. The presence of the brannerite and xenotime in the graphite schists of the black shale origin is reported for the first time.
Key words: Mineral chemistry, microprobe data, Azad Kashmir.

R/55. Rahman, M.A., 1981. Uranium-thorium mineralization in some granitic bodies of the Parachinar area, NWFP, Pakistan. Geological Bulletin, Punjab University 16, 23-36.

A uranium-thorium mineralization distributed in some granite gneiss and pegmatite bodies occurs in the Parachinar area, N. W. F. P. Laboratory investigations involving petrography, autoradiography, minerography and chemical analyses were conducted on sixteen selected rock samples from the area. The result indicated that allanite and radioactive epidote, present as accessory constituents of the granitic bodies, were the sources for both uranium and thorium. Another notable mineral was uraniferous limonite, which was present as secondary uranium enrichment, depending upon mobility of uranium and iron during weathering process. The study suggests that the mineralization is present in the form of discretely disseminated grains of allanite and radioactive epidote as well as uraniferous limonite in minor amounts.
Key words: Radioactive minerals, uranium, granite, Parachinar, NWFP.

R/56. Rahman, M.A., 1984. Mineralogy and genesis of uranium and associated metallic mineralization in graphite schists, District Muzaffarabad, Azad Kashmir. Abstracts, First Geological Congress, Lahore, 65-66.

The graphite schist belonging to the Salkhala Formation of Precambrian age is widely distributed in District Muzaffarabad, Azad Kashmir. Geological and mineralogical studies conducted on the graphite schist in the Mauji-Reshian area has indicated the presence of uranium mineralization associated with pyrite, graphite, rutile, chalcopyrite, marcasite, covellite, tetrahedrite and galena. Goethite is present as a secondary mineral.
Laboratory studies involving fission track radiography, autoradiography, mineragraphy, electron probe microanalysis and neutron activation analysis has indicated the presence of uranium and thorium as brannerite and xenotime respectively, as disseminated phases together with secondary uranium concentration in the fracture-filled geothite veins as well as graphite schist breccia.
The ubiquitous association of uranium and pyrite and the higher carbonaceous content of the graphite schist suggest an uraniferous black shale origin for the mineralization. Brannèrite and xenotime show detrital character and were probably deposited in the black shale sediments. Secondary uranium is probably derived from organ-uranium complexes which occur in the graphite schist below the zone of oxidation.
Key words: Mineralogy, metallic minerals, graphite schist, Salkhalas, Muzaffarabad.

R/57. Rahman, M.A., 1991. Uranium minerals from Pakistan: A review. Acta Mineralogica Pakistanica 5, 99-108.

In Pakistan, at least fourteen U-Th-bearing minerals species occur widely distributed in sandstone, granite, pegmatite, carbonatite and graphite schist rocks. The primary minerals are mainly associated with the acid

intrusives, carbonatites and graphite schists showing the disseminated type of occurrence. Invariably, the mineralizations are associated with minor concentration of uraniferous Limonite due to oxidation by weathering. Secondary U mineralization indicates wider distribution and is mainly associated with the fluviatile sandstone of Upper Miocene age. The nature of U-mineralizations and their petrogenetic significance are discussed.
Key words: Radioactive minerals, uranium, Pakistan.

R/58. Rahman, M.A. & Chowdhury, N.A., 1971. A note on magnetic survey for Iron Ore near Malakand Agency, Pakistan. GSP, Information Release 42, Rep. 3.

Key words: Iron ore, geophysics, magnetic survey, Malakand.

R/59. Rahman, M.A. & Chaudhry, M.N., 1981. Geology and petrography of metamorphic rocks in Mauji and Reshian areas, District Muzaffarabad, Azad Kashmir. Geological Bulletin, University of Peshawar 14, 123-139.

Geological mapping was conducted in 13-km2 area in Mauji and Reshian, District Muzaffarabad, Azad Kashmir. The work has involved detailed petrographic studies. Metasedimentary rocks in the Mauji-Reshian area consist of graphite, pelite and arenaceous schists with minor gypsum and calcareous bands belonging to the Salkhalas. These rocks are intruded by biotite granite gneiss and numerous dolerite dykes. The metasediments have been metamorphosed under the greenschist facies conditions. An almandine garnet schist has developed probably in the aureole around the biotite granite gneiss.
The mineralogical assemblage of the schist together with the presence of gypsum and calcareous bands in the area is indicative of flysch type deposits as a result of sedimentation under shallow water marine conditions. The graphite schist is characterized by extremely fine grained quartz averaging 50 μm in size, abundant carbonaceous material and ubiquitous presence of pyrite suggesting a black shale origin for these rocks.
Key words: Petrography, metamorphism, black shale, Salkhalas, Azad Kashmir.

R/60. Rahman, S., 1990-91. Structure, stratigraphy, micropaleontology and petrography of the western limb of the Hazara-Kashmir Syntaxis, Abbottabad and Manglaur areas, Northern Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 144p.

The Abbottabad and Manglaur area lies along the western extremity of the
Hazara-Kashmir syntaxis. The area has been divided into two zones on the basis of structure and stratigraphy. Because the rocks of the blocks belong to different stratigraphic provinces and have become in contact with each other tectonically. These zones are Garhi Habibullah-Abbottabad (east of Panjal thrust) and Mansehra zone (west of Panjal thrust).
Rocks east of Panjal thrust in the area consist predominantly of Precambrian to Paleocene sedimentary and very low-grade metasedimentary rock units (Hazara Formation) that represents the first deformation and metamorphism in the Hazara area. Whereas, in west of Panjal thrust, the area consists of Cambrian granite gneisses and very low to low-grade metasedimentary (Tanol Formation) that represent D2 deformation and metamorphism associated with the Himalayan deformation phases. The grade of metamorphism varies from chlorite-grade in the south to biotite-grade in the north. The Mansehra zone is intruded by the Permian Panjal mafic dykes and sills of dolerite and basalts. These dolerite and basalts are mostly fresh. The sedimentary, metamorphic and intrusive igneous rocks of these zones are classified and characterized by petrographic studies. The stratigraphy of the area has been developed in which the Abbottabad group has been divided into three formations which are Sobrah, Kakul and Sirban formations. The redivision was marked by an unconformity between Sangargali and Mahmdagali of the Sobrah and Kakul formations.
The rocks have undergone at least three phases of deformation (D1, D2 & D3) and have been metamorphosed to greenschist facies. The first deformation D1 took place as a result of Hazaran orogeny and produced first fabric (S1) in the Hazara Formation which is generally parallel or slightly oblique to the original lithologic layering S0. D2 is associated thrusting and folding phase. Himalayan orogeny folded S1 into open and closed F2 folds that range in size from small kink bands to larger map scale folds. It caused development of penetrative S2 foliation axial planar

to F2 folds. D3 deformation phase associated with the formation of Hazara-Kashmir syntaxis and formed F3 cross folds.
Key words: Structure, stratigraphy, petrography, Hazara-Kashmir Syntaxis, Abbottabad.

R/61. Rahmanullah, Ahmad, I. & Khan, K., 1999. Petrography of uraniferous quartzo-feldspathic veins and their wall rock from Marghazar, Lower Swat, Pakistan. M.Sc. Thesis, University of Peshawar, 71p.

The Lower Swat area consists of the Cambrian-Ordovician Swat granite gneisses that have intruded the metasedimentary rocks of the Precambrian Manglaur Formation and are overlain unconformably by the Paleozoic-Mesozoic metasedimentary rocks of the Alpurai group. The Swat gneisses contain minor amounts of younger tourmaline granite gneiss particularly at their margins. Besides locally (e.g. in the Marghazar area) the Swat gneisses host several quartzo-feldspathic vein systems, some of which are associated with radioactive element(s) mineralization.
The Swat gneisses are mostly medium-grained xenoblastic and almost equigranular. However at places they display a porphyroblastic augen-flaser texture. They consist of a variety of minerals. These in the order of decreasing abundance include quartz, alkali feldspar, plagioclase, muscovite, biotite, tourmaline, garnet, apatite, zircon and epidot. The metasedimentary rocks that are in contact with the Swat granite gneiss in the Marghazar area and elsewhere in Lower Swat belong to the Marghazar Formation - the lower most unit of the Alpurai group. They are fine- to medium grained xenoblastic and almost equigranular. They consist of quartz muscovite, biotite. Tourmaline, alkali feldspar and iron ore. They show well-developed schistosity due to the preferred orientation of muscovite, biotite and tourmaline. The radioactive quartzo-feldspathic veins are mostly medium-grained, xenoblastic to hypidioblastic and almost equigranular. They consist of distinct layers, which are alternately dominated by quartz and feldspar. With the exception of the radioactive minerals, the mineralogical composition of the vein systems is almost similar to that of the wall rock. In the order of decreasing abundance, the vein minerals include quartz, alkali feldspar, plagioclase, radioactive minerals, Iron ore, epidote, muscovite, biotite and tourmaline. The vein systems are associated with typical wall rock alteration phenomena that include kaolinitization, chloritization and epidotization. Reflected light study reveals that the radioactive minerals in the vein systems consist of pitchblende uraninite and allanite.
Field observations and mineralogical and textural characteristics suggest that the vein systems and their associated radioactive element mineralization resulted from a hydrothermal activity. The preferred orientation displayed by the vein minerals themselves indicates that the hydrothermal activity took place during a major phase of deformation and as such the veins are syntectonic in origin. The source of the hydrothermal solutions which formed the vein systems and their associated mineralization seems to be the relatively young syntectonic tourmaline granite that occurs at the margins of the Swat granite gneisses.
Key words: Petrography, uraniferous veins, granite gneisses, Swat.

R/62. Rahmatullah, & Naser, Z.J., 1985. Geology, petrography and microfacies of Lumshiwal Formation Kalachitta Range, Nizampur N.W.F.P. M.Sc. Thesis, University of Peshawar, 156p.

Key words: Petrography, microfacies, Lumshiwal Formation, Kalachitta, Nizampur, NWFP.

R/63. Raja, M.A.K., 1985-87. The geology and petrography of volcanic and carbonate rocks of upper Haveli (District Bagh) & Balgiran-Manjhoter District Muzaffarabad with special emphasis on Dara marble. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 110p.

The project area covers about 417 square kilometers located in District Bagh and Muzaffarabad, Azad Kashmir. The work has involved geological mapping of the area on a scale of 1:25,000 and 1:15,000 respectively. This thesis deals with the geology and petrography of Panjal Volcanics and carbonate rocks of the area. The geological sequence of the area consists of sedimentary, volcanics and metamorphic rocks. Lithologically metamorphic rocks present in the area are Schist, Slates, Phyllites, Quartzite and marble while sedimentary rocks comprise Sand stone, shales, silt stone, lime stone. Volcanic rocks belong to two distinct ages. Dogra trap are of Precambrian age and occur with in

the Dogra Slates. Panjal volcanics or Panjal trap flows are of Upper Carboniferous age and basaltic to andesitic in composition, while mineralogical studies of Dogra trap shows that they are of basaltic composition. Petrographic analysis of Panjal volcanics, Agglomeratic slates, limestone and marble have been carried out. The mineral assemblage in volcanics is plagioclase + chlorite + epidote+ Quartz + Calcite, while of agglomeratic slates is Quartz + epidote + chlorite + Calcite + plagioclase the mineralogical assemblage of lime stone and marble is calcite + quartz + muscovite + magnetite. Pb-Zn mineralization in carbonate rocks of Khetar-Treri areas has been interpreted. The evidences are strongly supporting that Pb-Zn mineralization is the result of hydrothermal solution. Petrogenesis of Panjal Volcanics has been carried out. The evidences reveal shallow water or submarine origin of the Panjal Volcanics. Tectonically the area is highly disturbed, being involved in Himalayan orogeny.
Key words: Geology, petrography, volcanics, carbonate rocks, marbles, Muzaffarabad.

R/64. Raja, M.K., 1981-83. Geology and petrology of Lower Yasin Valley, Gilgit Agency. M.Sc. Thesis, Punjab University, Lahore, 85p.

The project, area lies in central Punial area, adjoining to Yasin Valley, Gilgit Agency. The area is located in Karakoram Mountains. Area is intensely disturbed tectonically being involved in Himalayan orogeny. Evidence is provided by crushing and strained effect on minerals. Project area is composed mainly of igneous rocks and metasedimentary rocks. These different rock units are shown on map which was previously prepared by enlargement of toposheet. The major units in the project area are granite, diorite, amphibolite and paragniesse.
Special emphasis was given to the mineralogical description and petrographic analysis of the rock units and is reported in detail. The petrogenesis of these rock units have been discussed as well.
Granite is considered to be a part of Karakoram axial granite, which is emplaced as a partially fused and mobile mass rich in alkali feldspar during synthetic phase of orogeny. Diorite is probably tholeiitic basaltic magma injection. Granodiorite produced during differentiation with decrease of calcic contents. Green stone is metamorphic product of basic igneous rocks. Extensive glaciations of quaternary period is evident and glacial deposits are found commonly. The economic mineral potential of the project area is also discussed.
Key words: Geology, petrology, Yasin valley, Gilgit.

R/65. Raja, M.K.K., 1986. Petrography of Metasedimentary Rocks of Barian-Kundul Shahi area, Neelum valley, Azad Kashmir, Pakistan. Acta Mineralogica Pakistanica 2, 158-160.

A detailed petrography of pelitic-psammitic rocks of 20-km^2 area with modal analyses of 16 thin sections is presented. These metasediments include schists of the Salkhala Formation, metamorphosed under greenschist facies to epidote-almandine subfacies conditions. The details of index minerals are given.
Key words: Petrography, metasedimentary rocks, Neelum valley, Azad Kashmir.

R/66. Raja, M.K.K., 1987a. General Geology and Petrography of Chham-Traran area, Jhelum valley, Azad Kashmir. Abstract with Programs, Mineral Resources and Geology of Pakistan.

For details consult the following account.
Key words: Geology, petrography, Jhelum valley, Azad Kashmir.

R/67. Raja, M.K.K., 1987b. General Geology and Petrography of Chham-Traran area, Jhelum valley, Azad Kashmir. Acta Mineralogica Pakistanica 3, 116-122.

A geological map of the Chham Traran area, Jhelum Valley is prepared at a scale of 1:50,000 and a detailed description of various rocks units is presented. Pelitic to psammitic, calcareous and carbonaceous rock sequence of the Salkhala Formation is intruded by a body of granite gneiss. The Panjal Formation (volcanics) is thrusted over Precambrian Salkhala Formation and over ridden by the Upper Tertiary Murree Formation. Petrography and mineral assemblages of the Salkhala Formation resemble those of low-grade metamorphites. Presence of gypsum bands in the Panjal Formation is of volcanic nature. Economic Geology of the area is also outlined.
Key words: Geology, petrography, Jhelum valley, Azad Kashmir.

R/68. Rampini, L., 1991. Topographical report. In: Geodesy, Geophysics and Geology of the Upper Shaksgam Valley (North East Karakoram) and South Sinkiang. Scientific Report of the Italian Expedition to Karakoram 1988 (A. Desio leader). Consiglio Nazionale delle Ricerche-Milano, 93-98.

Key words: Geodesy, geophysics, Karakoram, Sinkiang.

R/69. Ramsay, J.G., F.R.S. 1987. The syntaxes of the western Himalayas. Tectonic Evolution of the Himalayas and Tibet. The Royal society Special meeting.

Syntaxial bends are regions where the overall structural trends of fold axes and fault traces make marked regional changes in directions. In the western Himalayas, several such re-entrants are known and in the two major bends of the Hazara and Nanga Parbat syntaxes the structural trends of folds and major suture lines change direction through angles of 180^0. Although these syntaxes occur at differing tectonic levels both show overall features of elongated domes or partial domes, and new data suggest that there may be aphysical and temporal connection between them.
Several mechanisms have been invoked for forming syntaxial bends: (1) geometric interference within cover structures produced during two separate orogenies or two phases within a single orogeny; (2) reactivation of pre-existing basement structures (folds or faults) during a later orogenic compression; (3) development of complex ramp-flat geometry during the formation of major thrust sheets, especially, that resulting from the formation of oblique-ramps or sidewall-ramps; and (4) differential displacement advance within thrust sheets perhaps associated with partial pinning in or around syntaxial zones.
In the Hazara syntaxis the geometric features of the large-scale structure and small-scale features of folds, cleavage, lineation, and vein systems support the evolution of this syntaxis by progressive change in the regional shortening directions from NE-SW, through N-S and finally to NW-SE directed contractions. The structural features of the Nanga Parbat syntaxis also suggest a complex polyphase movement history with the principal syntaxial form arising relatively late during the regional deformation sequences perhaps as a result of sinistral movement on a deep-seated shear zone.
Key words: Structure, Hazara, Nanga Parbat, Himalaya.

R/70. Ranjha, Z.U., 1993-94. Economic geology and petrology of graphite and other minerals in Naran-Pauldaran Area, middle northern Kaghan valley, District Mansehra. M.Sc. Thesis, Punjab University, Lahore, 90p.

Key words: Economic geology, petrology, graphite, Kaghan valley, Mansehra.

R/71. Rao, S.R.N., 1941. An algal flora from the Lockhart limestone (Ranikot Series) of the Samana Range (NW India). Mysor University Journal 2(7), 41-53.

Lockhart limestone is the name given by Lt.-Col. L. M. Davies to a compact, massive, grey limestone of some 200 feet in thickness, occurring in the region of Fort Lockhart on the Samana Range between Kohat and Thal. The Samana series as worked out by him consists of 12 beds; beds 8-12 (uppermost members of the sequence) are of Ranikot age, while the base of the series (bed 1) extends down to the Jurassic (or even the Triassic). The Lockhart limestone (bed 10) represents the uppermost portion of the Lower Ranikot and the lower portion of the Upper Ranikot.
Key words: Stratigraphy, Lockhart limestone, Ranikot, Jurassic, Samana Range, Hangu.

R/72. Rasheed, A., 1992-94. Geology of Sirgh area and sedimentary petrology of Kuldana Formation of Darya Gali, South Hazara, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 143p.

A comprehensive study of geology and structure of the area around Dhamtaur & Sirgah is presented along with a special section on the sedimentology of Kuldana Formation. Large scale (1: 10000) geological mapping of the area is, presented. The lithostratigraphic unit ranges from Precambrian to Eocene. Hazara Formation and Patala Formation being the oldest and youngest units respectively. Structurally the area comprises NE-SW trending double plunging folds constituting anticlinoria and synclinoria. The folds in general are cylindrical with a general vergance to the southeast. The folded sequence is disturbed mainly by reverse faults. A small number of normal faults also exist. Faulting is dip slip to oblique slip and in general involves a maximum displacement of few hundred meters. Apart from the regular faults decoupling is frequently noted at the formational boundaries 1eading to the slip and discontinuity of thin marker horizons. The lower Eocene Kuldana Formation is mainly composed of variegated Series of marl siltstone arenaceous mudstone and limestone. The siltstone horizons are rare but intercalation of sandstone may be found in places. The mudstone as well as calcareous mudstone are generally unfossiliferous. The conditions of deposition vary widely from subtidal to intertidal and supersubtidal. The red beds are either continental or supertidal. Alternately they may have derived their colour by diagenetic processes.
Key words: Petrology, Kuldana Formation, Hazara.

R/73. Rasheed, S., 1993-94. Geology and structure of Barian Area, Hazara, North West Himalayas and petrography of the Early Cretaceous Lumshiwal Formation. M.Sc. Thesis, Punjab University, Lahore, 136p.

Key words: Structure, petrography, Lumshiwal Formation, Hazara, Himalaya.

R/74. Rashid, A., 1984-85. The geology of Reshian-Nauseri area with special emphasis on petrology of granite & economic mineral deposits. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 171p.

The project area covers about 307 square kilometers, located between Reshian and Jura to the ESE and NE of Muzaffarabad, Azad Kashmir. The work has involved geological mapping of the area on a scale of 1:25,000. In this thesis an attempt has been made to introduce the detailed geology of the area. Bulk geological sequence of the area consists of sedimentary, volcanic, metamorphic and granitic rocks. The area is tectonically, highly disturbed being involved in Himalayan orogeny. For Petrographic analysis sixty thin sections were studied microscopically. Petrogenesis of the rocks particularly that of Jura and Reshian granites are interpreted. Tectonic setting and stratigraphy of the area are described briefly. Major and minor structures of the area are described with the help of figures and maps. Economic rocks and minerals found in the have been described in detail to some extent.
Key words: Petrology, granite, economic minerals, Azad Kashmir.

R/75. Rashid, A., 1990. Lateral and vertical building of sandstone bodies near Bori, Shakardara, District Kohat, N.W.F.P. M.Sc. Thesis, University of Peshawar, 63p.

Key words: Sandstone, Shakardara, Kohat.

R/76. Rashid, C.M., Afzal, P.A. & Majid, A.A., 1997. Uranium potential of the Potwar Plateau. Abstracts, National Symposium on Economic Geology of Pakistan, Islamabad, 2p.

Present studies are aimed at decisively evaluating middle Siwaliks (MS) of Potwar region for its uranium potential through geological modeling based upon the AEMC previous work and work of other professional organizations. Numerous radioactive anomalies and availability of sufficient geological data on this region helped to achieve the desired results. Out of comprehensive platform studies only uranium mineralization part is being discussed.
The Potwar Plateau has been divided into four subregions i.e. Northwest (NW). Southwest (SW). Northeast (NE) and Southeast (SE) PP. 8] out of total 127 radioactive occurrences scattered all over the PP were sub to detailed studies. The time-space distribution of anomalous sandstone horizons (ASH). Stratigraphic levels of host rock i.e. lower, middle and upper within this formation, radioactive zones, primary/secondary uranium mineralization and controls of radioactivity were geologically and statistically analyzed.

The radioactive occurrence are clustered in 17 anomalous zones considered as representative, at least partly, of some, above regional clark, uranium remobilization. The anomalous zones have been further sub-divided in 8 first rate and 9 second rate, on the basis of their geological environment and to the density, zone, uranium return and controls there anomalies. Conclusion based upon the syntheses and interpretation of data are as follow:
On regional basis, six (sub) units may be singled out as displaying a much better load in first rate anomalous zones. Time wise, the DPF on a formation basis and the lower NF, then the middle DPF, on a member basis. Space wise, the WPP, more specially its SE corner (lower NF and middle DPF), central part (middle DPF) and NW corner (upper NF and upper DPF).
Key words: Economic geology, uranium, Potwar plateau.

R/77. Rashid, C.M., Afzal, P.A. & Majid, A.A., 1998. Multistage role of tectonic deformation on uranium mineralization in the neogene fluviatile middle Siwaliks of the Potwar Plateau, Pakistan. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 165-166.

The evolution of uranium mineralization in the middle Siwalik (Nagri and Dhok Pathan Formations) of the Potwar Plateau is characterized by syn to post tectonic sedimentary deformation through space/time. This indicates a sequence of regional events, providing channel ways and media for remobilization and uranium trapping with some reductants or along permeability/ porosity barriers.
The syndiagenetic traps are mainly tectonically induced and associated in space i.e., on the lesser slopping, down thrown side of stream checking and reactivated basement faults. The post middle Siwaliks tectonic deformation caused Uranium epigenetic remobilization and its down dip concentration. It is enhanced to increasing of slope and or/ oxidation i.e., on the upthrown side of stream checking faults, water table checking lineaments.
Detailed analysis of different tectonic elements and their chronology and uranium favourability criteria (availability, remobilization and trapping) in each tectonic regions of the Potwar Plateau (PP) has been carriedout. Some interesting correlation parameters have been revealed after studying the impact of the tectonic setting on the uranium mineralization. All the 81 uranium anomalies in the middle Siwalik are grouped into 8 first rate and nine second rate anomalous zones: depending upon extent, nature and controls of radioactivity/mineralization. All the four tectonic regions of the PP i.e. North Potwar Deformed Zone (NPDZ), South Western Potwar Plateau (SWPP), East Potwar Plateau (EPP) and South East Potwar Plateau Comer (SEPP Corner), show different tectonic controls of individual anomalies as well as anomalous zones. In NPDZ the anomalous zones are controlled by minor NW-SE faults and the tight synclinal structures. In the SWPP, the control of uranium is down faulted blocks and incipient gentle folds. In EPP and SEPP comer the anomalous zones are located along W-E to NE-SW thrust faults, mainly on the northern flank of anticlinal structures.
Distribution pattern of uranium occurrences and their relationship with tectonic features (ductile and brittle) indicate western Potwar Plateau comparatively more favourable than the eastern Potwar Plateau. In SWPP appear to be the most favourable area for uranium exploration due to good source (synsedimentary arial volcanism), syn to digenetic remobilization/trapping evidences in the central western Potwar along down faulted blocks and incipient gentle folds as well as epigenetic post tectonic remobilization/trapping along Salt Range Thrust (Fig. 2).
There are six large-scale tectonic units in the SWPP namely:
Either NE trending, north to south; Lower Soan trough, Tamman ridge, Dhok Mosahib Wala trough to the NE and Chakarala basin to the SW (a composite unit most likely subdivided by secondary ridges and troughs), Western Salt Range. Or NW-trending; from west to east; Southern Kalabagh Salt Ranges, Pachnand ridge (rather subdued, but partly closing and possibly offsetting the Dhok Mosahib Wala trough and Chakarala basin).
Moreover the matallotects might be further enhanced by the possible remobilization or trapping action of oil drived products migrating upwards through deep seated active faults from known underlying oil reservoirs and source rocks through release of C02, H2S etc. in the underground waters. Evidences of such migrations upwards have been noted nearby majority of significant anomalous zones located over or close to known oil structures i.e., Jand (Dakhni oil field), Pindigheb (Dhulian), Khaur (Khaur), Tamman Talagang (Kot Sarang), Joyamair (Joyamair), Adhi (Adhi), Dina (Lehri gasfield), Chakarala (Dadhumber oil structure), Dhok Masahi Wala (Dhermud) producing or now barren.
At anomalies level, PanaKhel anomalous sandstone horizon Jand in Upper Nagri Formation indicates genetic relationship with hydrocarbon derived reducing fluids. Oil products contribution is also visible in the form of solid bitumen collected around the Nikki anomaly (Chakarala). It is first clue on the migration of oil products as far as the lower DPF.

Key words: Tectonics, deformation, uranium mineralization, Dhok Patan Formation, Nagri Formation, Siwaliks, Potwar.

R/78. Rashid, M.A., Hussain, M., Master, J.M. & Meissner, C.R., 1965. Mineral deposits of eastern Kohat region, West Pakistan. GSP Records 13(2), 16p.

Key words: Mineral deposits, Kohat.

R/79. Rashid, M.A. & Khan, A.L., 1991. Bed rock aggregate resources of the Attock District, Punjab, Pakistan. GSP, Information Release 409.

Reserve evaluation of selected bed rock aggregate resources of the area comprising Fateh Jang (43 C/10) and Kot Fateh Khan (43 C/11) quadrangles of Attock District in the Punjab Province, is presented.
Limestone and sandstone are the two rock types considered for evaluation. Vast reserves of alluvial clay, commonly used for pottery and brick making, sand and gravel, available in the area but outside the scope of the present work, have not been considered for estimation.
Limestone aggregate resources of the Jurassic Samana Suk, Paleocene Lockhart Limestone and Eocene Margala Hill Limestone Formations exposed in the area, have been estimated as 1734 million tonnes.
Sandstone aggregate resources of the Murree and Kamalial Formations of Miocene age, exposed in the area, have been estimated as 1266 million tonnes.
Key words: Aggregate resources, sandstone, limestone, Attock.

R/80. Rashid, S., 1993-95. Electrical resistivity survey for ground water exploration in Zulmkote Area, District Malakand, NWFP, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 110p.

Key words: Geophysics, electrical resistivity, groundwater, Swat.

R/81. Rashid, S., 1994-96. Geology and structure of Barian Area, Hazara, NW Himalayas and Petrography of the Early Cretaceous Lumshiwal Formation. M.Sc. Thesis, Punjab University, Lahore, 124p.

It is the study of Geology and Structure of the Barian area (50 km2) along with a special microfacies study of the Early Cretaceous Formation from Kalas. A large-scale geologic map of the Barian area at (1:10,000) is presented. The area comprised sedimentary rocks from Middle Jurassic to Early Miocene age, tectonically forming a part of the lesser Himalayan sequence in the Galiat area, Hazara. The paleogene and older sequence is mainly limestone and shales of shallow massive shelf faces. The overlying Neogene rocks are gypsiferous marls. Limestone and shale supratidal to Sabkha facies in the lower sandstone, shale continental molasse of Murree Formation in the upper part. Structurally the area comprised NE-SW trending cylindrical to double plunging folds constituting anticlinoria and synclinora. The folded sequence is disturbed by numerous reverse faults. However, small number of normal faults also exist. Faults are either dip slip or oblique slip and except for the MBT, involves a maximum displacement of few hundred meters.
MBT is the major tectonic discontinuity of regional significance. At Darya Gali the thrust is a high angle feature dipping to the northwest with opposing dips in the rocks on the two sides. The surface expression of the MBT is accompanied by a fault-related escarpment and much degradation, accompanied by landsliding.
The Kalas section of Lumshiwal Formation comprises six facies and sixteen microfacies. The sandstone is predominantly medium grained and only four microfacies are fine grained. Quartz, carbonate and glauconite are the common cements while iron oxides and clay occur as subordinate cements. At Kalas presence of ooids in the lower part of Lumshiwal Formation indicates shallowing of basin and high-energy environment while glauconite in the upper part indicates reducing subtidal environment.
Key words: Structure, microfacies, petrography, Hazara, Himalaya.

R/82. Rashid, S., Ahmed, S. & Sheikh, M.I., 2001. Natural resources of Islamabad-Rawalpindi northern Punjab, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.47.

Islamabad, the capital of Pakistan is a planned city constructed since about 1960 at the foot of Margala hills just north of the old city of Rawalpindi. The limestone gravel, sand and clay are the most important material resources of Islamabad, which have been utilized as construction material resources. These are limestone/gravel for cement, aggregate for concrete, sand for mortar and clay for bricks and pottery. Huge reserves of these items (limestone, gravel, sand, aggregate and clay) are qualitatively and quantitatively present which can fulfil the demands of constructing materials with rapid increase of population of Islamabad/Rawalpindi Metropolitan area. Abandoned pits of gravels, sand and clay can be reclaimed for recreation parks, reserved forest, waste disposal and agriculture use.
Key words: Natural resources, Rawalpindi, Islamabad.

R/83. Rashid, S., Din, A. & Arif, M.R., 1964. Study of heavy minerals of Pakistani sands. Pakistan Journal of Scientific and Industrial Research 43?, p.16.

Key words: Heavy minerals.

R/84. Rashid, S., Khan, A.Q. & Asghar, K., 2000. Hydrological studies and groundwater potential of Islamabad region. Abstracts, Third South Asia Geological Congress, Lahore, 158-159.

Islamabad is the capital city of Pakistan situated between latitude 33" 29' and 33°-49' N and longitude 72°-50’ to 72°-24' E bordered by Rawalpindi city in the South and Southeast, Margalla hills in the North and Murree Hills in the Northeast. Climatically the area lies in sub-humid region. Annual average rainfall is about 925 mm. Temperature ranges between 3° to 40 °C. Access to city is through Grand Trunk road and Motorway, connected with Peshawar and Lahore. The area is generally an uneven landform covered with alluvial deposits and bedrock outcrops of Miocene Rawalpindi Group (Murree Formation) skirted by Eocene Margalla Hill limestone in the North. The northern mountainous area rises abruptly and appears as Himalayan foothill extension. The area is drained by many perennial streams out of which Korang river, Gumrah Kas, Kantiwali Kas, Tanawala Kas, Bedarwali Kas and Lei Nala are the major constituents of drainage system. During rainy season the velocity of water is very fast in these hill torrents due to high relief and slope of the area.
Hydrogeologically, the area lies in Soan River catchment basin in Potwar Plateau formed as part of Indo-Gangetic synclinorium of Tertiary and Pre-Tertiary sediments, Consolidated and unconsolidated deposits exposed in the area are of sedimentary origin and belong to Eocene to Recent in age. The consolidated deposits are mainly composed of limestone, sandstone, clay, shale and conglomerates. These deposits do not serve as aquifer and water travels through joints, cracks and fissures only. Unconsolidated deposits of recent age are found as terrace graveland alluvial fill.
Groundwater in Islamabad area occurs in alluvial deposits and hardrock deposits. The transmitting capacity of consolidated deposits is very low. Therefore, it can be considered only for small yields for requirements at the places of acute local shortage of water availability. Nevertheless alluvial aquifers are suitable for large scale groundwater development.
In order to locate the sites feasible for exploitation of groundwater, hydrogeological and geophysical surveys were carried out in 1979-80 referred to Hydrogeology Directorate, WAPDA by Capital Development Authority to overcome the acute shortage of drinking water in the capital city. The work was conducted to locate prospective sites by spot investigation in different sectors selected on priority bases fixed by Capital Development Authority.
The work was completed in two phases, phase-I included sectors F-10, F-11, G-9, G-10, G11, H-9 and National Park area and phase-II covered sectors F-8 and 1-9. Based on the findings of reconnaissance and geophysical survey test drilling and water sampling from various subsurface horizons at 21 locations were carried out. An aquifer test was also conducted to determine the aquifer parameters. Groundwater samples collected during survey and test drilling were got analyzed from WAPDA laboratory. The groundwater quality is good and suitable for drinking, agriculture and other domestic uses. Findings of these studies are summarized in this paper.
Key words: Hydrology, groundwater, Islamabad.

R/85. Rashid, S., Malik, M.H. & Khan, M.S., 2000. Elaboration of aquifer system and its application for protection of groundwater contamination in the Dhamrah Kas Basin, Wah Cantt. Pakistan. Abstracts, Third South Asia Geological Congress, Lahore, p.161.

Interdisciplinary investigational techniques 1 (hydrogeological reconnaissance, Geophysical survey, Testhole drilling, installation of tubewells and capacity tests) were used for the interpretation of subsurface hydrogeology of the Dhamrah Kas Basin. A multilayered acquifer system spread over an area of about 150 Sq. Km was proved with the help of 20 test holes and 10 dug wells extending to a depth of 300 to 600 feet. The acquifer is classified as multilayered semiconfined fresh body with an average well capacity of 250-350 gallons. The shallow aquifer (A-Layer) is in severe danger of contamination near northern boundary of the basin through induced recharge from a polluted nullah. The bacterial contamination Coliform Faecal Coliform) has polluted shallow aquifer very severely. Treatment and protectional measures are discussed, particularly for elimination of physical and bacterial pollution.
Key words: Acquifer, groundwater, Wah cantt, Attock.

R/86. Rashid, T., 1974-76. Lithostructure mapping and geology of Nilt Area, Hunza Valley, Gilgit. M.Sc. Thesis, Punjab University, Lahore, 79p.

Key words: Lithostructure, mapping, Hunza.

R/87. Rathur, A.Q., 1959. Salt Range, Potwar, Quetta, Hazara and Swat. M.Sc. Thesis, Punjab University, Lahore.

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

R/88. Rathur, A.Q., 1980. Occurrence of fossil Charophyta in Samana Suk Formation, Jurassic, Chichali Nala, Surghar Range, and their stratigraphic significance. Contributions to the Geology of Pakistan 1, 27-44.

Five species assigned to four genera of fructifications of Charophyta, from the Samana Suk Formation (Callovian), Surghar Range, Pakistan, are described. In one case, Porochara obovate (Peck) comb.nov cdrtain morphological characters have been used for statistical analysis to show its variation. The palaeological and stratigraphical significance of these forms is also discussed.
Key words: Palaeontology, stratigraphy, Samana Suk Formation, Jurassic, Surghar, Trans Indus Salt Range.

R/89. Rauf, A., 1974-76. Geology of Taghma Area, Swat District, NWFP Pakistan. M.Sc. Thesis, Punjab University, Lahore, 79p.

This report presents a geological map on a scale of 4.735 cms to a km (3 inches to a mile) and petrographic account of the rocks of Taghma area, which were previously mapped as a single units (Upper Swat Hornblendic Group of Martin et al. 1962 and Epidote Amphibolites of Jan et al. 1973). The present mapping on a larger scale has permitted the further sub division of the rocks of the area into various types of plutonic rocks, like peridotites, diorites, hornblendites and pegmatites; metamorphosed rocks, like amphibolites and gneisses; and their secondary alteration products such as China clay and serpentinites.
Petrographic description of various rock types have been included, which is based on the study of more than fifty thin sections, selected from two hundred rock samples collected during field work. The mineralogical data presented in this report includes the optical data on certain selected mineral; their micrometeric measurements, refractive indices measured by liquid immersion method, determination of end member composition using 2V and extinction angles. Discussion and conclusions regarding petrogenesis, based on field relations, petrography and mineralogy of various rock units of the area are also given in this report. The structural features of the rocks are also described, based on the three hundred joints and foliation measurements. The foliation and joints orientation diagrams are also included. An account of the economic geology of the area is included, putting more emphasis on that of the china

clay deposits situated inside the Taghma area. Important features of field as well as of thin sections are expressed with the help of photographs.
Key words: Petrography, ultramafics, gabbros, diorite, amphibolites, Swat.

R/90. Ray, D.K., 1976. Geotectonics of Kashmir Himalaya: Karakorum-Hindu Kush-Pamir orogenic belts. Atti dei Convegni Lincei 21, 316p.

Key words: Geotectonics, Hindukush, Karakoram, Himalaya.

R/91. Raynolds, R.G.H., 1980. The Plio-Pleistocene structural and stratigraphic evolution of the eastern Potwar Plateau, Pakistan, Ph.D. Dartmouth College, Hanover, New Hampshire, 265p. 86 fig. 7 tabs, 1 pl.

Key words: Stratigraphy, structure, Pliocene, Pleistocene, Potwar plateau.

R/92. Raynolds, R.G.H., 1981. Did the ancestral Indus flow into the Ganges drainage? Geological Bulletin, University of Peshawar 14, 141-150.

The Late Miocene, Pliocene and Pleistocene Upper Siwalik Group molasse sediments of the eastern Potwar Plateau are shown to include two distinctive sandstone complexes. The older sandstone complex is white colored and carries granitic pebbles. The younger sandstone complex is brown colored and carries quartzite and igneous pebbles. Palaeocurrent measurements together with preliminary provenance analysis suggest that the white sandstones were deposited by and ancestral Indus River which flowed to the east-northeast across the Eastern Potwar Plateau. This river system was replaced between 4.5 – 5.0 MY ago by a southward flowing ancestral Jhelum River. It is possible that the ancestral Indus River may have drained into the Bay of Bengal Rather than into the Arabian Sea.
Key words: Indus River, sandstone, Miocene, Pliocene, Pleistocene, Potwar plateau.

R/93. Raynolds, R.G.H. & Johnson, G.D., 1985. Rate of Neogene depositional and deformational processes, northwestern Himalayan foredeep margin, Pakistan. In: Snelling, N.J. (ed.), The chronology of the geological records. Geological Society, London, Special Publication 10, 297-311.

The dynamics of molasse accumulation and the subsequent structural displacement of a foredeep basin during orogenesis have rarely been chronometrically defined. The Himalayan foothill belt of northern Pakistan and India constitutes a detailed record of molasse sedimentation in a classical foredeep setting. Subsequent deformation of this sedimentary sequence has resulted in the exposure of over 3000 metres of the Neogene and Quaternary aged Siwalik Group. Recently, the development of a magnetic polarity stratigraphy constrained by the fission-track dating of numerous intercalated volcanic ashes has permitted a precise chronostratigraphic statement to be made concerning the accumulation and deformational history of this non-marine sedimentary sequence. Data from numerous localities in northern Pakistan and India document the onset, development, and termination of various events in this sedimentation history with a precision of from ~20000 to ~50000 yrs. Sediment accumulation rates associated with the progressive migration of the foredeep depocentre have been determined to range from -20 to -50 cm/1000 yrs. The southward progradation of lateral facies changes at rates of up to 30 m/1000 yrs together with the southward advance of the basin depocentre at rates of over 20 m/1000 yrs suggest a rough equilibrium between the modelled northward plate motion of the Indian subcontinent and the southward displacement of depositional processes within the foredeep. This illustration of the dynamic involvement of proximal foredeep terraine in the continuing Himalayan orogenesis yields a model potentially useful in similar tectonic settings.
Key words: Stratigraphy, molasses, marine sediments, sedimentation, deformation, Potwar.

R/94. Raynolds, R.G.H., Johnson, G.D., Johnson, N.M. & Opdyke, N.D., 1980. The siwalik molasse: A sedimentary record of orogeny. Geological Bulletin, University of Peshawar 13, 47-50.

The Siwalik molasse basin lies on the southern margin of the Himalayan orogenic belt. Continuously exposed from the Sulaiman Range in western Pakistan to Assam in the eastern India, the Siwalik sediments consist of over 7000 meters of fluvial sediments ranging in age from late Miocene to Pleistocene.
The continuation of the mountain building activity which first uplift the source area to the north, is now responsible for the deformation and hence exposure of these sediments. This deformation characteristically diminishes in intensity southwards from a boundary thrust fault to the undisturbed Indo-Pakistan shield.
The Siwalik sediments have been extensively studied – initially because of their excellent record of late Tertiary mammalian evolution and more recently, because of their record of source area unroofing and changing sedimentary environments.
Key words: Orogeny, sedimentary, molasses, siwaliks.

R/95. Raza, H.A., 1981. Geothermal gradients in Pakistan. Geological Bulletin, Punjab University 16, 71-82.

Hydrocarbons are generated by thermal diagenesis of organic matter. The study of sub-surface temperatures and thermal gradients within the earth, therefore, offers clues for hydrocarbon exploration. Temperature ranges within which particular types of hydrocarbons, for example oil or gas, would form are now well known. Geothermal gradients as determined from bottom hole temperatures recorded during logging operations in 27 wells drilled in Pakistan show that general geothermal gradients in Pakistan are between 1 and 2°F per 100 feet. The gradients are comparatively higher in the south perhaps because of the Cretaceous/Paleocene igneous activity. Oil window i.e. the depth sector having prospects for liquid hydrocarbons, lies at variable depths in different regions but within the depth range 6,000 to 18,000 feet.
Key words: Hydrocarbons, geothermal gradient.

R/96. Raza, H.A., 1984. Estimating the volume of oil and gas resources in Pakistan. Abstracts, First Pakistan Geological Congress, Lahore, 2-3.

There are four standard methods of estimating ultimately recoverable oil and gas: (1) Past Performance extrapolation (2) Volumetric (3) Geologic-Analog (4) Play Analysis. Computer techniques can be combined with these methods to determine probability ranges. The basin area of Pakistan can be divided into a number of petroleum zones on the basis of similarities in producing horizons, types of hydrocarbons and kinds of traps. Some of the aforementioned methods are suggested for these zones to asses the quantity of oil and gas likely to exist in them. The choice of method has been based on the level to exploration in a particular zone.
Key words: Hydrocarbons, Pakistan.

R/97. Raza, H.A., 1986. Evolution of sedimentary basins in Pakistan and their hydrocarbon potential. Abstracts, Symposium/Workshop on Plate Tectonics and Crust of Pakistan. Institute of Geology, Punjab University, Lahore, p.12.

Sedimentary basins of Pakistan evolved as a result of plate interactions that went with the Paleozoic formation of the Pangean superplate and its subsequent fragmentation, Cenozoic collision of the Indian and Eurasian plates and subduction of the Arabian plate under Eurasian plate. The ultimate recoverable hydrocarbon resources of Pakistani basins amount to about 53x109 brl of oil and 143x1012 cubic feet of gas; the Potwar, Sulaiman and Kirthar subbasins are current producers.
Key words: Hydrocarbons, sedimentary basin, plate collision.

R/98. Raza, H.A., 1991. Petroleum source rock in Pakistan. International Petroleum Seminar, Islamabad.

Key words: Hydrocarbons, source rocks, Pakistan.

R/99. Raza, H.A., 1992-93. Plate interactions, basin development and implications for hydrocarbon accumulation in Pakistan. Regional Postgraduate Training Course in Plate Tectonics, Punjab University, 33-34.

Hydrocarbons reside in sedimentary basins which are produced as a consequence of plate interactions. The lithosphere is formed of a network of 13 large plates which converge, diverge or slip-by relative to each other. In this process new crust is created while the earlier is destroyed.

Worldwide more than 600 basins are known which are classified into 5-8 main types based on location, tectonics and deposition. The concept of plate tectonics is the key element in basin classification. Pakistan's 3 sedimentary basins: Indus, Baluchistan and Pishin contain a number of distinct petroleum zones which exhibit varying prospectivities for occurrence of oil and gas. The area suitable for oil and gas exploration in Pakistan forms 2/3rd part of its total area.

Geologically, northern part of the Indus basin contains the most complete sedimentary column (Precambrian to Recent). The plate tectonics were active over Indus basin since Permian and the first collision of the Indian plate, where Indus basin sits, with the Eurasian plate occurred in Palecoene time. The subduction is an ongoing process, The Baluchistan basin contains sediments of Cretaceous-Recent ages. Its tectonics are comparatively young and involve subduction of oceanic crust of Arabian plate beneath Eurasian plate. Pishin basin is also a young basin (Cenozoic) containing flysch derived from surrounding high blocks. Its development took place in plate margin region. Indus basin is the only producing basin of Pakistan which contains more than 80 oil, gas and condensate discoveries including 2 world class giant gas fields, Baluchistan basin is under-explored and Pishin is a frontier, both hold prospects for future.

Key words: Tectonics, plate movement, hydrocarbon.

R/100. Raza, H.A., 2000. Exploitation and use of energy resources of Pakistan. In: Hussain, S.S. & Akbar, H.D. (eds.), Proceedings, National Symposium on Economic Geology of Pakistan, 1997, Islamabad, 185-192.

Key words: Exploitation, energy resources.

R/101. Raza, H.A. & Ahmed, R., 1990. Hydrocarbon potential of Pakistan. Journal of Canada-Pakistan Cooperation, 4, 9-27.

Key words: Hydrocarbons.

R/102. Raza, H.A., Ahmed, R., Alam, S. & Ali, S.M., 1989. Petroleum zones of Pakistan. Pakistan Journal of Hydrocarbon Research, 1(2), 1-19.

Key words: Hydrocarbons, petroleum.

R/103. Raza, H.A., Ahmed, R., Ali, S.M., Sheikh, A.M. & Shafique, N.A., 1989. Exploration performance in Sedimentary zones of Pakistan. Pakistan Journal of Hydrocarbon Research 1(1), 1-7.

Key words: Hydrocarbons, sedimentary zones.

R/104. Raza, H.A. & Iqbal, M.W.A., 1977. Mineral deposits. In: Shah, S.M.I. (ed.)., Stratigraphy of Pakistan. GSP, Memoir 12, 98-120.

Key words: Stratigraphy, mineral deposits.

R/105. Raza, H.A., Khan, A.M. & Jalal, A.I., 1992. Pakistan perspective on energy for the 1990s. Pakistan Journal of Hydrocarbon Research 4(1), 1-7.

Key words: Energy resources.

R/106. Raza, H.A. & Kemal, A., 1986. Geology of petroleum in Kohat-Potwar depression, Pakistan. American Association of Petroleum Geologist, Bulletin 70, 396-414.

Key words: Hydrocarbons, Kohat Potwar depression.

R/107. Raza, S.M., 1967. Stratigraphy and palaeontology of Gandhian-Dartian area, Hazara District, West Pakistan. M.Sc. Thesis, Punjab University, Lahore.

Key words: Stratigraphy, palaeontology, Hazara.

R/108. Raza, S.M., 1970. Cincoriola Haque from Dhak Pass Formation, Surghar Range, District Mianwali, Pakistan. Geological Bulletin, University of Peshawar 5, 111-114.

Haque (1956) described a new Cincoriola (pro Punjabia) and its two species, viz., C. ovoidea and C. patalensis from the upper horizons of the Patala Formation in Nammal Gorge, western Salt Range, Pakistan. The present investigation has recorded for the first time a rich assemblage from the Dhak Pass Formation in Lumshiwal Nala, Surghar Range, which is the oldest lithostratigraphic unit of the Paleocene Series in the region. Cincoriola patalensis Haque and new species C. sp. A is described. This genus is proved to be good time indicatrix for the Paleocene Epoch.
Key words: Palaeontology, Surghar Range, Trans-Indus salt Range, Mianwali.

R/109. Raza, S.M., 1983. Taphonomy and paleoecology of middle Miocene vertebrate assemblages, southern Potwar Plateau, Pakistan. Unpublished Ph.D. dissertation, Yale University, New Haven.

Part of the information in this works is summarized in Raza (1997) below.
Key words: Palaeontology, vertebrates, Miocene, Potwar Plateau.

R/110. Raza, S.M., 1984. Siwalik lithofacies and Himalayan orogeny; A preliminary appraisal. Abstracts, First Pakistan Geological Congress, Lahore, 53-54.

The rocks of the Siwalik Group of the Subhimalayan ranges can be arranged in three mega fining-upward sequence (MFUS) which roughly corresponds to the conventional tripartite subdivision of the Lower, Middle and Upper Siwalik subgroups. The three MFUS's can be recognized by their peculiar lithofacies, heavy-mineral compositions, and faunal characteristics. Recent calibration of the Siwalik sequences in the Potwar Plateau through the magnetic polarity stratigraphy suggest that the Siwalik Group ranges from 18 Ma B.P. to as recent as 600,000 years B.P. Within this temporal framework, each of the MFUS (in ascending order) spans approximately 8 million years, 5 million years and 4.5 million years, respectively. The transition from one to the next MFUS in various parts of the Potwar Plateau may fluctuate on the order of 10~ years.
The deposition of the fluvial Siwalik rocks along the southern foothills of the Himalayan orogenic belt are considered to be the consequence of underthrusting of the lndo-Pak Plate with the Asian plate (s). Thus, the appearance of various tectonic elements and the episodic uplift of the Himalayan mountains are expected to seriously effect and control lithofacies composition of the Siwalik rocks. An approximate correspondence exist

between the development of major Himalayan tectonic elements and the initiation of each of the MFUS. Three of the significant correlations proposed here are the appearance of MCT (around 20-18 Ma B.P.) and the beginning of the MFUS I (around 18 Ma. B.P.), the MBT and the MFUS II (around 10 Ma B.P.), and the MFT coinciding with the establishment of almost modern physiography (around 1 to 0.5 Ma B.P.).
Key words: Lithofacies, orogeny, siwaliks, Himalaya.

R/111. Raza, S.M., 1991. Stratigraphic events in the Neogene Siwaliks of the Indus Basin, Pakistan. Abstracts, 1st Postgraduate Training Course in Plate Tectonics, Punjab University, Lahore, 11-13.

Key words: Stratigraphy, Indus basin, siwaliks.

R/112. Raza, S.M., 1997. Vertebrate fauna and taphonomy of the Middle Miocene Chinji Formation in the stratotype Chinji area, southern Potwar Plateau, Pakistan. Abstracts, 3rd GEOSAS Workshop on Siwaliks of South Asia, Islamabad. GSP, Records 109, p.74.

Chinji Formation, ranging in age from 14 Ma to 10.8 Ma, is the basal unit of the Neogene Siwalik Group in the Upper Indus Basin. It is lithologically the most distinctive formation of the molassic rocks of the Himalayan foredeep belt being composed of red-brown mudstone and grey sandstone in the ratio of 3:1 to 5:1. The typical “Siwalik- aspect form” characterized by the association of small ruminants, suid, gamphotheres and muroid rodents have been well established during the Chinji times. Faunal distribution, especially the first appearance datum (FAD) in the Chinji Formation suggest two major immigration event at Ca. 14 to 13.5 Ma and 12 Ma. These two events record appearance of a host of bovid, tragulid, hominoid and giraffid species with close affinities with the contemporary East African fauna.
Taphonomic analyses of the Chinji Formation based upon carefully selected twelve localities to represent variety of all depositional context and also ensuring of no prior faunal collection from these sites. These fossil localities represent channel, channel related (e.g. abandoned channels) and floodplain (e.g. paleosol) environments. Each bone assemblage is unique in skeletal element composition, tooth/vertebra ratio, proportions of proximal and distal limb ends, taxonomic frequencies, and body-size distribution. However, tests for correlation and degree of association suggest a basic similarity in skeletal elements and taxonomic distribution regardless of sedimentary context.
The Chinji bone assemblages show a number of similarities to modern assemblages, such as relative abundance of skeletal elements, tooth/vertebra ratios, and proximal-distal limb proportions., Modern bone assemblages from different areas are as different as fossil assemblages from different localities (within similar sedimentary contexts). One important difference is that modern bone assemblages have exceptionally low bone densities. High bone concentration in relatively small areas m the Chinji Formation probably reflect relatively short time-periods of more-than-overage mortality rates. This model does not envisage catastrophies but rather such episodic events as droughts, epidemics, and low rainfall periods. These occur in modern African environments every 50-100 years and do not change overall community composition.
The autochthonous nature of the Chinji faunal assemblages is determined by sedimentary and tophonomic characteristics which permit paleoecological interpretation. Taxonomic frequencies and morphological characters of Chinji bovids, rhinocerotids, and suids, suggest that the Chinji faunal assemblages sample woodland-forest mosaic habitats.
Key words: Palaeontology, Miocene, Chinji Formation, Potwar Plataeu, siwaliks.

R/113. Raza, S.M., 2001. The Eocene red beds of the Kala Chitta Range (Northern Pakistan) and its stratigraphic implications on Himalayan Fore Deep Basin. Geological Bulletin, University of Peshawar 34, 83-104.

The Eocene redbeds unit of the Western Himalayas Foredeep basin are critical in two aspects: first, it is the oldest Tertiary sequence containing detritus unequivocally derived from the incipient Himalayas and secondly, it contains a diverse fauna key for understanding the evolution of several modern mammal groups. This sequence is known as the Kuldana Formation in the Kohat-Potwar region (=Upper Indus Basin) and the Upper Subathu formation in Kashmir and Himachal Pradesh. This paper focuses on the lithostratigraphic details of the Kuldana Formation from the Kala

Chitta Range (Kohat-Potwar region), which also has yielded the best Eocene mammalian fauna in the region. It is a mudstoned dominant unit, mainly red to purple in the Lower Kuldana but green in the Upper Kuldana. The Lower Kuldana also contains channel sandstone, immature paleosols and fresh-water limestone with molluscs (Planorbis) and algae (Chara), suggestive of terrestrial deposition regime with shallow channels, ephemeral lakes and wide floodplains. The Upper Kuldana has relatively thicker limestone interbeds with common oysters and rare benthic foraminifera, indicating return to marginal and shallow marine environment as existed before the onset of Kuldana Formation. This marine transgression, correlated with the early Lutetian highstand, deposited the overlying limestone-dominant Kohat Formation. The Kuldana-Kohat couplet was restricted to the Kala Chitta and Kohat regions whereas the rest of the Western Himalaya foredeep turned into a lowland after the Kuldana and Upper Subathu deposition. The shift from marine to terrestrial environment as witnessed in the Kuldana/Upper Subathu sequence is related to early Eocene Himalayan orogeny, when the incipient Himalayas became highland and started shedding sediments to the Foredeep basin. By early late Eocene, the Neotethys drained out from the Paleogene foredeep and shifted to the Katawaz-Makran basin in the west, which then was the main depocenter for the sediments shed from the Himalayan orogene highlands. These tectonic events produced a chain of highlands along the north and western margin of the Indian plate, providing jilter bridges for dispersal and migration of mammals to and fi-om South Asia. The Eocene mammalian fauna from the Foredeep and also form the Ladakh basin is a curious blend of some endemic and a few migrants of Eurasian and North American affinities.
Key words: Stratigraphy, Eocene, Kalachitta, Himalaya fore deep.

R/114. Raza, S.M., Barry, J.C., Pilbeam, D., Rose, M.D., Shah, S.M. & Ward, S., 1983. New hominoid primates from the middle Miocene Chinji Formation, Potwar Plateau, Pakistan. Nature, 306, 52-54.

We report here eight new hominoid specimens, attributable to Ramapithecus and Sivapithecus 1,2, from the middle Miocene Chinji Formation of Pakistan. Hominoids previously described from the Chinji Formation cannot be precisely located although they most probably come from the upper two-thirds of the formation3−9. The new material, from the middle portion of the formation, is ~12−13 Myr old based on magnetostratigraphy (refs 10, 11 and N. Johnson, personal communication). Two earlier specimens are supposedly from the underlying Kamlial Formation6,12, although the best candidate for an earliest Ramapithecus or Sivapithecus is an undescribed molar, AMNH 19565B, collected by Brown13 from a locality believed to be basal Chinji14, for which magnetostratigraphy indicates an age of 14.5 Myr (ref. 11 and N. Johnson, personal communication). Small hominoids are definitely known in the older Manchar Formation in Sind15. Together with the material discussed here, the new specimens record the earliest phases of Asian hominoid evolution following dispersal from Africa−Arabia16, and the apparent division of large hominoids into 'African' (lineages leading to Pan, Gorilla and Homo) and 'Asian' (leading to Pongo) clades at a minimum of 13 Myr17−19, probably more.
Key words: Palaeontology, Hominoid, Miocene, Chinji Formation, Potwar Plataeu, siwaliks.

R/115. Raza, S.M., Friend, P.F., Hutt, J.A. & Jah, M.A., 1992. Neogene evolution of the ancestral Indus River systems. Abstracts, First South Asia Geological Congress, Islamabad, p.35.

Key words: Indus River, neogene.

R/116. Raza, S.M., Hussain, A. & Khan, S.H. (eds.), 1993. Geological Map of Pakistan, (Scale 1:1,000,000). Compiled by Qureshi, M.J., Tariq, M.A. & Abid, Q.Z., Geological Survey of Pakistan, Quetta.

This is a revision and improvement on a larger scale of the 1: 2,000,000 scale Geological map of Pakistan by Bake and Jackson, 1964. A significant aspect of this map is the coverage of the unmapped territory in the northern area (now Gilgit-Baltistan) of Pakistan.
Key words: Geological map.

R/117. Raza, S.M. & Khan, I.A., 1994. Mineral resources of Pakistan: Annotated Bibliography (Part 1). Geological Survey of Pakistan, Records 105, 78p.

This is bibliographic compilation is a useful document for researchers, and those interested in mineral exploration and development. It provides information on the mineral resources of Pakistan up to 1993. The document comprises three sections and two appendices. The sections comprise metallogenic provinces of Pakistan: An Introduction; Mineral commodity references; and annotated bibliography. Appendices give infor4mations on current literature on coal and selected books on the geology and mineral resources of Pakistan. Pakistan has been divided into nine metallogenic provinces. Mineral commodities are given in alphabetical order.
Key words: Bibliography, mineral resources.

R/118. Raza, S.Q., 1959. Salt Range, Potwar, Hazara, Bakrala Ridge. M.Sc. Thesis, Punjab University, Lahore.

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

R/119. Raza, S.Q. & Khattak, A.K., 1972. Gypsum deposits of Kohat District, NWFP, Pakistan. GSP, Information Release 48, 29p.

Key words: Economic geology, gypsum, Karak, Kohat.

R/120. Raza, T.A., 1993-95. Sedimentology of Murree Formation and lithostructural mapping of Barian Area, Southern Hazara, Northwestern Pakistan. M.Sc. Thesis, Punjab University, Lahore, 120p.

A detailed geological study of a small part of the Attock-Hazara Fold and Thrust Belt in Khaira Gali-Kuldana Area of Galliat was carried out. Geological mapping at the scale of 1:21120 of an area of 50 km2 was carried out in detail. The lithostratigraphic units in the study area range in age from Middle Jurassic to Upper Eocene age. Samana Suk limestone of Middle Jurassic age is oolitic dolomitic limestone and represents shallow carbonate shelf sedimentation. The Chichali Formation is composed of black shale condensed sequence deposited in a basin of restricted circulation and represents deepening of basin. This continues into glauconitic Lumshiwal Formation deposited in middle subtidal conditions. Further deepening of the basin deposited pelagic Kawagarh Formation of Cretaceous age. It was deposited in lower subtidal conditions near the shelf edge. This was followed by sudden regression due to contact between Kohistan Island Arc and Indian plate, which resulted in general uplift and continental conditions. Residual Hangu Formation of Danian age was thus developed on to of Kawagarh Formation. This was followed by a rise in sea level and deposition of shelf foraminiferal Lockhart Limestone of Paleocene age which is overlain by Patala Shale, Margala Hill Limestone and Chorgali Limestone and Marl. All these are open shelf foraminiferal deposits. At this point in time collision between India and Asia took place and mixed marine-continental Kuldana Formation developed. This was followed by a rise of Himalaya, which shed debris in the foredeep. This formed fluvial Murree Formation Molasse.
The sedimentary package is composed of lower marine sequence from Jurassic to Middle Eocene dominated by carbonates with a residual laterite horizon of Damina age. The upper part of the package starts from mixed marine fluvial sequence (Kuldana Formation) and an upper molassic sequence (Murree Formation) of Upper Eocene to Miocene age. Structurally the area is mapped in detail and is composed of Chumbu Anticlinorium, Khaira Gali Synclinorium, Kali Mitti Synclinorium and Dary Gali Anticlinorium. The area is also cut by Thrust faults. General trend of the rocks in northeast to southwest. The rocks are cross-folded and double plunging. The folds are tight to isoclinal with a general vergence to southeast. Murree Formation of Upper Eocene to Miocene age is a molassic fluvial sequence deposited by a meandering river system. This sequence was derived from rising Himalaya after the collision of India with Asia in Eocene times. Facies, microfacies, diagenesis and provenance of this formation were studied in detail. For the purpose of forgoing sedimentological studies a section between Darya Gali and Kuldana Chowk was measured and sampled in detail. The Murree Formation is composed of an alternating sequence of gray to greenish gray sandstone and chocolate, maroon and brown shales. Conglomerates-breccias, limestones and marl are minor lithologies. This sequence was derived from rising Himalaya to the north as well as upper part of Kohistan Island Arc. The sandstone is lithic arenites, which are texturally sub-mature and compositionally immature.
Key words: Sedimentology, lithostructure, Murree Formation, Hazara.

R/121. Razvi, M.A., 1984. Seismic exploration of geothermal areas. First Pakistan Geological Congress, Lahore, 43-44.

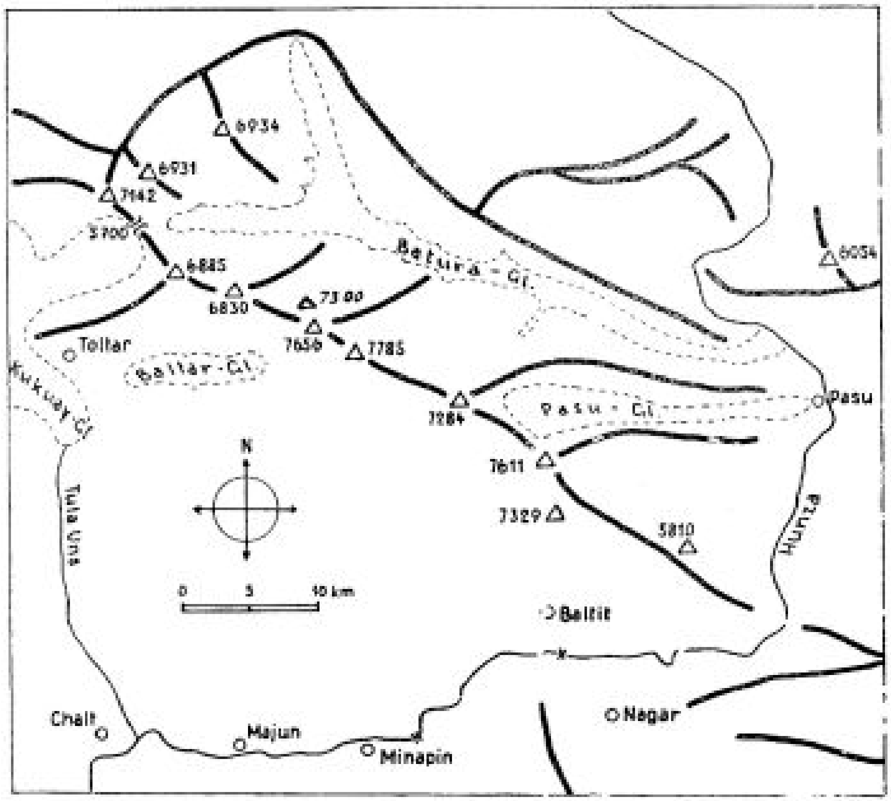
Different seismic methods for exploring geothermic areas have been used widely in USA, Japan, New Zealand and other countries with great success. Two such methods, refraction and reflection have generally been in practice. In volcanic areas, mostly reflection and partly refraction methods have been applicable. The velocity distribution in such areas are highly complicated. It is very difficult, therefore, to pinpoint cap rock, hot fluid reservoir, fault structure, heat source and other such information's from these data. To overcome this difficulty two remedies have been tried. First is to remove noises and multiple reflections by digital data processing and the second one is to calculate (besides conventional arrival time) wave energy absorption caused by fluid viscosity and high frequency and to study the wave length of a seismic wave to estimate geophysical state in such areas. By first method, very deep structures related to heat source have been discovered and from the second it has been obvious that areas of low frequency wave pattern correspond usually to fluid reservoir. Comparison of geological, geophysical and geochemical data with seismic data will increase the applicability of seismic methods for confirming the suitability and utilization of geothermal potentials for electric power generation and other facilities.
Key words: Geophysics, seismology, geothermal.

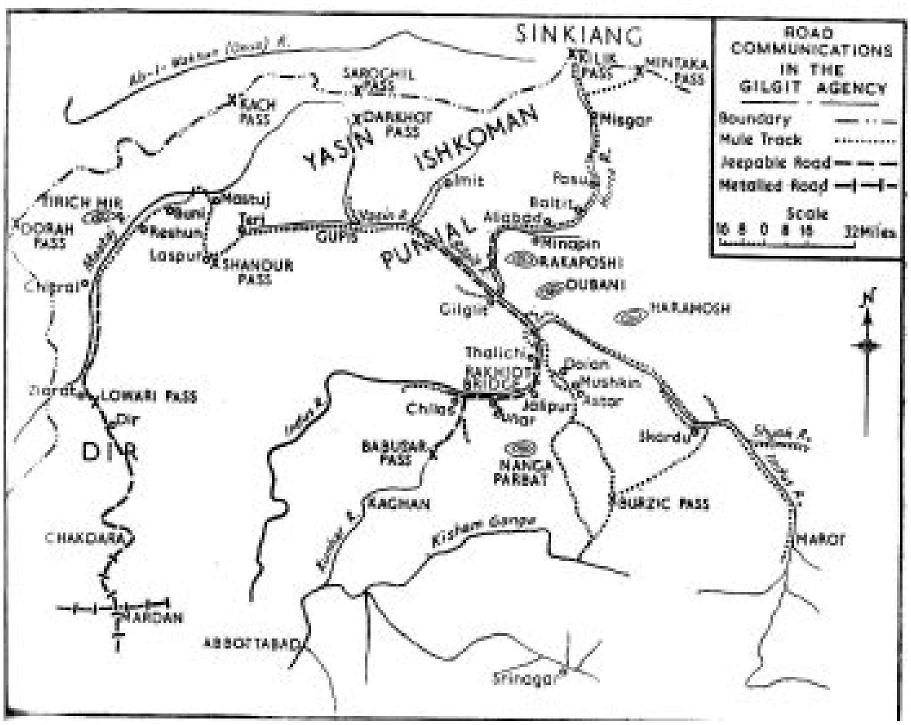
R/122. Razzak, S.D.A., 1982. The stratigraphy, petrography and structural geology of Kohat pass, North West Frontier Province, Pakistan. M.Sc. Thesis, Peshawar University, 204p.

Key words: Stratigraphy, petrography, structure, Kohat Pass.

R/123. Rebitsch, M., Klamert, G. & Meyer, D., 1955. The Batura Glacier. The Himalayan Journal 19, 120-130.

Report of the German-Austrian Himalaya-Karakoram Expedition, 1954, Translated by Eleanor Brocket? and Anton Ehrenzweig
The Austro-German expedition had intended to attempt Rakaposhi, but found on arrival that a party from Cambridge, under George Band and Tissieres, had a prior claim to the south-west approach. They explored other approaches but found them impracticable. Splitting into groups, they then set out to explore the Baltar, the Kukuay, the Batura, the Minapin, and the Hassanabad glaciers. Rebitsch has given us the story in detail of their doings on the Batura ridge.
As it's a very long document with no abstract, we are including two maps of produce by Astro-German expedition group.





Key words: Glaciers, Batura, Hunza, Karakoram.

R/124. Reddy, S., 1991. A microstructural and argon laserprobe study of fault rocks developed during Himalayan continental collision: a preliminary study. Abstract Volume, 6th Himalaya-Karakoram-Tibet workshop, Auris, France, 67-68.

Areas of NW Pakistan and Nepal have been selected to investigate the processes and timing of microstructural development associated with fault and shear zone development. In NW Pakistan, a series of ductile-brittle thrust faults associated with the collision of India with the Asian plate, are developed within the Indian plate in the footwall of the Main Mantle Thrust (MMT). These range from synmetamorphic to postmetamorphic in origin, developed at a series of metamorphic grades and are thought to have given rise to the apparent metamorphic inversion observed in the footwall of the MMT itself records of complex deformation history involving thrusting and emplacement of the Indian plate onto Kohistan arc material and subsequent normal reactivation and overprinting (Williams, 1989).
Recent studies have illustrated that the late normal faults are important structural features throughout the Himalayas and show displacement up to about 20-km (Burg et al, 1984). Within the Langtang area of Nepal the North Himalayan Fault is recognized as a large normal fault which places basement gneisses of the Higher Himalayan Group against low grade Tethyan metasediments (Burchfiel and Royden 1985; Herren 1987). Metamorphic grades across the normal shear zone are variable and decrease within the footwall towards the contact with the hangingwall sediments. Within the hangingwall itself, cataclasites associated with the extension developed below greenschist conditions. Beneath the normal fault, high strain rocks of the MCT record inverted metamorphism, but in this case the inversion is considered to be the result of high heat production in the footwall and the insulation effect of the low thermal conductivity sediments in the hangingwall.
Previous studies which have attempted to date deformation within Himalayan fault and shear zones have largely relied on indirect dating methods. These methods have included bracketing deformation by dating pre- or post-deformational intrusions, dating metamorphic recrystallization at temperatures close to individual mineral cooling temperatures and by relating deformation to the rapid cooling established by analyzing a suite of minerals with different isotope blocking temperatures. However, the recent advances in the geochemical investigation of argon isotopes utilizing the laser microprobe system, provide a powerful tool, which is capable of analyzing minerals of different generations with different textural relationships. This enables mapping of mineral grain age contours ("chrontours") and the characterization of argon diffusion profiles across single grains which in turn may be used to constrain the complexities of mineral growth and/ or the thermal phases within a rock. The technique can therefore provide valuable information on timing and understanding of processes taking place in fault zones which record protracted deformation histories characterized by multistage mineral growth, dissolution and fracturing.
This study focuses on the application of the laserprobe to the investigation of the temporal variations of deformation processes and development of fault zones and integrates detailed microstructural observations, utilizing the SEM, with laserprobe dating techniques. This work represents a research program, which has only recently been started. At this workshop meeting, the specific problems associated with these fault zones, and the methodology by which they are hoped to be solved, are presented.
Key words: Tectonics, continental collision, MMT, Kohistan, Himalaya.

R/125. Reddy, S.M., Kelley, S.P. & Magennis, L., 1992. A Microstructural and ^{40}Ar-^{39}Ar laserprobe study of a greenschist facies shear zone from the Liachar Thrust, Northwest Pakistan. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, 74.

A sample of banded amphibolite from the Liachar Thrust Zone exposed on the 'Tato Road Section' in northwest Pakistan has been studied using microstructural and 40Ar-39Ar laserprobe techniques in order to place temporal constraints on deformation within this tectonically complex zone and to understand the relationship between deformation and the resetting of argon isotopes within a natural system.
Early Himalayan amphibolite-grade banding associated with the south-directed overthrusting of the Kohistan arc over India along the Main Mantle Thrust (MMT), has been steepened by relative uplift along the western margin of the Nanga Parbat syntaxis and subsequently overprinted by a discrete shear zone associated with westwards thrusting of the Nanga Parbat Indian basement back onto Kohistan. The shear zone in this sample comprises two overlapping but discrete displacement planes approximately 3mm apart, which are connected through a complex link zone. This zone is characterized by plastic deformation along with fluid infiltration and mineral growth.
Laserprobe analyses of minerals in the zone of deformation show a large variation (over three orders of magnitude at a sub-millimeter scale) in the distribution of apparent 40ArP9Ar ages due to the heterogeneous distribution of excess argon between different minerals. Amphiboles both outside and inside the fault zone record old ages, which are

associated with the incorporation of excess argon within the mineral lattice, probably during formation of the amphibolite-grade MMT fabric. Excess argon is also extremely abundant within quartz and feldspar augen (apparent ages > 4Ga). However, biotites exhibit much lower concentrations of excess argon, indicating their equilibration in a relatively excess argon poor fluid (biotite is normally susceptible to a high concentration of excess argon). The difference between excess argon components in amphibole and feldspar and that in the biotite seems to preclude a simple thermal resetting of biotite. It is suggested that the excess component in the biotite was associated with syn-deformational fluid infiltration and the ages of c. 10 Ma obtained from the biotite represent minima for the deformation.
Key words: Tectonics, continental collision, MMT, Liacher thrust, NPHM, Himalaya.

R/126. Reddy, S.M., Kelley, S.P. & Magennis, L., 1997. A microstructural and argon laserprobe study of shear zone development at the western margin of the Nanga Parbat-Haramosh massif, Western Himalaya. Contributions to Mineralogy and Petrology 128, 16-29.

Consult the preceding paper for further information.
Key words: Tectonics, continental collision, MMT, Nanga Parbat, Himalaya.

R/127. Reed, F.R.C., 1910. Pre-Caboniferous life-provinces. Geological Survey of India, Record 40(1), 1-35.

Key words: Palaeontology, Pre-Carboniferous, India.

R/128. Reed, F.R.C., 1911. Devonian fossils from Chitral, Persia, Afghanistan and the Himalayas. Geological Survey of India, Record 41(2), 86-114.

This is one of the earliest account on the palaeontology of the Chitral area. It compares the Devonian fossils of Chitral with those of the Himalayas, Persia and Afghanistan.
Key words: Palaeontology, Devonian, Chitral, Afghanistan.

R/129. Reed, F.R.C., 1912. Silurian fossil from Kashmir. GSI Records 42(1), 16-33.

Key words: Palaeontology, Silurian, Kashmir.

R/130. Reed, F.R.C., 1922. Devonian fossils from Chitral and the Pamirs. Geological Survey of India, Memoirs, Palaeontologica Indica (New Series) 6(2), 1-136.

This monograph describes in detail the Devonian paleontology of Chitral and compares the fossils with those of the Pamir Mountain.
Key words: Palaeontology, Devonian, Chitral, Pamir.

R/131. Reed, F.R.C., 1925. Upper Carboniferous fossils from Chitral and the Pamirs. Geological Survey of India, Memoirs, Palaeontologica Indica (New Series) 6(4), 1-134.

This monograph describes in detail the Upper Carboniferous paleontology of Chitral and compares the fossils with those of the Pamir Mountain.
Key words: Palaeontology, carboniferous, Chitral, Afghanistan.

R/132. Rehana, I. & Yawar, W., 1996. Construction of elemental determination profile for pyrochlore carbonatite ore. Proceedings, Second SEGMITE International Conference on Export

Oriented Development of Mineral Resources and Mineral Based Industries, Karachi, 1994, 146-148.

Key words: Carbonatite, ore processing.

R/133. Reinemund, J.A., Davis, A. & Rossman, D.L., 1969. Operation, plans and proposed evaporite minerals programme for West Pakistan. US Geological Survey/Geological Survey of Pakistan, (IR) PK-54, 22p.

Key words: Mineral deposits, evaporate, West Pakistan.

R/134. Rehman, A., 1981-83. Lithostructural mapping of Mansehra Susal and Matial Area District Mansehra with special reference to structural studies. M.Sc. Thesis, Punjab University, Lahore, 109p.

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

R/135. Rehman, A. & Saifullah, 1989. Factors affecting change in groundwater levels and storage in Naraji area Swabi. M.Sc. Thesis, University of Peshawar, 53p.

Key words: Groundwater, aquifer, Swabi.

R/136. Rehman, F., Khan, A. & Wahabuddin, 1983. Regional geology of Karak quadrangle, Karak District, N.W.F.P., Pakistan. Geological Survey of Pakistan, Information Release 131, 25p.

The report presents interim results of regional geological mapping on 1:50000 scale of about 645 sq. km. covered by 38 O/4 quadrangle in Karak district of North West Frontier Province, Pakistan. The mapped area, a part of the Kohat evaporate basin, is entirely underlain by sedimentary rocks ranging from Eocene to recent. The area is moderately folded with some accompanied faulting. Minerals of proved economic value include rock salt, gypsum and limestone. Clays including calcium – bentonite also occur in limited quantity.
Key words: Mapping, stratigraphy, structure, economic minerals, Karak.

R/137. Rehman, F., Khan, A. & Wahabuddin, 1986. Geological map of Gumbat (38 O/11), Kohat District, scale 1:50,000. Geological Survey of Pakistan, Map Series 3.

Key words: Mapping, structure, Kohat.

R/138. Rehman, H., 1963. Industrial minerals and rocks of Pakistan, review of mining activities. CENTO Symposium on Industrial Rocks and Minerals, Lahore, 34-49.

Key words: Industrial minerals.

R/139. Rehman, H., Ali, M. & Eldin, G., 1998. Petrography of diorites from Gabral valley, upper Swat, North Pakistan. M.Sc. Thesis, University of Peshawar, 90p.

The Gabral valley occurs in the uppermost part of Swat Kohistan. North of the Utror village, it is occupied by granitoids of the Kohistan batholiths. In this thesis, field features and petrographic characteristics of diorites, within or without quartz, are described in detail.
Key words: Petrography, diorites, Kohistan batholiths, Swat.

R/140. Rehman, I., 1993. Structural model for the evolution of a part of the eastern Kalachitta Range: Hasanabdal-Fatehjhang transect. M.Phil. Thesis, University of Peshawar, 59p.

The eastern part of the Kalachitta Range occupying the southern periphery of the hill ranges exposes a suite of shelf platform rocks of Mesozoic-Cenozoic age. Stratigraphic column comprises the Samana Suk (Jurassic), the Lumshiwal (Cretaceous), the Lockhart and Patala (Paleocene), the Margala, Chorgali, Kuldana and Kohat (Eocene) and the Murree (Miocene) Formations. The structure of the area is characterized by two distinct styles of deformation controlled by two detachment levels. The lower detachment is at the base of the Samana Suk Formation and the upper one is within the Patala Formation. The deformation between the two detachment levels is controlled by thrusting in the form of a duplex structure, in which the lower detachment is acting as sole or floor thrust and the upper one as roof thrust.
This duplex is best exposed at Katha colony, where the Jurassic Paleocene strata is repeated four times in the form of south verging horses. No folding except for that related with thrusts (open hanging wall anticlines) has been observed in the sequence between the two detachment levels. In contrast the structural style in the Cenozoic strata overlying the upper detachment is fold dominated, with both hinterland and foreland vergence. The structural model of the area is of a forward verging duplex separated from the roof sequence by a passive back thrust in Patala shale. This structure is expressed at the surface by fault related folds with north-south vergence.
Key words: Stratigraphy, structure, Mesozoic, Cenozoic, Kalachitta Range.

R/141. Rehman, I., Badshah, S. & Khan, H., 1985-86. Geology and structure of a part of Karak Quadrangle District Karak. M.Sc. Thesis, University of Peshawar, 63p.

Key words: Mapping, structure, minerals, Karak.

R/142. Rehman, J. & Zeb, A., 1970a. Geology of the Shah Dheri-Kabal area, Swat. M.Sc. Thesis, University of Peshawar, 52p.

For further information, consult the following account.
Key words: Mapping, geology, Swat.

R/143. Rehman, J. & Zeb, A., 1970b. Geology of the Shah Dheri-Kabal area, Swat. Geological Bulletin, University of Peshawar 5, 96-110.

This paper presents a geological map and petrography of about 20 square miles of the Shah-Dheri-Kabal area in upper Swat. The previously undivided (? Precambrian) Hornblendic Group of Martin et al, 1962, which covers most of the area, has been divided into Homogenous Amphibolites and Banded Gneisses, Dioritic Rocks, Alpine ultramafic Rocks, and Quartz Diorites and Simple Pegmatites. With the exception of the amphibolites and gneisses, the rocks are considered to be connected with Himalayan orogeny and may be middle Cretaceous to early Tertiary. The Amphibolites, gneisses, and dioritic rocks have generally been metamorphosed to Amphibolite-grade; hornblend, epidote and, in some, garnets are very common. The group has a thrust-faulted contact with the rocks of the lower Swat-Buner Schistose Group (Siluro- Devonian or possibly Ordovician), which cover the southern most part of the area. These are represented by low grade eugeosynclinal sediments metamorphosed to phyllitic schists, marble and green schists. The area is of some economic importance due to the presence of china clay, corundum and magnetite (the latter to the north of the area investigated)

Key words: Geological map, petrography, amphibolites, ultramafic rocks, diorites, Swat.

R/144. Rehman, M. & Haqqani, F., 1983. Petrology of a part of Ambela granitic complex (Babaji syenites) Buner-Swat, North West Frontier Province. M.Sc. Thesis, University of Peshawar, 84p.

Geological investigation in Ambela area aimed at preparation of a thesis in master degree in geology. The area under investigation cover almost 60 square km and consists of syenites, quartz syenites and granites. The rocks studied are a part of Ambela granitic complex and intruded into the Lower Swat Buner schistose Group of Martin et al.
The main syenite and granitic bodies are elongated with general trend of NEE. Contacts between the various rock units are predominantly NEE, and parallel to the general trend of the complex. The rocks comprises of babji Syenite in a northern most zone of Ambela granitic complex.
Petrographic studies and field investigations reveal that it is a calcalkaline type complex, a part of the alkaline igneous province of Peshawar plain which is intruded as a large batholith mass in the compressional release fractures formed at the basal part of the Indian plate.
Key words: Petrology, granite, Ambela, Buner, Swat.

R/145. Rehman, N. & Faisal, S., 2001. Structure and stratigraphy of a part of North Waziristan south of the Mir Ali and Miran Shah Road. Abstracts, 4th Pakistan Geological Congress, Islamabad, p.73.

The detailed mapping of the study area has resulted in establishing five lithostratigraphic units, ranging in age from Triassic to Cretaceous (Mesozoic sequence). The oldest rocks in the area consist of Spalga Formation of Triassic age, followed by shelf sediments comprising Sarobi and Isha formations of Jurassic age. These units are unconformably overlain by rocks of Cretaceous age, which include Tappi and Zer Ghar formations. The Mesozoic sequence exposed along Mir A-Miran Shah road contains well-preserved fossils of their respective ages: Structurally the area is very disturbed. The structural geometry of the area comprises macroscopic and mesoscopic scale folds and thrust faults. The general structural trend is north-south with slight swing towards northeast and northwest. This longitudinal trend is well followed by the axial trend of the macroscopic scale folds. However, some mesoscopic scale folds do not follow this general trend. A large thrust sheet is spread over the entire mapped area and plays an important role in the tectonics of the area. The thrust sheet is divided into three major thrusts i.e. Miran Shah, Tal and Isha thrusts. Generally, all these thrust faults trend north-south and have moderate surface dips. This thrust sheet emplaces the Triassic rocks over the Jurassic rocks. It is folded along the buckling of the underlying rocks suggesting that thrusting pre- date the folding. The cross sectional view indicates that east verging anticlinal and synclinal folds dominantly control the structure of the area. The folds are open to tight and symmetric to asymmetric inclined towards east. All the structural geometry belongs to compressional regime and an eastward directed tectonic transport associated with the oblique subduction of Indian plate underneath the Afghan plate.
Key words: Structure, stratigraphy, Mesozoic, sediments, North Waziristan.

R/146. Rehman, O. & Ali, S., 1969. General geology of alluvials of the rivers Kabul, Swat, Sardaryab, Khiyalai and Jindai River Charsadda. M.Sc. Thesis, University of Peshawar, 58p.

Key words: Alluvial deposits, Peshawar basin.

R/147. Rehman, S.S., 1986. The geology and tectonic setup of western margin of Nanga Parbat-Haramosh loop, Gilgit, Northern Pakistan. M.Phil. Thesis, University of Peshawar, 123p.

Part of the western margin of the Nanga Parbat-Haramosh loop has been studied in detail in the present work. The loop represents the tectonic boundary between the Kohistan island arc to the west and the Indian plate to the east. Major rock types, west of the fault are pyroxene-granulites and a sequence of interlayered amphibolite-gneiss-marble. Chemical constraints of these rocks are indicative of their derivation from an igneous parent, in an island arc-type environment. The rocks east of the fault are mostly schists and gneisses of the Nanga Parbat granitoid

group. The fault which separates the two contrasting lithologies is a young, right lateral, reverse fault. It trends roughly north-south and dip steeply east, with an east-side-up displacement, It is the northern extension of Raikot fault locally named Shahbatoot fault. Beside this, two other major active faults are present in the area, both showing evidences of recent activity. Indus River has been laterally offset for about 15 km along Shahbatoot fault. Three episodes of folding have also been recognised in the area, all of them related to younger tectonics and are produced by rapid uplift of the Massif.
Key words: Tectonics, structure, NPHM, Himalaya.

R/148. Rehman, S.S., 2000. Conservation of surface water in Pakistan--The controversy of Kalabagh Dam. Abstracts, Third South Asia Geological Congress, Lahore, 163-164.

Despite the fact that Pakistan’s economy is heavily dependent on agricultural produce, contributions to her GDP from his sector has been steadily declining from over 35% in 1970’s to 24% at present. This has been partly attributed to deficit water availability. The Tarbela reservoir was commissioned in 1974 with a gross storage capacity 0f 11.62 million acre feet (MAF) but now its live storage capacity is just 11.21 MAF. The Warsak reservoir has completely silted up, while Mangla and Chashma storages have also depleted by I MAF. Thus our storage capacity has consequently fallen by about 2.5 MAF so far and if we didn't add to our existing facility, we will soon be faced with acute shortage of irrigation water and hence, decline in crop yield. Increasing population and high demand for more food requires vertical and lateral increase in agriculture productivity, which can only be achieved by conserving surface water and its judicious use. In fact not only the lost reservoir space has to be reclaimed but new storage must be built to preserve the 85% discharge available in summer.
Record shows that the mean annual runoff of the Indus river at Basha has been 50 MAF while at Kalabagh it has been about 90 MAF. Downstream Kalabagh the Indus is joined by the Jehlum and Chenab rivers thereby increasing its total volume to about 147 MAF, annually. Presently about 104 MAF is utilized for irrigation through canals while the remaining 33 MAF is discharged to the Arabian Sea downstream Kotri. According to the revised design, the Kalabagh dam will store 6.1 MAF of water and pose little threat to Sindh and Baluchistan because there will still be a balance outflow of 84 MAF annually available downstream Kalabagh whereas, the water of Jehlum and Chenab rivers will continue unchanged. Thus the interests of lower reparians would not be sacrificed but instead it would only reduce the water discharged downstream Kotri to the sea. The option of Basha dam instead of Kalabagh is not right in terms of conservation of surface water as the available volume at Basha is about 50% less than that available at Kalabagh. It would severely affect the inflow into Tarbela reservoir, particularly during the low discharge months of winter. Besides, it would not be possible to draw canals from the reservoir because of its location and terrain. Thus Basha or Kachura dams can be accepted as additional reservoirs but not as an alternative to the Kalabagh dam. In view of the ever-increasing demand for higher crop yield and cheap electricity, the construction of new dams has attained urgent national priority. The construction of Kalabagh dam is, therefore, a matter of national interest and must be undertaken without further delay.
Key words: Water conservation, Basha dam, Kalabagh dam.

R/149. Rehman, S.S. & Majid. M., 1989. Petrology of a part of the western limb of the Nanga Parbat-Haramosh Loop, northern Pakistan. Geological Bulletin, University of Peshawar 22, 181-195.

A part of the western limb of Nanga Parbat-Haramosh loop has been studied in terms of petrography and geochemistry of the constituent rocks. In this area a recent fault, the Raikot fault, separates the tectono-stratigraphic zones of the Kohistan Island arc in the west from the Nanga Parbat massif (which forms the basement of the Indian plate) in the east. Major rock types, west of the fault, include a sequence of inter-layered amphibolite-gneiss and gabbros / gabbronorites. Chemical constants of these rocks are indicative of their derivation from an igneous parent, in an inland arc-type environment. East of the fault, the rocks are schists and gneisses of the Nanga Parbat-Haramosh Group. These rocks, on the basis of major-oxide geochemistry, are shown to be formed from a Proterozoic granitic protolith of I-type origin and are geochemically distinct from the S-type Mansehra and equivalent granites in the Indian Plate.
Key words: Petrology, structure, NPHM, Himalaya.

R/150. Rehman, S.S. & Sabir, M.A., 1997. Qualitative and quantitative analysis of suspended load with physicochemical characteristics of water from N.W.F.P. rivers, Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.51.

Key words: Hydrogeology.

R/151. Rehman, Z., 1990-92. Sedimentary petrology/sedimentology of Eocene Margala Hill Limestone and lithostructural mapping of Changla Gali Area in Galiat region, Southern Hazara, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 121p.

A Comprehensive study of Geology and structure of Chhangla Gali area is, presented along with special constraints on the sedimentology of Margalla Hill, Limestone. Large scale (1: 7000) Geological mapping of a small segment of the Lesser Himalaya in the Chhangla Gali area is presented. The lithostratigraphic unit range from Upper Jurassic to Upper Eocene, Samanasuk Formation being the oldest. Structurally the area comprises NE-SW trending double plunging folds constituting anticlinoria and synclinoria. The folds are tight to isoclinal with a general vergence to the southeast. The folded sequence is disrupted by a number of high angle dip slip strike faults especially within or on the margins of anticlinoria. A detailed petrographic study of a section of Margalla hill Limestone that comprises 63 microfacies ranging from mudstone, wackestone and packstone, with intercalated marls. The deposition of Margala hill limestone took place in open marine shallow shelf conditions. Diagenetic dolomite and neomorphism of syndepositional micrite has taken place under various conditions during different phases of tectonic activity.
Key words: Sedimentary petrology, Margala Hill limestone, Eocene, Abbottabad.

R/152. Rehman, Z.U., Ahsan, N., Ghazanfar, M. & Chaudhry, M.N., 1998. Lithofacies and microfacies studies of Margalla Hill limestone, Jabri area, southern Hazara, Pakistan. Pakistan Journal of Geology 7, 78-98.

Key words: Microfacies, Margalla hill limestone, Abbottabad, Hazara.

R/153. Rehmani, J., 1997. Gold-silver and base metal prospects south of Skardu and part of northern Deosai Plateau, District Skardu, north Pakistan. M.Sc. Thesis, University of Peshawar, 58p.

Key words: Precious metals, base metals, Skardu, Deosai Plateau.

R/154. Reichert, C., 1967. Nature of Permian glacial record, Salt Range and Khisore Range, West Pakistan. Neues Jb. Geol. Paleont. 127, 167-184.

Key words: Glacial record, Permian, Salt Range, Khisore Range.

R/155. Rendell, H.M., 1984. New perspectives on the Pleistocene and Holocene sequences of the Potwar Plateau and adjacent areas of northern Pakistan. In: Miller, K.J. (ed.), The International Karakoram Project, Volume 1, 389-398. Cambridge University Press.

The Pleistocene and Holocene sequence of the Potwar Plateau requires re- examination, particularly in the light of the development of new dating techniques. Some preliminary results of work on the post-Siwalik deposits of the Soan valley are presented. A revision of the relative chronology of the Pleistocene deposits is suggested, and the possibilities of the construction of an absolute chronology are discussed.
Key words: Pleistocene, Holocene, Potwar Plateau.

R/156. Rendell, H.M., 1987. Magnetic polarity stratigraphy of upper Siwalik sub-group, Soan valley, Pakistan: Implications for early human occurrence of Asia. Earth and Planetary Science Letters 85, 488-496.

The results of a detailed paleomagnetic study of a 68 m section of Upper Siwalik sediments in the Soan syncline, northern Pakistan, are presented. A palaeolithic artefact and other pieces of struck quartzite were found in situ in a gritstone/conglomerate horizon near the base of the section. Incremental thermal demagnetization was used to remove later magnetic overprints in these sediments, since alternating field demagnetization was shown to be inappropriate. With the exception of the lowest stratigraphic level, the Upper Siwalik sediments examined in the Riwat section show reverse polarity magnetization. The declination values are consistent with a 16° (±4°) counterclockwise rotation of the Soan syncline tectonic block since deposition of the sediments. On the basis of the palaeomagnetic analyses and the tectonic and stratigraphic context of the section, our current best estimate of the age of the artefact-bearing horizon is 2.0 ± 0.2Ma.
Key words: Stratigraphy, paleomagnetism, Soan syncline.

R/157. Rendell, H.M., 1989. Loess deposition during the late Pleistocene in northern Pakistan. In: Derbyshire, E. & Owen, L.A. (Eds.), Quaternary of the Karakoram and Himalaya. Zeitscrift fur Geomorphologie 76, 247-255.

Key words: Sedimentation, loess deposits, Quaternary, Pleistocene.

R/158. Rendell, H.M., 1992. The paleoclimatic significance of the loess deposits of northern Pakistan. In: Shroder, J.F. Jr. (ed.), Himalaya to the Sea: Geology, Geomorphology and the Quaternary. Routledge, London, 227-235.

The evidence of glacial/interglacial cycles within the Quaternary sediments record of the Potwar plateau and adjacent areas of northern Pakistan is reviewed. Thermoluminiscence (TL) dating of the loess deposits of the potwar provide a chronology for the late Pleistocene and enables comparison with the record from deep-sea cores from the Indian Ocean and Arabian sea. The record of loess deposition and preservation is used to infer changes in the degree of penetration of the southwest monsoon into the northern part of the subcontinent during the late Quaternary.
Key words: Sedimentation, loess deposits, Pleistocene.

R/159. Rendell, H.M., 1995. Luminescence dating of Quaternary sediments. Geological Society of London, special publication, 89, 223-235.

Luminescence techniques have the potential to date Quaternary sediments from a range of depositional environments. Recent developments of optical dating complement thermoluminesscence dating techniques, extending their applicability. The age range of samples that can be dated shows a strong dependence on the material involved. Recent work on both dune sands and loess indicates that accurate dating to beyond 500 ka may be possible in certain circumstances. The age range limits for other material may be closer to 100 ka. Examples are given of luminescence dating of material from a range of sedimentary environments.
Key words: Sedimentation, loess deposits, Quaternary, Pleistocene.

R/160. Renz, H. & Riechel, M., 1939. Palaeontologie. In: Visser, Ph.C. & Visser-Hooft, J. (eds.), Wissenschaftliche Ergebnisse der Niederlandischen Expidition in den Karakorum und die Angrenzenden Gebeite 1922, 1925, 1929-30, Bd 3, 3-293.

Key words: Palaeontology, Netherlands 1922 Expedition to Karakoram.

R/161. Rex, A.J., Searle, M.P. & Tirrul, R., 1985. Field relationships of the Karakoram granite batholith along the Baltoro glacier transect, Baltistan, North Pakistan. Abstract Volume, 1st Himalayan Workshop, Department of Geology, University of Leicester.

Key words: Granite, glacier, Baltoro, Karakoram.

R/162. Rex, A.J., Searle, M.P., Tirrul, R., Crawford, M.B. & Prior, D.J., 1988. The geochemical and tectonic evolution of the Central Karakorum, North Pakistan. Philosophical Transactions of the Royal Society London, 326, 229–255.

The Karakoram granite batholith (KGB) of probable mid-late Cretaceous age in Northern Pakistan has been studied along the Baltoro glacier transect. The batholith is 15-20 km wide and extends for at least 100-km in a WNW-ESE direction from Snow Lake and the northern Biafo glacier to the Hushe and Kondus valleys. Major compositional and structural differences exist between the Baltoro area and the Hunza Valley. Along the Baltoro glacier transect the composition of the KGB ranges from biotite granodiorite to muscovite and garnet-bearing monzogranite. Amphibole is totally absent. Locally developed K-feldspar phenocrysts and minor K-feldspar megacrysts granite represent late metasomatic activity. A rare occurrence of orbicular granite with compositionally layered spherical orbicals up to 15-cm diameter was discovered near the Trango Towers in the central part of the KGB. Both the batholith and the country rock to the south are affected by widespread intrusions of pegmatites, aplite and leucogranitic bodies. These intrusions are rich in biotite, muscovite and garnet; tourmaline and other phases indicative of high volatile content are mostly absent. A prominent feature of the batholith is the development of at least 3 joint sets, one dipping approximately 45oN, one subvertical and another subhorizontal.
Both the northern and southern contacts of the KGB are intrusive. The northern contact shows a superbly developed contact metamorphic aureole along the Vigne glacier and Mitre peak near Concordia. Metamorphic protoliths are Baltoro black slates and progressive HT/LP mineral assemblages in hornfels include biotite, andalusite (chiastolite) and sillimanite. The southern margin of the KGB at Paiyu is also intrusive into vertically foliated sillimanite-garnet gneisses. The southern part of the KGB in the Masherbrum area comprises a large migmatite terrain with a vast network of leucogranitic dykes intruding both biotite-rich gneisses, restite and leucosome.
The complete absence of mafic dykes, the absence of an extrusive volcanic component and the abundance of leucogranitic crustal melt material all support the model of a high-heat production (HHP) granite terrain of late orogenic to post orogenic setting. The KGB shows little strain and no strong foliation is developed unlike the high-grade metamorphic terrain to the south.
Key words: Geochemistry, tectonics, structure, Karakoram batholith.

R/163. Rex, A.J. Tirrul, R., Searle, M.P., Barnicoat, A., Rex, D.C., Crawford, M.B. and Windley, B.F. 1986. Geological and tectonic evolution of the central Karakoram Range. The Royal Society Discussion Meeting on Tectonic Evolution of the Himalayas and Tibet, Organized By Professor R.M. Shackleton, F.R.S., Professor J.F. Dewey, F.R.S., And Professor B.F. Windley.

The central Karakoram north of the Main Karakoram Thrust (MKT) includes three major geological zones. The southern Karakoram metamorphic series and the northern Karakoram terrane are separated by the composite Karakoram batholith. Four major metamorphic-deformation events and three magmatic events are geochronologically well constrained and allow a refined model of tectonic evolution. Low-pressure metamorphism (MI) associated with the Hushe gneiss complex preceded subduction- related magmatism of mid-Cretaceous age. Barrovian metamorphism (M2) was synchronous with crustal thickening during the Eocene that followed the late Cretaceous closing of the Shyok Suture between the Kohistan microplate and the Karakoram. Initial crustal underplating resulted in Oligocene peraluminous magmatism. Continued crustal thickening allowed melting of crystalline basement material and intrusion of the Baltoro plutonic unit at 20 Ma with peripheral contact metamorphism (M3). Retrogressive metamorphism (M4) occurred along the hangingwall of the MKT, a later Tertiary break- back thrust feature.
Key words: **T**ectonics, metamorphism, MKT, Karakoram.

R/164. Rey, R., 1989. Einige Aspekte uber die Geologie des Kaghan-Tales, NE-Pakistan. Thesis (Diplomarbeit), ETH, Zurich.

This account gives a brief about geology of the Kaghan valley and surroundings.
Key words: Geology, structure, Kaghan valley, Mansehra.

R/165. Reynolds, P.H., Brookfield, M.E. & McNutt, R.H., 1983. The age and nature of Mesozoic-Tertiary magmatism across the Indus suture zone in Kashmir and Ladakh (NW India and Pakistan). Geologische Rundschau 72, 981-1004.

The authors report new Ar40/Ar39 ages: 180--150 and 90--100 Ma from monzodiorite and tremolite-actinolite schist of the Kohistan Complex; 44 + 0.5, 39.7 plus 0r minus 0.2 Ma from dikes cutting the Ladakh-Deosai Batholith Complex; 130-145 Ma from a diorite in the Shyok melange; and 7.8 + 0.1 Ma from a late stage monzogranite of the Karakorum Batholith. A 261 +/- 13 Ma age from gneiss of the Karakorum Batholith is of uncertain significance.
These dates, previously published ones which we summarize here, and some Sr isotope data suggest the following, (due to subduction switching between the Indian and Asian margins during closing of the Tethys Ocean): Late Cretaceous emplacement of the Dras-Kohistan Cretaceous Island arc, followed by rapid cooling between abut 85 and 45 Ma. A quiet phase tectonically on the northern Indian plate during the Palaeocene to early Eocene, when subduction was occurring on the Asian margin.
Key words: Magmatism, Indus suture, Mesozoic-Tertiary, Kashmir, Ladakh.

R/166. Riaz, M., 1990. Structure and stratigraphy of the Northern Gandghar Range, Hazara District, Pakistan. M.Phil. Thesis, University of Peshawar, 48p.

The structure of the northern Gandghar Range is shown to be controlled by the folding and faulting processes. Folding and faulting has apparently exaggerated the true thicknesses of the strata. The majority of the folds (F2) are southeast vergent indicating a southeast-directed thrusting. The other group of folds (F1) is oriented perpendicular to the F2 folds, and indicate a compression direction from the NE, distinctly different from those of the F2 folds which is from the NW. The thrusting system developed in the northern Gandghar Range locally defines a small schuppen or imbricate zone. The stratigraphic status and ages of all the rocks of the northern Gandghar Range have been revised. This study indicated that all the rocks of the northern Gandghar Range are of the Proterozoic or early Paleozoic age.
Key words: Structure, stratigraphy, Gandghar Range, Haripur, Hazara.

R/167. Riaz, M., Hylland, M.D., Ahmad, S. & Ghauri, A.A.K., 1991. Structure and stratigraphy of the northern Gandghar Range, Hazara, Pakistan. Geological Bulletin, University of Peshawar 24, 71-84.

The northern Gandghar Range comprises four structural blocks, separated by the Baghdarra, Sirikot and Darrah faults. In contrast to the southern Gandghar Range none of them shows a complete succession of stratigraphy. The stratigraphy of the northern Gandghar Range is different from that of the southern Gandghar Range in two ways. Firstly, the northern Gandghar Range has an additional stratigraphic unit, the Tanawal formation that is completely missing from the southern Gandghar Range. Secondly, the Utch Khattack Formation which is so widely developed in the southern Gandghar Range is not found in the northern Gandghar Range. The deformation of the northern Gandghar Range is accomplished by thrusting and associated folding. The nature deformation of each block suggests a piggy-back style of thrusting and attitudes of folds indicate two distinct phases of deformation.
Key words: Structure, stratigraphy, Gandghar Range, Haripur, Hazara.

R/168. Riaz, M., Khan, M.K. & Khan, G.N., 1998. Geology of Koi Barmol and adjoining areas, District Mardan, N.W.F.P. M.Sc. Thesis, University of Peshawar, 76p.

Key words: Structure, stratigraphy, Mardan.

R/169. Riaz, M., Latif, A. & Qasim, M., 1983-84. Geology of southern part of Attock-Cherat Range east of Indus River. M.Sc. Thesis, University of Peshawar, 51p.

Key words: Structure, stratigraphy, Attock Cherat range.

R/170. Richards, H.C., 1960a. Mining in Pakistan: Part-1, Coal mining in Pakistan. Mining Journal 254(6448), 266-268.

Key words: Mining, coal.

R/171. Richards, H.C., 1960b. Mining in Pakistan: Part-3, Other Mineral Production of Pakistan. Mining Journal 254(6500), 324-325.

Key words: Mining.

R/172. Richards, R.L., 1962. Evaporite deposits in Pakistan. Proceedings, CENTO Symposium on Industrial Rocks and Minerals, Lahore, 267-274.

Key words: Evaporite deposits, Pakistan.

R/173. Richards, R.P., 1996. Twinned hambergite from the Gilgit District, northern Pakistan. Canadian Mineralogist 34, 615-621.

Hambergite crystals from a locality in northern Pakistan occur attached to elbaite, and show two different habits on the same specimen. Neither habit has been previously described. Crystals of the first habit are twinned by reflection on {110} and consist of plates flattened parallel to the twin plane, and bounded by {001}, {100}, {010}, {210}, {110}, and {341}. Crystals of the second habit, including the main crystal on the specimen, are also twinned and have a conspicuously hemimorphic habit. They are double twins by reflection on {110}, composed of a large central crystal in twinned relationship to two platy crystals, one on each side. Twin boundaries are marked by re-entrant grooves, and by optical discontinuity observable even in unpolarized light at low magnification under a binocular microscope. The forms present include those on the platy twins, face {241}. The difference between the two habits results from differences in the effect of twinning on crystal growth in the presence of one or two twin planes. The observed hemimorphy is a property of the twinned aggregate, and does not call into question the holohedral symmetry of untwinned hambergite.
Key words: Hambergite, twinning, Gilgit.

R/174. Ringuette, L., 1996. Thermobarometry of the garnet-bearing rocks of the Jijal Complex (western Himalayas, northern Pakistan). M.Phil. Thesis, Leicester, United Kingdom, Leicester University, 146p.

A summary of this thesis is presented in the following two accounts.
Key words: Ultramafics, garnet, Jijal complex, Kohistan, Himalaya.

R/175. Ringuette, L., Martignole, J. & Windley, B.F., 1998. Pressure-Temperature evolution of garnet-bearing rocks from the Jijal complex (western Himalayas, northern Pakistan): from high-pressure cooling to decompression and hydration of a magmatic arc. Geological Bulletin, University of Peshawar 31, 13th Himalayan-Karakoram-Tibet International Workshop, 167-168.

The Kohistan terrane located in the western Himalayas is an oceanic arc of Early Cretaceous age accreted to the Asian plate and subsequently obducted onto the Indian plate. It can be observed along a complete tilted section from ultramafic/mafic rocks to supracrustal volcanics. The 150-km2 Jijal complex constitutes the lowermost exposed part of this arc, and consists of rocks that probably crystallized in the vicinity of the crust/mantle boundary.
Petrographic observations of garnet-bearing rocks of the Jijal complex attest to the magmatic origin of several mineral species like garnet, plagioclase, clinopyroxene and amphibole, which are incorporated within, or pseudomorphosed by metamorphic minerals. According to experimental data on crystallization of basaltic magmas at high-pressure, garnet may appear on the liquidus of partially hydrated basalts if pressure reaches 2.0 GPa. Very high-pressure granulite, amphibolite and greenschist facies assemblages partly or completely overprint the magmatic assemblage. Consequently, many incompatible phases are present at the thin section scale. Very high-pressure granulite assemblages consist of garnet, clinopyroxene, plagioclase, quartz, ± amphibole. Most of these minerals are unzoned but their composition varies from grain to grain attesting to disequilibrium at the scale of the thin section, probably due to relict compositions inherited from the magmatic stage. However, most garnets are zoned and display a net increase of grossularite content at their rims, compensated by a simultaneous decrease in the almandine and pyrope contents; this results either from an increase in pressure under isothermal conditions, or from an isobaric cooling, the latter being more likely if magmatic garnet crystallized around 2.0. GPa. The jadeite content of clinopyroxene ranges from 7-19 wt.% and increases toward the rims of magmatic clinopyroxene grains; this increase is also compatible with isobaric cooling of the initial magmatic assemblage. Moreover, the Ca-tschermak content of clinopyroxene ranges from 1-16 wt.%, with Al^{iv}/Al^{iv} increasing toward the rims of the grains. Thermobarometric calculations based on Grt-Qtz-Cpx-PI net transfer reaction and Grt-Cpx exchange reaction give P-T estimates covering a very wide range of 1.2-1.9 GPa and 750-1150°C. If the magmatic sequence of the Jijal complex is continuous, then the calculated depth-pressure range largely overpasses its thickness, estimated at around 12 km [2]. Similarly, the temperature range shows that relict magmatic compositions have probably been included in the calculations. Therefore, these values reflect disequilibrium or rather a mixing of magmatic and metamorphic equilibria. Nevertheless, average pressures and temperatures calculated for garnet and clinopyroxene cores are 60 MPa lower and 45°C higher than those calculated for the rims. Consequently, the post-magmatic stage of metamorphism is a very high-pressure granulite facies resulting from nearly isobaric cooling. The superimposed lower grade hydrous assemblages consist of tremolite-anorthite corresponding to amphibolite facies conditions, tremolite (anthophyllite)-epidote of the transitional epidote-amphibolite facies, and finally actinolitic hornblende-chlorite assemblages of the greenschist facies. The above assemblages attest to a switch of the isobaric cooling path to a major decrease in both pressure and temperature. This magmatic and metamorphic evolution can be correlated with already known tectonic stages: the 120-80 Ma [3] magmatic stage of the arc (magmatic assemblages): the partial cooling during the 80-65 Ma-old post-accretion stage (very high-pressure granulite facies conditions); the abduction of the arc onto the Indian plate, starting at around 65 Ma [4] (hydration of the granulitic assemblages with the development of amphibolite to greenschist facies assemblages).
Key words: Ultramafics, garnet, Jijal complex, Kohistan, Himalaya.

R/176. Ringuette, L., Martignole, J. & Windley, B.F., 1999. Magmatic crystallization, isobaric cooling, and decompression of the garnet-bearing assemblages of the Jijal sequence (Kohistan terrane, western Himalayas). Geology 2, 139-142.

The Jijal ultramafic-mafic sequence is the lowermost exposed part of the Kohistan terrane. Petrography and geothermobarometry show that garnet-bearing assemblage of the Jijal sequence consist of a mosaic of magmatic and metamorphic equilibria. Garnet-bearing magmatic assemblage started their crystallization at a depth>50 km, either at the base of a thickened arc-type crust or within rising magmatic batches in the upper mantle. Quasi-isobaric cooling of magmatic assemblages occurred in the high-P, high-T granulite field without reaching the eclogite field. Subsequently, these assemblages were partly retrograded under amphibolite-to greenschist-facies conditions. This succession of equilibria attests to a switch from a high-P quasi-isobaric cooling regime to a major decompression followed by final cooling at the upper-crustal level. This P-T evolution is best explained by a yet unrecognized tectonic event that consists of partial exhumation of the base of the Kohistan terrane during its accretion to the Asian plate. Final cooling and unloading in turn, could be related to extension following the obduction of the Kohistan terrane onto the Indian plate.
Key words: Ultramafics, petrography, geothermometry, Jijal complex, Kohistan.

R/177. Rizwani, I.A., 1983. A methodolic approach to evaluate a deposit with reference to high aluminous clays of Attock. Second National Seminar on Development of Mineral Resources, Peshawar, 1, 4p.

Key words: Economic geology, clays, Attock.

R/178. Robertson, A.H.F. & Collins, A.S., 1999. Significance of the Shyok Suture Zone (Northern Suture) in NW Pakistan (Skardu area): Twofold division into Cretaceous Kohistan arc-margin and Eurasian (Karakoram) continental margin units. Terra Nostra 99, Abstract Volume, 14^{th} Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 128-130.

The Shyok Suture Zone (Northern Suture) in Northern Pakistan is a critical lineament that separates the Karakoram Terrane to the north (Eurasia) from the Kohistan Terrane to the south (Cretaceous island arc). The Shyok Suture Zone was widely interpreted as a narrow back-arc marginal basin that opened in the Early Cretaceous between the Kohistan arc and the Eurasian (Karakoram) margin. However, it was recently proposed that the Kohistan arc was formed at a near-equatorial palaeolatitude above a S-dipping subduction zone (Khan et al., 1998). In this model, Kohistan drifted northwards, after its formation, as part of a Neothyan oceanic plate that was simultaneously subducted northward beneath the Eurasian margin and sutured to Eurasia during the Late (pre-75 Ma). The site of any oceanic basin between the Kohistan arc and Eurasia (Karakoram) now forms the Shyok Suture Zone. The Shyok Suture Zone was previously summarized as “mélange including sedimentary and tectonic mélanges with blocks of volcanic rocks, limestone, quartzite and serpentinite in a shaley matrix” (Geological Map of North Pakistan: Searle and Khan, 1991); however, few detailed studies have been published (an exception being Pudsey, 1986).
We are presently investigating the Shyok Suture Zone in NW Pakistan (Baltistan), centred on Skardu. Lugma/Tarmac area (Le Fort et al., 1994) the suture zone was recently interpreted as a low-grade (greenschist) metamorphic tectonic mélange, divided into a “Southern Band”, a volcanic-sedimentary unit, and a “Northern Band”, comprising “tectonic lenses” including ophiolitic lithologies. We first mapped a corridor across the Shyok Suture Zone from the Askole Amphibolite (Gilgit Complex) in the SW (near Dasu) to the Main Karakoram Thrust exposed in tributaries NE of Shigar, combined with detailed units from the structural base upwards: Based ultramafic unit (ophiolitic; ca. 1-km)-overlain by talc-rich sediments (Dasu);
Lower volcanogenic unit: (ca. 4-km)-An intact succession of green volcaniclastic turbidites and volcanogenic debris flow deposits, micaceous shales, fissile tuffs, basic-intermediate-acidic lava flows/breccias and local limestone lenses (upper Turmik valley/lower Skoro valley/Bauma-harel area); Carbonate-volcanogenic unit (ca. 2-km)-Dominated by the “Pakora Limestone”, which is redeposited carbonate (calciturbidites) interbedded with subordinate carbonate debris flow deposits and micaceous sediments. It forms lenses up to 800-m thick and is intercalated with volcanogenic sediments and minor lava flows (Ganto-La/Munbluk/Tisar areas); Upper volcanogenic unit (ca. 4-km)-Heterogeneous volcanogenic sediments (structurally thickened), dark phyllite, pale tuff, silicic and intermediate lava/lava breccias and calciturbidites (Ganto La/Tisar/Skoro R./Bauma-harel areas); Serpentine-basalt-chert complex (<250m)-Imbricated tholeiitic basalt (pillow lava/breccia-analysis in progress), red radiolarian chert and serpentinized ultramafic rock intercalated with greenish volcaniclastic sediments (Bauma-harel area/Skoro R.); Conglomerate-sandstone-shale (ca. 0.5-km several slices)-Reddish sediments (fluvial?) including well-rounded clasts of mainly volcanogenic lithologies forming thrusts sheets, found locally between units vi) and within viii) (Bauma-harel area); Terrigenous shale-sandstone unit (>2-km)-Dark micaceous shales, subordinate quartzose sandstones and siltstones (turbiditic?) (Bauma-harel R/Skoro R.); Shale-sandstone-limestone-conglomerate unit (>2-km)-Early Carboniferous (and older?) to early Mesozoic? Shallow to deeper marine succession (Bauma-harel area). Serpentinite shear zone-marking the Main Karakoram Thrust, cuts obliquely across units iv-viii and overlain by high-grade metamorphic rocks (Eurasian).
Units are interpreted as: i) oceanic arc basement: ii-iv) a coherent (in the SW) to thrust imbricated (in the NW) Lower Cretaceous arc-margin succession (northward younging; apparent thickness ca. 10-km). Limestones are channelized calciturbidites and not tectonic blocks or slices; v) probably imbricated oceanic arc basement in view of the close association with volcaniclastic sediments; alternatively a highly dismembered remnant of oceanic crust that lay between Kohistan and Eurasia; v-vi) Late Paleozoic-Early Mesozoic? mixed carbonate/siliciclastic shelf sediments overlain by terrigenous unstable slop succession with minor volcanics=imbricated upper levels of the Eurasian margin. Secondly, we investigated Cretaceous volcanic/sedimentary units in a structurally separate area

further S (S of Skardu), previously mapped as Kohistan arc (Yasin Group). Two main points are of note in making a comparison with the Shyok Suture Zone further north (see above):
General facies similarities suggest correlation as relatively proximal units of mainly unit iv) above; Large scale thrust imbrication exists, with included thin slices of serpentinized ultramafic rocks and fluvial? “molasses”.
Thirdly, we investigated lithologies further E (Thalle and Hushi valleys), areas previously mapped as part of the Karakoram Batholith. Well exposed volcanogenic successions there (intersliced with local “molasses”) can be generally correlated with unit iv) (Shigar area). Abundant siliceous tuffs are interbedded with relatively thin bedded lithoclastic/silicicturbidites? However, these rocks are found without the redeposited limestone abundant further west. Overall, the areas studied divided into: Coherent, or thrust imbricated Cretaceous Kohistan arc-margin volcanogenic sediments, volcanics and redeposited limestone, associated oceanic basement (serpentinite/lava slices); Paleozoic/Early Mesozoic? Shallow to deeper-marine continental margin successions of Eurasian (Karakoram) affinities. Accreted units e.g. large-scale “olistostromes”, or exotic tectonic melange are restricted to a thin sliver separating rocks with Kohistan affinity from rocks with Eurasian affinity. Petrographic studies do not indicate the presence of any terrigenous (Eurasian-margin) derived sediment within the inferred Kohistan-arc-margin units. This suggests that there must have been a barrier to sedimentation (e.g. an ocean) between Kohistan and Eurasia. However, any intervening Neothyan oceanic crust was subducted with little or no trace. The regional evidence favours collision of the Dras/Kohistan arc with the Eurasian (Karakoram) margin along the Shyok Suture Zone late Cretaceous time (pre-75 Ma). The arc was exposed and underwent shallow fluvial erosion prior to large-scale thrust imbrication, possibly related to Late Cretaceous arc/Eurasian margin collision. Tertiary overthrusting along the Main Karakoram Thrust today conceals much of the suture zone.
Key words: Structure, tectonics, Shyoke suture, Cretaceous, Skardu, Karakoram.

R/179. Robinson, J., Beck, R., Edwin, G. & Vincet, R.K., 2000. New structural and stratigraphic insights for northwestern Pakistan from field and Landsat Thematic Mapper data. Geological Society of America Bulletin, 112, 364-374.

The remote Waziristan region of northwestern Pakistan includes outcrops of the India-Asia suture zone. The excellent exposure of the Waziristan ophiolite and associated sedimentary lithosomes and their inaccessibility made the use of Landsat Thematic Mapper (TM) data desirable in this study. Landsat TM data were used to create a spectral ratio image of bands 314,514, and 715, displayed as red, green, and blue, respectively, and a principal component analysis image of bands 4,5, and 7 (RGB). These images were interpreted in the context of available geologic maps, limited field work, and biostratigraphic, lithostratigraphic, and radio- metric data. They were used to create a coherent geologic map of Waziristan and cross section of the area that document five tectonic units in the region and provide a new and more detailed tectonic history for the region. The lowest unit is comprised of Indian shelf sediments that were thrust under the Waziristan ophiolite. The ophiolite has been tectonically shifted and consists of two separate tectonic units the top thrust sheet is a nappe comprised of distal Triassic to Lower Cretaceous Neo- tethyan sediments that were underthrust during the Late Cretaceous by the ophiolite riding on Indian shelf strata the uppermost unit contains unconformable Tertiary and younger strata. The crust sheets show that the Waziristan ophiolite was obducted during Late Cretaceous time and imply that the Paleocene and Eocene deformation represents collision of India with the Kabul block and/or Asia
Keywords: Geologic mapping, tectonics, remote sensing, Himalaya.

R/180. Roccati, A., 1909. Sopra alcune rocce e sabbie del bacino del ghiacciaio Hispar (Himalaya Nord-occidentale). Revisitie di Mineralogia e Cristallografia Italiana 39, 33-46.

Key words: Glaciology, Hispar, Himalaya.

R/181. Roccati, A., 1910a. Etudes sommaire du materiel lithologique rapporte par M. le Dr. Calciati du bassin du Glacier d’Hispar. Bulletin de la Societe Fribourgeoise des Sciences Naturelles 17.

Key words: Lithology, Hispar basin, Karakoram.

R/182. Roccati, A., 1910b. Etudes sommaire sur le bassin du Glacier d'Hispar (Himalaya N.W.). In: Workman, W.H. & Workman, F.B. (eds.), The Call of the Snowy Hispar. A Narrative of Exploration and Mountaineering on the Northern Frontier of India. Appendix II. Constable, London, 283-285.

Key words: Glaciers, Hispar, Himalaya.

R/183. Roccati, A., 1914. Sulle rocce dell Karakorum sud orientale. Bollettino della Reale Societa Geografica Italiana 51, 1086-1093.

Key words: Lithology, southeastern Karakoram.

R/184. Roccati, A., 1915. Studio litologico e mineralogico del materiale raccolto dal conte Dott. Cesare Calciati nella Spediozione al Karakorum sud-orientale durante l'estate del 1911. Bollettino della Reale Societa Geografica Italiana 34, 2-78.

Key words: Lithology, mineralogy, Karakoram.

R/185. Roe, J., 1996. Biogeographic and geologic importance of Neogene Siwalik Chacidae (Teleostei, Siluriformes) from Pakistan. Journal of Vertebrate Palaeontology 16(3), Supplement, 60-61.

Key words: Palaeontology, biogeography, fossils, siwaliks.

R/186. Rolfo, F., 1994. Studio geologico-petrografico dei terreni compresi tra Himalaya e Karakorum nella regione ad est della sintassi Haramosh-Nanga Parbat (Baltistan, Pakistan Settentrionale). Ph.D. Thesis, University of Turin.

Key words: Petrography, NPHM, Karakoram, Himalaya.

R/187. Rolfo, F., Compagnoni, R., Le Fort, P., Lemennicier, Y., Lombardo, B. & Pecher, A., 1995. Metamorphic Evolution of the NE Nanga-Parbat-Haramosh massif and the Ladakh terrain in the Chogo Lungma-Turmik area (Northern Pakistan). Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

Petrographical and geothermobarometrical data from the north-eastern sector of the Nanga Parbat-Haramosh Massif (NPHM) and the overlying Ladakh Terrain are used to constrain the metamorphic history of the thickened Indian Plate crust and of the Ladakh paleo-arc in this tectonically key area (Le Fort et al., personal Communication).
The NPHM consists of high grade paragneiss and orthogneiss, minor granulite (possibly deriving from Permian basaltic dykes) and rare diopside-bearing marbles; near the contact with the Ladakh Terrain, deformed pegmatitic dykes are common (Pognante et al., 1993). In both ortho-and paragneiss the mineral assemblage is quartz-plagioclase-biotite-muscovite-garnet-kyanite-rutile±Kfeld spar. Kyanite, defining a S_i inclusion fabric, is also enclosed in syn-tectonic garnet porphyroblasts. Locally, both fibrolitic sillimanite and kyanite have been found in a single garnet porphyroblast: the former in the core and the latter in the rim. This petrographic evidence, together with the results of geothermobarometry and study of garnet zoning, suggests an early compressional evolution from the sillimanite to the kyanite stability field, followed by a decompressional cooling path in which kyanite is stable during different stages of recrystallization. In mafic granulites, geothermobarometry of the assemblage clinopyroxene ($Di\text{-}Hd_{74}Jd_{24}Ts_2$)-plagioclase-garnet-quartz-rutile±hornblende±biotite suggests T=650º-700ºC and P=12-15 kb for the metamorphic peak. This climax is followed by a retrograde decompressional evolution in which clinopyroxene is partly replaced by a symplectite of plagioclase (An_{30}) and diopside ($Di\text{-}Hd_{80\text{-}90}Jd_{3\text{-}8}Ts_{2\text{-}8}Acm_{3\text{-}4}$).

The Ladakh Terrain includes medium-grade hornblende-bearing gneisses, the "Askore Amphibolite" of Desio (1963), minor ultramafics and a low-grade volcano-sedimentary series, the "Greenstone Complex" of Tahirkheli & Jan (1979) or "Turmik Fm" of Desio et al. (1985). The "Askore Amphibolite" is intruded by syn- to post-tectonic plutons and related dyke swarms, ranging in composition from granodiorite to gabbro: both the syn-tectonic intrusives and their host rocks share the same metamorphic evolution in the epidote-amphibolite fades. The commonest mineral assemblage in the gneisses is garnet. This assemblage defines the regional metamorphic foliation, and is overprinted by a later static recrystallization at comparable P-T conditions. In spite of similar peak temperatures (660º±70ºC), preliminary thermobarometry reveals a marked difference between garnet-epidote-andesine amphibolites exposed close to the NPHM at the top of Turmik Valley, which have apparently equilibrated at high pressures (10.3±0.4kb), and biotite-epidote-oligoclase amphibolites outcropping at the mouth of Turmik Valley (P=6.2±0.5kb).
Lens-shaped bodies of metaperidotite, possibly representing relics of the island arc oceanic basement, separate the "Askore Amphibolite" and the "Greenstone Complex". These metaperidotites are usually antigoritic serpentinites often with talc and magnesite, in which relict cumulus structures are locally recognizable. The ultramafites exhibit a polyphase metamorphic evolution, characterised by an early serpentinization of magmatic olivine, followed by the static growth of porphyroblastic olivine and/or tremolite and, finally, by antigorite development. At the northern tip of the NPHM, where the maximum tectonic thinning of lithological units occurs, cumulitic peridotites are transformed into chlorite-talc-magnetite rocks, which still preserve the original cumulitic structure.
The "Greenstone Complex" mainly consists of low-grade quartz-albite-epidote-Chlorite-carbonate arenaceous slates and conglomeratic schists, in which the clasts are dacite and andesite (possibly deriving from the erosion of the Ladakh paleo-arc) and minor marble, quartzite, amphibolite and serpentinite. Markers of this series are interlayers of light-green quartz-plagioclase-muscovite-chlorite-biotite-epidote phyllites with rhombohedral porphyroblasts of dolomite, and rare plagioclase porphyroclasts almost completely pseudomorphosed by low-iron epidote.
Further north-eastward, a thick band of calcite marbles ("Pakora Limestone" of Le Fort et al., in press) with still preserved remains of post-Valanginian rudists and belemnites in dark calcschist layers (Le Fort et al., 1992), separates "Turmik Fm" from the "Blanzgo Fm" of Desio (1963). The latter includes minor marble and quartzite bands, biotite-amphibole greenschists, oligoclase-andesite biotite-epidote gneisses, phillytic calcschists, amphibole±epidote prasinites and rare serpentinite lenses. Some muscovite-carbonate schists contain porphyroblasts of Fe-rich chloritoid, whereas graphitic schists contain porphyroblastic kyanite. Sharp differences in mineral assemblages (from lower to upper greenschist facies), together with field evidence of local shearing, suggest that this unit, the nearest to the Main Karakorum Thrust, is actually a thrust stack of sub-units with different metamorphic histories.
Key words: Petrography, metamorphism, NPHM, Himalaya.

R/188. Rolfo, F., Compagnoni, R., Lombardo, B. & Visona, D., 1997. HP-HT Coronitic Reaction in metadolerites and metamorphism of the Higher Himalayan crystallines in the North-Eastern Nanga Parbat-Haramosh Massif, Baltistan (N Pakistan). Abstract volume, 12th Himalaya-Karakorum-Tibet International Workshop, Rome, Italy, 197-198.

Metamorphism of basalt and dolerite dykes hosted in the north-eastern sector of the Nanga Parbat-Haramosh Massif (NPHM) has been studied in the Stak valley, north of the Indus river, and in Susrut Nala, south of the Indus. Petrographical and geothermobarometrical data on these metabasics are used to constrain the metamorphic history of the thickened Indian plate in the area of maximum convergence with the Asian plate and the intervening Ladakh-Kohistan paleo-island arc (Le Fort et al., 1995).
The north-eastern NPHM consists of a layered unit of high grade paragneiss and minor orthogneiss, both with kyanite-bearing leucosomes. The gneiss hosts granulitized dykes of basalt and dolerite, and metagabbro bodies. Near the contact with the Ladakh Terrain, deformed pegmatitic dykes are common. Boulders of marble, calc-silicate rocks and serpentinized lherzolite have been found in the moraine of the Kuthiah glacier on the eastern flank of Haramosh. The main petrographic features of ortho- and para-gneiss in the Stak valley have been described by Zanettin (1964), Pognante et al. (1993) and Rolfo et al. (1995). In both ortho- and para-gneiss, the mineral assemblage is quartz + plagioclase + biotite + muscovite + garnet + kyanite + rutile ± K-feldspar. The stable assemblage biotite, muscovite and kyanite defines the main metamorphic foliation; staurolite, which appears in equilibrium with the foliation-forming assemblage, has been found only rarely. A higher grade, possibly earlier, mineral assemblage of quartz - K-feldspar-plagioclase-biotite-garnet-kyanite was only found in gneiss samples from Skango Lungma (middle Stak valley). Usually kyanite defines a S1 inclusion fabric in syn-tectonic garnet

porphyroblasts, but locally, both fibrolitic sillimanite and kyanite have been found in a single garnet porphyroblast, the former in the core and the latter in the rim.

The basalt and dolerite dykes which, occur in the gneiss are usually concordant with the main metamorphic foliation. Geochemically, most dykes have tholeiitic basaltic composition, though a few of them are picritic basalts, with MgO~16,wt % and normative divine up to 30%. The peak, granulite-facies assemblage of the basalt dykes in Stak valley is garnet + clinopyroxene + plagioclase, with rutile as ubiquitous accessory mineral. Amphibolite facies retrogression is present in some dykes, particularly in the more deformed portions and at the selvages. It is characterized by the growth first of amphibole and later of biotite, and by titanite development at the expense of rutile. In these metabasaltic dykes, geothermobarometry of the granulite assemblage clinopyroxene (Di-Hd81 Jd17 Ts2)-plagioclase (An14-18)-garnet (Aim57-59 Prp16-19 Grs21-24)- quartz - rutile suggests T around 700-7500C and P around 12-13 kb for the metamorphic peak. This climax is followed by a retrograde decompressional evolution in which clinopyroxene is partially replaced by tschermakitic amphibole or, more rarely, by a symplectite of plagioclase (An30) and diopside (Di-Hd80-90Jd3-8Ts2-8Acm3-4).

Coarser-grained metadolerite dykes have been found in a few outcrops of Stak valley, the texturally best preserved metadolerite occurring at the junction of the Goropha and Lecho valleys. This metadolerite has a peculiar coronitic texture and is essentially undeformed, except for minor shearing at the margins. Its importance lies in the possibility it affords of investigating mineral reactions through which the metabasics have passed during the granulite transformation, whereas the mineralogy and structure of the granulitized metabasalts do not allow to see back beyond the P and T at which the granulite assemblage equilibrated.

The coronite metadolerite preserves the original igneous subophitic texture originally defined by euhedral plagioclase laths, anhedral clinopyroxene and orthopyroxene, and minor ilmenite. The igneous clinopyroxene, with a dusty appearance for the presence of very small inclusions, has a metamorphic composition with moderately high Na-content (≤Jd17) and still contains thin orthopyroxene exsolution lamellae. The inclusions are tiny needles of rutile and ilmenite exsolved from the igneous zoned clinopyroxene. Coronas around clinopyroxene mainly consist of garnet (A1n49-51 Prp22-5 Grs23-27). Orthopyroxene is pseudomorphically replaced by a fine-grained clinopyroxene aggregate (compositionally similar to the large pyroxene crystals) + minor plagioclase (An18-22) ± biotite and is surrounded by a corona of asymmetrically zoned garnet (A1m55-50 Prp23-26 Grs20-23 from the inner towards the outer corona). This indicates that the granulite facies reaction: Pl + Opx → Grt + Cpx has taken place. The partially preserved igneous plagioclase (An40) is usually replaced by a metamorphic oligoclase (An16) often crowded with thin needles of kyanite. Small idioblastic garnet (Aim50-56 Prp20-24 Grs29-20 from core to rim) occasionally grows in the original calcic core. A thick corona of zoned garnet (Aim5348 Prp27-24 Grs24-19 from the inner towards the outer corona) surrounds the original Fe-Ti-oxides, which are transformed to an aggregate of rutile + ilmeno-magnetite.

In the coronite metadolerite, geothermobarometry of the peak mineral assemblages gives P=13-14 kbar and T around 8000C. The highest temperatures are thus preserved in the less deformed rocks. Subsequent deformation and re-crystallization during the retrograde path account for the less extreme conditions recorded in most of the mafic dykes and in the gneiss, where muscovite appears to be stable and to define, together with biotite and kyanite, a metamorphic foliation. Post-granulite-facies retrogression and hydrous infiltration in the metadolerite is recorded by the high-T growth of K-rich (up to 0.51 atoms p.f.u.) hornblende and of biotite, which requires the introduction of K-rich fluids from the host gneiss during the post-peak metamorphic stage. These retrograde reactions were apparently quenched b the fast uplift and cooling of the NPHM. U/Pb ages on monazite (Smith et at., 1992) and 39Ar/40Ar ages on micas (Villa et al., 1996) suggest that the granulite-facies metamorphism is Mio-Pliocene, as also shown by the Pliocene ages of white micas in the gneisses and pegmatite dykes of the middle Stak valley (Laurs et al., 1996).

Both the mafic dykes and the host gneiss exposed in the North-Eastern Nanga Parbat-Haramosh Massif show a consistent, relatively simple metamorphic evolution. However, some evidence for a polymetamorphic history is given by the presence of dykes which are slightly discordant to the main metamorphic foliation of the hosting gneiss, and by sillimanite inclusion trails inside garnet porphyroblasts of the gneiss, whose growth is related to a HT-MP event predating the HT-HP event.

Key words: Dolerite dykes, metamorphism, NPHM, Baltistan, Himalaya.

R/189. Rolfo, F., Lombardo, B., Compagnoni, R., Le Fort, P., Lemennicier, Y. & Pecher, A., 1997. Geology and metamorphism of the Ladakh terrane and Shyoke suture zone in the Chogo Lungma-Turmik area (northern Pakistan). Geodynamica Acta 10, 251-270.

Metamorphism of the Askore Amphibolite, metabasaltic and metasedimentary medium-grade hornblende-bearing schists at the northernmost portion of the Ladakh Terrane and of the Shyok Suture Zone, mainly a low-grade volcano-sedimentary series, has been studied in the area between the Chogo Lungma glacier and the Indus river halfway between Skardu and Rondu. In the Askore Amphibolite the peak assemblage in the amphibolite facies defines the regional metamorphic foliation, and is overprinted by a later static recrystallization at comparable P-T conditions. Inspite of similar peak temperatures (630 - 650 degrees C), geobarometry based on amphibole composition reveals a marked difference between garnet - epidote - andesine amphibolites exposed just above the Main Mantle Thrust at the head of Turmik valley, which equilibrated at high pressures (about 10 kbar) in late Miocene (Tortonian), and biotite epidote - oligoclase amphibolites outcropping at the mouth of Turmik valley, which equilibrated at pressures of c. 6 kbar before late Eocene (Priabonian). The Dasu Ultramafite and other smaller lens-shaped bodies of low-to medium-grade metaperidotite separate the Ladakh Terrane from the Shyok Suture Zone. They are antigorite serpentinites, often with talc and magnesite, in which relict cumulitic structures are locally recognisable. The ultramafites may represent remnants of oceanic lithosphere separating the Ladakh-Kohistan island are from the Asian plate, or they may be deep crustal rocks stripped from the basement of the arc. The mostly greenschist-facies Shyok Suture Zone shows the lithology of a calc-alkaline volcano-sedimentary series. It is supposed to be a remnant of a back are basin of early Cretaceous age, separating the arc from the southern margin of Asia. Chloritoid, kyanite and biotite have been found in individual thrust sheets occurring al different structural levels and totally subordinate in volume to very low-and low-grade rocks. Such sharp differences in mineral paragenesis, together with field evidence of local shear, suggest a complex internal structure for the Shyok Suture Zone. From the head of Chogo Lungma glacier to the Basha valley, close to the contact with the Karakorum Metamorphic Complex, the rocks of the Shyok Suture Zone record a late Miocene metamorphic event al medium pressures and temperatures. Thermobarometric and geochronological evidence suggests that this event can be related to the exhumation and thrusting of the Karakorum metamorphic core over the Shyok Suture Zone.
Key words: Metamorphism, Ladakh, Shyok suture, Skardu.

R/190. Rolland, Y., Maheo, G., Villa, I.M., Pecher, A. & Guillot, S., 2001. NW Himalayan belt granulites, mantle heat advection in a transpressive regime. Journal of Asian Earth Sciences 19, p.55.

In the Karakoram metamorphic complex (KMC), the oblique India - Asia convergence has been accommodated by (1) horizontal strike slip motions along the dextral Karakorum Fault (KF) and by (2) intense horizontal shortening with huge isoclinal fold structures and south-vergent nappe stacking (Fig. 1). Within the KF zone (Pangong Massif), granulitic assemblages (meionite scapolite±clinopyroxene±pargasite±plagioclase or orthoamphibole ± rutile ± spinel ± pyrope) are found. Thermobarometry on the metabasites yield conditions of T ,800^{0}C and P ,5.5 kbar. These conditions suggest that the KF, accommodating the lateral extrusion of Tibet, should be a lithosphere-scale shear zone, similar to the Red River fault. Ar±Ar data show that the granulitic metamorphism occurred before 32 Ma, and that retrogression in the amphibolite facies conditions occurred at ca. 18 Ma. 2. In the KMC, granulitic assemblages (sillimanite±K±feldspar± garnet) associated with migmatitic layers post-date the southwest vergent nappe piling and polyphased M1 metamorphic history (pre-37 Ma). M2 metamorphic conditions are estimated at T . 750±8008ºC and P. 5±6 kbar. M2 granulitic isograds defin an E±W thermal anomaly, also marked by migmatitic domes. Far from the zone, in the Shyok Suture zone, Ar±Ar amphibole cooling ages range from 52 to 38 Ma. At the rim of the domes, ages decrease from 20 to 13 Ma, and at the core of the dome, young U±Pb monazite ages of 6±7 Ma date the M2 metamorphic peak. Chronological, metamorphic gravimetric (Caporali, 2000) and magmatic data, and the presence of young (9 Ma) mantle-derived plutons in domes area (Lemennicier, 1996), clearly indicate that metamorphism is related to heat advection from the mantle. We propose that this late M2 tectonometamorphic and magmatic evolution is due to Indian slab detachment, initiated at 20±25 Ma.
Key words: Granulites, metamorphism, tectonics, Himalaya.

R/191. Rolland, Y. & Pêcher, A., 1999. Late structural and metamorphic evolution along the Shyok Suture zone and the Main Karakorum Thrust (NW Himalaya). Terra Nostra 99, Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 132-133.

The contact between the Kohistan-Ladakh Arc and the Asian paleomargin (Karakorum) is defined in Indian Ladakh as the Shyok suture zone. Westwards, in the Skardu area (Pakistan) the Arc-Karakorum contact is an imbricate

South vergent thrust system, the MKT (Main Karakorum thrust), with thrust contacts underlined by serpentinite strips. Still farther west, north of the Nanga-Parbat /Haramosh spur (Himalayan high grade gneisses), the MKT is no more a thrust, but a recent vertical and rectilinear fault. Actually, the Arc-Asian margin boundary is often unclear: geochemical studies suggest that some amphibolitic series of the South Karakorum metamorphic pile are parts of the Ladakh Arc, abducted onto the Asian margin, then metamorphosed and deformed during the early south-vergent tectonics (from 67 ± 2 Ma to 35 ± 5 Ma) period of the apparently syntectonic Mango Gusar granite emplacement.
Late metamorphic evolution along the MKT/Shyok suture is marked by local high temperature anomalies, best studied in Skardu area, but also known in Indian Ladakh, South of the Shyok suture zone and Karakorum fault. North of Skardu, late metamorphic isogrades draw an E-W elongated pattern, ablate to the MKT and the earlier structural pattern. It underlines a lineament of kilometric scale domes, from the Baltoro glacier in the east to the Nanga Parbat Himalayan spur in the west. Various thermochronological data from gneisses in the domes or from syn-doming plutonic cores (Hemasil syenite) indicate young ages, most of them less than 10 Ma, to the north as well as to the south of the MKT. Thus they can be interpreted in the light of the very recent to present stress and kinematic data.
The recent tectonic pattern was investigated using strain trajectories, as marked by the late metamorphic foliation, and the stress directions obtained by inversion of post metamorphic striated planes:
-The isogrades pattern, the E-W alignment of domes and the lack of small scale extension shear criteria suggest that the thermal anomalies are linked to a transpressive deformation regime, with along strike and down dip movements on the MKT/Shyok zone,
The MKT, as the dextral Karakorum fault, offset the young metamorphic patterns confirming that the MKT is not the suture, but a very young reactivation of a former contact,
-In the western part of the study area, the stress pattern is quite heterogeneous: the maximal principal stress can be vertical (in the core of the domes, e.g. the Haramosh dome), or horizontal and either parallel or perpendicular to the MKT (shortening perpendicular and parallel to the belt). In the eastern part (Ladakh Shyok zone), preliminary studies give maximal stress position either vertical (in the Ladakh batholith) or gently plunging and perpendicular to the Shyok suture (both side of the batholith, in the Indus and Shyok/Nubra valleys).
As a whole, stress, stain and thermal patterns can be linked to a transpressive deformation regime partly controlled by inherited major crustal discontinuities, with very irregular exhumation and partitioning of the deformation during the oblique Indian-Asian convergence.
Key words: Metamorphism, structure, Shyoke suture, MKT.

R/192. Rolland, Y., Picard, C. & Pêcher, A., 1998. Geology of the Ladakh-Karakorum suture zone (NE Pakistan). Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 168-170.

On the northern side of the MKT/Shyok suture zone, in the Karakorum, the authors distinguished two metasedimentary units: (i) a low-metamorphic unit, characterised by limestones (1 and 3, fig 1). In those limestones up to now very poorly mapped and dated, we have found several occurrences of fossils (mainly bryozoa and crinoid), leading to a late Paleozoic age, (ii) underlying this unit, a amphibolite facies metapelitic unit (5, Fig 1), passing (?) to the Hushe series (Searle and al., 1989).
South of the Karakorum units, an imbricated pile of sedimentary, volcano-sedimentary, volcanic and plutonic rocks is observed, bounded by steeply-dipping irregular contacts, with intricated serpentinised ultramafic rocks (7). Thus, in this area MKT is a complex melange zone, rather than a well-defined contact as described farther West. The base of the volcanic series (9) are made of alternating basaltic flows (locally displaying pillow-lava structures) and greywackes. Towards the top of the series the lavas are more differenciated and are interbedded with pyroclastic deposits.
The volcano-sedimentary units (the "Greenstone Complex") is made of reworked volcanic and sedimentary deposits, with: (i) metric to hectometric-scale basic volcanic blocks enclosed in a carbonaceous matrix (unit 8b) and (ii) olistolithes constituted of limestone and sandstone blocs enclosed in a shaly volcano-detritical matrix (unit 8a).
Those series are overlained by late discarding molassic deposits, with a shallowing upwards sequence (unit 8c).
To the South, the plutonic rocks (diorites and granodiorites, 1 1) of the Ladakh batholithe intrudes the volcano-sedimentary units (9) of the suture zone. Hectometric non-assimilated blocks of marble (10) are visible inside the northern part of the pluton. The lithological and geochemical characters of the volcanic rocks show some affinities with volcanic series of the Shyok suture zone between Karakorum and Ladakh of North western India and of the MKT zone between Karakorum and Kohistan.

Key words: Metasediments, metamorphism, Shyoke suture, MKT.

R/193. Rosenberg, P.S., 1985. Himalayan deformation and metamorphism of rocks, south of Main Mantle Thrust zone, Karakar Pass area, southern Swat, Pakistan. M.S. Thesis. Oregon State University, Corvallis, U.S.A., 67p.

Karakar pass is located to the south of the Indus Suture or Main Mantle Thrust, between lower Swat and Buner. It comprises sedimentary rocks that have undergone Barrovian type metamorphism. The area also contains granitic plutons, including those with abundant tourmaline. The thesis gives details of Early Tertiary Himalayan deformation and metamorphism.
Key words: Deformation, metamorphism, Buner, Swat.

R/194. Rosenberg, P.S., Lawrence, R.D. & Khan, I., 1984. Deformation and metamorphism of rocks south of the Main Mantle Thrust in Southern Swat, Pakistan. EOS 65, p.1094.

Rocks south of the Main Mantle Thrust (MMT) in Swat, Pakistan consist of metamorphosed shelf sediments of the northern margin of the Indian subcontinent. They form the rear of the Himalayan fold and thrust belt in this area. Rocks in the area include fossiliferous marble (Siluro-Devonian?), graphitic schist, calcschist, amphibolite, quartz-mica-garnet schist and concordant bodies of granitic gneiss. These rocks have undergone at least two main deformations. D, produced a pervasive regional foliations (S1) in both granitic gneisses and metasedimentary rocks. S1 is generally parallel original layering (S0) but locally axial-planar to small, tight to isoclinal F, folds. D2 folded S1//S0 into open to tight F2 folds that range in size from small crenulations to folds of kilometer scale. D2 locally caused the development of an S2 crenulation cleavage or transposed S1//S0. Some rocks have a second crenulation that may be related to D2 or may represent an as yet undefined D3. The area has undergone regional metamorphism that was syn- and post-kinematic with respect to D1. Mineral paragenesis (clinozoisite-amphibole-oligoclase-biotite-garnet-quartz) indicates metamorphism reached transitional greenschist-amphibolite facies to lower amphibolite facies. Temperature-pressure conditions associated with D2 were sufficient only to allow recrystallization of quartz, carbonate, muscovite and possibly chlorite. Both D1 and D2 probably relate to the collision of the Indian subcontinent with Kohistan rocks north of the study area (Maluski and Matte, 1984) suggests D1 ended 30 my ago. Rapid uplift, probably associated with major Himalayan thrusting, occurred 20 my ago (Zeitler, 1981) and is the youngest possible age of D2.
Key words: Deformation, metamorphism, MMT, Swat.

R/195. Rossi Ronchetti, C., 1965. Rudiste e nerinee del Cretaceo di Yasin (Pakistan nord-occidentale). In: Italian Expeditions to the Karakorum (K2) and Hindu Kush, (A. Desio leader), Scientific Reports IV (1), 229-272. Paleontology-Zoology-Botany. Brill, Leiden.

The Yasin group occurs along the northern fringe of the Kohistan Island Arc and apparently overlies the Chalt volcanics. The group contains highly fossiliferous Cretaceous (Aptian-Albian) sediments and volcanic rocks. This paper describes rudistid pelecypods and nerineid gastropods (including one new species of each) from an Yasin area to the west of Gilgit, northern Pakistan.
Key words: Palaeontology, Yasin group, Kohistan arc.

R/196. Rossi Ronchetti, C., 1967. Molluscs from the Upper Cretaceous at Burji-la. Rivista Italiana de Paleontologia e Stratigrafia 73, 811-827.

A group of molluscs fossils from the valley of Burji –la in Baltistan has been studied. They are considered to belong to Turonian (Cretaceous).
Key words: Palaeontology, Cretaceous, Burji-la, Baltistan.

R/197. Rossi Ronchetti, C. & Farioli, M.A., 1959a. Rudists and nerineids of north-west Pakistan Cretaceous. Rivista Italiana di Paleontologia i Stratigrafia, 65, 91-96.

From the study of the fossils from the type locality near the Yasin Guest House, the authors conclude that the Yasin Group is Lower Aptian or thereabouts in age. For further information, consult Rossi Ronchetti, C., 1965.
K**ey words**: Palaeontology, Rudistid, Nerineid, Yasin group, Gilgit.

R/198. Rossi Ronchetti, C. & Farioli M.A., 1959b. Rudistids and nereids of northwest Pakistan Cretaceous. Review Italiana Palaentologia 65, 355-360.

Consult Rossi Ronchetti, C., 1965.
Key words: Cretaceous, palaeontology, Rudistids, Nerineids, Yasin Group, Gilgit.

R/199. Rossi Ronchetti, C. & Mirelli, A.F., 1958. Rudistids and nereids of north West Pakistan, Cretaceous. 20th International Geological Congress, Mexico 7, 355-360.

Consult Rossi Ronchetti, C., 1965.
Key words: Palaeontology, Yasin group, Gilgit.

R/200. Rossman, D.L. & Abbas, S.G., 1982. An ultramafic chromite bearing rock complex near Dargai, Peshawar division, Pakistan. USGS project report PK-59

The Dargai ultramafic complex in Peshawar Division, Malakand Agency, Pakistan, contains 52 chromite prospects and 4 small deposits. The complex is believed to have been emplaced along a major thrust fault which lies along the front of the Himalayan mountain range. Rocks making up the complex include dunite and harzburgite and a few small gabbro bodies concentrated along the north side of the mass.
Two sets of compositional layering are present. One set is universally steeply dipping and strikes east, parallel to the long direction of the complex. The other set, called the subhorizontal set, is nearly horizontal, but is visible with certainity only on the upper slopes of Bada Sar mountain where the layers extend over an area of several square miles. However, traces of a flat - dipping dunitic zone are visible in the upper part of the main east - trending ridge which extends most of the complex; the extent the subhorizontal may be considerably greater than can be positively shown.
The bulk of the chromite occurs as layers, some of which are parallel to the subhorizontal layering; it is likely that the subhorizontal layering formed by crystal settling, and can, in this respect be regarded as primary. The steeply dipping layers i n the peridotite probably transect the subhorizontal set , and at places the structure of the steeply dipping set passes at angles through the chromite zones. The steeply dipping set probably formed from flowage and recrystallization of the original rock.
This differential movement probably has been responsible for destroying or masking the subhorizontal layering in most areas. In many places the steeply dipping layered structure extends across the chromite zones at large angles. This transecting relationship is particularly well shown at the Barjokanri deposit.
Recommendations for further work include: detailed tracing out of all chromite layers and exploration on thickened portions; some surface excavation at the Barjokanri deposits; an economic feasibility study of the possibility of finding, mining, and concentrating disseminated chromite; and developing a practical method of pelletizing chromite fines.
Key words: Ultramafic rocks, chromite, Malakand Agency.

R/201. Rothlisberger, F. & Geyh, M.A., 1985. Glacier variations in Himalayas and Karakorum. Zeitschrift fur Gletscherkunde 21, 237-249.

Key words: Glaciers, Himalaya, Karakoram.

R/202. Rowley, D.B., 1996. Age of initiation of collision between India and Asia: a review of stratigraphic data. Earth and Planetary Science Letters 145(1-4), 1-13.

The collision of India with Asia is perhaps the most profound tectonic event to have occurred in past 100 Ma. It is responsible for the uplift of the Himalayas and Tibetan Plateau and has been argued to have been responsible for geological, geochemical, and climatological consequences of global extent. Yet the age of initiation of this collision remains poorly constrained. The literature is replete with estimates that range from the Late Cretaceous (> 65 Ma) to latest Eocene (< 40 Ma) with little consensus in between. This paper reviews the available stratigraphic evidence from the Himalayan region, and concludes that only in the western Zanskar-Hazara region is the age well constrained as starting in the Late Ypresian (~ < 52 Ma). To the east only in the Malla Johar region of the Tethyan Himalayas have potentially syn-collisional sediments been recognized south of the Indus Yarlung Zangbo suture. However, here the correlation of the upper part of the Sangchamalla Flysch is contentious, with correlations ranging from Late Cretaceous to Middle Eocene (Lutetian). In the most eastern sections of Tertiary rocks thus far recognized within the Tethyan Himalayas north and east of Everest (Mount Qomolangma) normal, shallow shelf-type carbonates extend into the Lutetian, without evidence of a change in sedimentation to the top of the section, so the start of collision must be still younger. Along-strike of the Indus Yarlung Zangbo suture thick submarine delta-fan complexes derived from erosion of the Himalayan-Tibet system provide independent estimates that agree with a diachronous collision initiating in the late Ypresian in the west and progressing into and perhaps through the Lutetian in the east. The stratigraphic and magmatic history along the north side of the suture are compatible with such a diachronous history. This diachroneity has important implications for estimates of the accommodation of strain within this orogenic system.
Key words: Tectonics, stratigraphy, collision, Hazara, Tibetan plateau, Himalaya.

R/203. Rowell, G., 1976. The Karakorum opens up. Mountain, 49, 18–35.

The construction of the Karakoram Highway provides an easy access to the central Karakoram and eastern Hindukush. The Highway crosses obliquely the northwest Himalayan terrain, followed northward by Kohistan and central Karakoram mountain ranges.
Key words: Karakoram Highway.

R/204. Ruschelli, M.A. & Cita, M.B., 1959. Cretaceous microfacies from Western Pakistan and Afghanistan. Institute of Geology, Palaeont. Geog. Fisen. University of Milano 100, 231-252.

Key words: Cretaceous, microfacies, Pakistan, Afghanistan.

R/205. Rushton, A.W.A., 1973. Cambrian fossils from the Hazira shale, Pakistan. Nature 243, 130-142.

Until recently the Abbottabad Group in the Hazara area, western Pakistan, was thought to be Upper Carboniferous-Permian in age. But when Latif found Hyolithid shells in the Hazira Shale Formation at the top of the Abbottabad Group, he suggested that a Lower Palaeozoic age was more probable; on lithological grounds he favoured a Cambrian age for the Hazira Shale2. Preparation of Latif's material not only confirmed the presence of Hyolithids (Circotheca? and Linevitus?) but yielded spicules of the Heteractinellid sponge Chancelloria Walcott. Chancelloria is known from the Middle Cambrian of North America3, the Ordian of Australia4, and from the Lower Cambrian in England5. A Cambrian age for the Hazira Shale is therefore fully confirmed. If the Tanakki boulder bed at the base of the Abbottabad Group is of glacial origin1, it becomes feasible to correlate it with the widespread late Precambrian glaciation.
Key words: Palaeontology, carboniferous, Permian, shale, Hazira, Abbottabad, Hazara.

R/206. Russel, D.E. & Gingerich, P.D., 1980. Une nouveau primate omovayide dan la Eocene du Pakistan. CRNS Accademy des Sciences, Paris 291, 621-624.

Key words: Palaeontology, Eocene.

R/207. Russel, D.E., Thewissen, J.G.M. & Sigogneau, R.D., 1983. A new dichobunid artiodactyls (mammalia from the Eocene of north-west Pakistan; II, Cranial osteology.

Proceedings of the Konianklijke Nederlandse Akademie van Wetenschappen, Series B: Palaeontology, Geology, Physics and Chemistry 86, 285-300.

Key words: Palaeontology, Eocene.