J/1. Jabeen, N., 1992. Mineralogy and geochemistry of Koga syenites, carbonatites and fenites Buner, N.W. Pakistan. M.Phil. Thesis, University of Peshawar, 163p.

The Koga complex is composed of alkali granite, alkali syenite and nepheline syenite. The syenite and nepheline syenite ae intruded and fenitized by carbonatite and ijolites at different places. The ijolites and carbonitites are exposed mainly in the western part of Koga complex.
Amongst the mafic minerals in the Koga syenite, the fenitic Na-pyroxene show trends of crystallization from acmitic to diopsidic and/or hedenburgitic components, which is reversed to the magmatic trend. The fenitic amphibole show a trend from magnesio-arvedsonite to richterite which is opposite to the magmatic subsolidus trend. The fenitic alkali feldspar solid solution series in the Koga fenitized syenite are anamolously low albite and maximum microcline. Temperature for this solid solution series is suggested as 350-500 C in contrast to the magmatic feldspar for which temperature is 800 – 1000 C.
From the whole rock geochemistry and petrography of Koga complex it is suggested that the carbonatite has produced two types of fenites: 1. Na- fenites and 2. K-fenites. Both the types of fenites show great differences in their Ba, Sr, Nb, and Th contents. K- fenites are depleted in REE as compared to the unfenitized rocks whereas Na-fenites show enrichment of REE,
The composition of Na –pyroxenes, Na –amphiboles, feldspars and whole rock geochemistry of Koga complex suggests that the rock s have been fenitized by the solution emanating from at least two carbonatites which have different Na/ K ratios.
Key Words: Mineralogy, geochemistry, syenites, carbonatites, fenites, Koga, Buner.

J/2. Jabeen, N. & Mian, I., 1992. Alkali-feldspar from Koga syenites, Ambela granitic complex, NW Pakistan. Geological Bulletin, University of Peshawar 25, 77-84.

The Koga syenites are intruded at least two carbonatite intrusions, having different Na/K ratios. The carbonatite with high Na/K ratio has produced Na-fenites, while the other formed k-fenites. XRD study of low albite indicates that changes occur in the structural state of albite with increasing grade of fenitization. The Na-feldspar in the unfenitized rocks is low albite, while in the fenitized rocks is anomalous low albite. The degree of order increases with the increasing intensity of fenitization. The K-feldspar is maximum microcline in both the fenitized and unfenitized rocks. The tie lines between the co-existing Na- and K-feldspar deviate from the generally agreed magmatic trend.
Key Words: Syenites, carbonatites, Ambela granite, Buner.

J/3. Jackson, B., 1992. Vanadian grassular garnet (tsavorite) from Pakistan. Journal of Gemmology 23, 67-70.

Facited vanadian grossular from Swat, Pakistan, has a strong emerald green colour. Average EPMA results show V_2O_3 4.52, Cr_2O_3 0.00% n 1.734, D 3.640: molecular composition grossular 86.08, goldmanite 12.83%. Inclusions noted include graphite, wollustonite, mica and zircon. Comparison is made with tsavorite from East Africa.
Key Words: Garnets, gemology, Swat.

J/4. Jackson, J. & King, G., 1984. Tectonic studies in the Alpine-Himalayan belt. In: Miller, K.J., (ed.), The International Karakoram Project, Volume 1. Cambridge University Press.

Plate tectonics has successfully explained the behavior of the major ocean basins. However, it has proved to be less successful in describing the processes of continental collision and its associated deformation. Seismic studies proved crucial in providing information on which plate tectonics was established. Recent developments in the study of seismic signals recorded on distant instruments and on portable seismographs temporally installed in the Alpine-Himalayan belt are beginning to reveal the relation between extension, sedimentation, compression and major strike slip faulting such as the Karakoram fault.
Key Words: Tectonics, seismicity, Himalaya.

J/5. Jackson, J. & Yielding, G., 1983. The seismicity of Kohistan, Pakistan: Source studies of the Hamran (1972.9.3), Darel (1981.9.12) and Pattan (1974.12.28) earthquakes. Tectonophysics, 91, 15-28.

Long period body waves are examined to show that the Hamran (1972.9.3), Darel (1981.9.12) and Patan (1974.12.28) earthquakes in Kohistan had focal depths of about 8–10 km. All involved high angle reverse faulting (thrusting) and had seismic moments of about 2.2 to 2.7·1025 dyne cm. These shallow depths contrast with the deeper hypocentres found in the Hindu Kush and northeast Karakoram to the north and in Hazara to the south. The Hamran and Patan shocks were assigned depths of 45 km by the ISC, indicating that even well-recorded events in this region may have focal depths in error by 30 km.
Key Words: Seismicity, earthquakes, Hamran, Darel, Pattan, Kohistan.

J/6. Jackson, J.A. & McKenzie, D., 1984. Active tectonics of the alpine Himalayan belt between western Turkey and Pakistan. Geophysical Society London Journal 77(1), 185-264.

Over 80 new fault plane solutions, combined with satellite imagery as well as both modern and historical observations of earthquake faulting, are used to investigate the active tectonics of the Middle East between western Turkey and Pakistan.
The deformation of the western part of this region is dominated by the movement of continental material laterally away from the Lake Van region in eastern Turkey. This movement helps to avoid crustal thickening in the Van region, and allows some of the shortening between Arabia and Eurasia to be taken up by the thrusting of continental material over oceanic-type basement in the southern Caspian, Mediterranean, Makran and Black Sea. Thus central Turkey, bounded by the North and East Anatolian strike-slip faults, is moving west from the Van region and overrides the eastern Mediterranean at two intermediate depth seismic zones: one extending between Antalya Bay and southern Cyprus, and the other further west in the Hellenic Trench. The motion of northern Iran eastwards from the Van region is achieved mainly by a conjugate system of strike-slip faults and leads to the low angle thrusting of Iran over the southern Caspian Sea. The seismicity of the Caucasus shows predominantly shortening perpendicular to the regional strike, but there is also some minor elongation along the strike of the belt as the Caucasus overrides the Caspian and Black Seas.
The deformation of the eastern part of this region is dominated by the shortening of Iran against the stable borders of Turkmenistan and Afghanistan. The north-east direction of compression seen in Zagros is also seen in north-east Iran and the Kopet Dag, where the shortening is taken up by a combination of strike-slip and thrust faulting. Large structural as well as palaeomagnetic rotations are likely to have occurred in NE Iran as a result of this style of deformation. North-south strike-slip faults in southern Iran allow some movement of material away from the collision zone in NE Iran towards the Makran subduction zone, where genuinely intermediate depth seismicity is seen.
Within this broad deforming belt large areas, such as central Turkey, NW Iran (Azerbaijan), central Iran and the southern Caspian, appear to be almost aseismic and therefore to behave as relatively rigid blocks surrounded by active belts 200-300 km wide. The motion of these blocks can usefully be described by poles of rotation. The poles presented in this paper predict motions consistent with those observed and also predict the opening of the Gulf of Iskenderun NE of Cyprus, the change within the Zagros mountains from strike-slip faulting in the NW to intense thrusting in the SE, and the relatively feeble seismicity in SE Iran (Baluchistan). This description also explains why the north-south structures along the Iran-Afghanistan border do not cut the east-west ranges of the Makran.
Within the active belts surrounding the relatively aseismic blocks a continuum approach is needed for a description of the deformation, even though motions at the surface may be concentrated on faults. The evolution of fault systems within the active zones is controlled by geometric constraints, such as the requirement that simultaneously active faults do not, in general, intersect. Many of the active processes discussed in this paper, particularly large-scale rotations and lateral movement along the regional strike, are likely to have caused substantial complexities in older mountain belts and should be accounted for in any reconstructions of them.
Key words: Structure, tectonics, Alpine-Himalayan belt, Turkey.

J/7. Jackson, J.A. & Yielding, G., 1984. Source studies of the Hamran (1972.9.3), Darel (1981.9.12) and Patan (1974.12.28) earthquakes in Kohistan, Pakistan. In: Miller, K.J. (ed.), The International Karakoram Project 2, 170-184. Cambridge University Press.

Long period body waves are examined to show that the Hamran (1972.9.3), Darel (1981.9.12) and Patan (1974.12.28) earthquakes in Kohistan had focal depths of about 8 to 10-km. All involved high angle reverse faulting (thrusting) and had seismic moments of about 2.2 to 2.7X1025 dyne-cm. These shallow depths contrast with the deeper hypocenters found in the Hindu Kush and northeast Karakoram to the north and in Hazara to the south. The Hamran and Patan shocks were assigned depths of 45-km by the ISC, indicating that even well recorded events in this region may have focal depths in error by 30-km. The accurate focal depth control in Kohistan provided by the micro seismic network operated during the International Karakoram Project will be important in understanding how the deeper seismicity further north is related o that in the south.
Key Words: Seismicity, earthquakes, Hamran, Darel, Pattan, Kohistan.

J/8. Jacob, K., 1938. Fossil algae from Waziristan. Journal of the Indian Botanical Society, 17, 173-176.

The author, a Research Fellow in the Botany Department, Lucknow University, analyzes two collection of fossils sent to him by the Director, Geological Survey of India. Their provenance is given and the author states that though they are of little value stratigraphically, "botanically they are of interest as practically no records of algal impressions from the Indian rocks are in existence."
Key Words: Fossils, stratigraphy, India.

J/9. Jacob, K.H., Pennington, W.D. & Armbuster, J., 1975. The Patan earthquake of December 28, 1974 in the western Himalayas Pakistan: Damage, tectonic and possible premonitory effects. Abstract volume EOS. Trans America Geophys. Union, 56, p.396.

Key Words: Earthquakes, tectonics, Pattan, Himalaya.

J/10. Jacob, K.H., Pennington, W.D., Armbruster, J., Seeber, L. & Farhatullah, S., 1979. Tarbela reservoir, Pakistan; a region of compressional tectonics with reduce seismicity upon initial reservoir filling. Seismological Society of America Bulletin 69, 1175-1192.

The Tarbela reservoir is located on the Indus River in the lesser Himalayas of northern Pakistan, a region of considerable natural seismicity. A microseismic survey conducted prior to impounding has indicated that crustal shortening under horizontal north-south compression dominates present-day tectonics, resulting in thrusting and strike-slip motion along numerous faults.
The reservoir was first partially filled for a few weeks in 1974 and then completely filled in 1975. In both cases, the microseismic activity decreased slightly during the impounding period and recovered quickly upon commencement of drainage or establishment of a constant reservoir level. In tectonic environments where the maximum principal stress is horizontal and the tectonic system is compressive, a vertical surface load can move the crustal stresses away from a Navier-Coulomb failure criterion, and hence can temporarily decrease seismicity. The observed rapid recovery of seismicity may alternately be explained by: (1) high rates of tectonic strain accumulation which, in turn, increase horizontal stresses at crustal depths; they may quickly overcome the stabilizing effects of the small vertical stress changes and increased friction across faults from reservoir loading and, hence, may return the crustal stress system to one of failure; or (2) high diffusivity of the basement rock results in a pore pressure increase after a few weeks of raised reservoir head; the raised pore pressure equally reduces the effective horizontal and vertical stresses and brings the crustal system back to failure. Since direct monitoring of pore pressure at crustal depths is not available at Tarbela, it is presently not possible to distinguish between the two alternatives. Indirect

observations, such as long-term monitoring of space-time changes in seismicity, may aid in the resolution of this ambiguity.
A few reservoirs, located in regions with preferentially extensional or pure strike-slip tectonics, have triggered or induced seismic activity, whereas Tarbela reservoir, in a region of convergent tectonics, has (to present) only slightly modified the natural seismicity. Here, in a region of active Himalayan tectonics, it is likely that any severe earthquake to occur in the near future would occur sooner or later, regardless of the presence of the reservoir. Within hundreds of years a major earthquake near Tarbela appears tectonically inevitable. Yet the presence of the reservoir may strongly affect, say, the time of occurrence, exact location, and the details of rupture of an earthquake. The time most likely for inducing a tectonic stress release (if any) would be during or shortly after a rapid draw-down of the reservoir, when the decrease in pore pressure from its high level at crustal depths lags behind the instantaneous stress decrease from reservoir unloading.
Key Words: Tectonics, seismicity, Tarbela reservoir.

J/11. Jacobs, L.L., 1977. A new genus of Muride rodent from Miocene of Pakistan and comments on the origin of Muride. Paleontology and Biostratigraphy 25, 1-12, University of California, Berkely.

Key Words: Stratigraphy, paleontology, rodent, Miocene, Siwaliks.

J/12. Jacobs, L.L., 1978a. Pakistan and fossils. Plateau 15, 4-17, Museum of North Arizona, Flagstaff.

Key Words: Paleontology, fossils.

J/13. Jacobs, L.L., 1978b. Fossil rodents (Rhizomyidae & Muridae) from Neogene Siwalik deposit, Pakistan. Museum of Northern Arizona, Bulletin 52, 103p.

Key Words: Paleontology, Rodents, Siwaliks.

J/14. Jacobs, L.L., 1981a. Miocene lorisid primates from the Pakistan Siwaliks. Nature (London), 289, 585-587.

In 1975–79, joint expeditions from Yale University and the Geological Survey of Pakistan (YGSP) recovered fossil lorisids in the Siwalik Group of Pakistan from four localities, spanning a period before 10 Myr ago to about 7 Myr ago. In three of the localities, only isolated teeth or fragments were found, whereas the fourth and youngest locality yielded dental, cranial and some postcranial remains of a single individual described here as a new genus and species. These specimens are the first fossil lorisids known from outside East Africa, and include the only recovered postcranial remains from slow-moving arboreal lorisines. The findings indicate that significant tracts of forests in the Siwalik environmental mosaic may have been utilized by hominoid primates, notably Ramapithecus.
Key Words: Paleontology, Miocene primates, Siwaliks.

J/15. Jacobs, L.L., 1981b. The small mammal fauna of the Neogene Siwalik Group, Potwar Plateau, Pakistan. Geological Bulletin, University of Punjab 16, 11-22.

Thirty-five genera of small mammals have been recorded from the Siwalik Group (Miocene-Pleistocene) of the Potwar Plateau, northern Pakistan, by Yale, Geological Survey of Pakistan and Dartmouth-Peshawar expeditions. Preliminary range zones constructed for selected rodent taxa indicate non-synchronous appearances and last occurrences of taxa throughout the section. The small mammal fauna suggests that much of the Siwalik molasse was deposited in an area of warm moist climate. In the Pliocene to Early

Pleistocene, the trend toward modern warm dry conditions may have started. There is no evidence from the small mammal fauna to indicate a cold Pleistocene in the Potwar Plateau area.
Key Words: Paleontology, mammals, Potwar, Siwaliks.

J/16. Jacobs, L.L., & Downs, W.R., 1994. The evolution of murid rodents in Asia. In Tomida, Y. & Setoguchi, C.K.L.t. (eds.), Rodent and lagomorph families of Asian origins and diversification. National Science Museum, Tokyo, Monographs, 8, 149-156.

Key Words: Paleontology, rodents, Siwaliks.

J/17. Jacobs, L.L., & Flynn, L.J., 1981. Development of the modern rodent fauna of the Potwar Plateau, northern Pakistan. Neogene/Quaternary Boundary Field Conference, India, 1979, Proceedings, 79-82.

Key Words: Paleontology, rodents, Potwar, Siwaliks.

J/18. Jaeger, J.J., Courtillot, V. & Tapponnier, P., 1989. Paleontological view of the ages of the Deccan Traps, the Cretaceous Tertiary boundary and the India-Asia collision. Geology, 17, 316–319.

Volcanism in the Deccan Traps of India occurred over at most three magnetic chrons, centered on a main reversed chron. Paleontological data indicate that this reversed chron must coincide with 29R, which contains the Cretaceous/Tertiary (K/T) boundary. Recent 40Ar-39 Ar data may therefore provide one of the best estimates of the absolute age of the K/T boundary, 65.7 ±2.0 Ma. Moreover, the Eurasian character of K/T boundary terrestrial faunas in India suggests that this was also close to the time of India-Asia collision. This is significantly earlier than generally recognized, and implies about 4000 km of continental shortening in the collision zone, probably absorbed jointly by crustal thickening and strike-slip extrusion.
Key Words: Paleontology, KT boundary, Deccan Traps, collision.

J/19. Jadoon, I.A. & Saeed, T., 1982. Geology of Yasin group south of Chalt in Hunza valley northern Pakistan. M.Sc. Thesis, University of Peshawar, 139p.

Key Words: Geology, Yasin group, Chalt, Hunza.

J/20. Jadoon, I.A.K., 1996. Application of magnetostratigraphy in thrusting, kinematics evolution, migration and accumulation of hydrocarbons in the North Potwar, Himalayan foreland, Pakistan. Extended Abstracts, International Seminar on Paleomagnetic Studies in Himalaya-Karakoram Collision Belt and Surrounding Continents, November 20-21, 1996, Islamabad. Geosciences Lab, GSP, Islamabad, 113-115.

The Salt Range and Potwar Plateau (SRPP) represents active Himalayan foreland deformation in north Pakistan. It is typified by a tapering wedge of Neogene clastic sedimentation. Magnetostratigraphic (Burbank and Raynolds, 1988; Johnson et al., 1982) and structure combined with seismic reflection and well data (Lillie et al., 1987) provide useful information's on the general features and mechanics of the SRPP. Such studies are critical to provide insight into the evolution of foreland basins.
The SRPP has evolved due to southward translation of a coherent slab (over 90 km) over a thick layer of Eocambrian evaporites. The southern part of this system is relatively undeformed. The northern part, North Potwar Deformed Zone (NPDZ), is characterized by complicated deformation with emergent and buried thrust fronts. The buried thrust front has a triangle zone geometry in the eastern NPDZ (Fig. 1). Here, a core wedge of allochthonous strata is bounded by the Dhurnal backthrust (Jaswal, 1990) and the Khairi-Murat thrust. The Khairi-Murat Range represents a thrust sheet with about 12 km of minimum shortening.

This is overlain by a duplex horse, further deformed by out-of- sequence thrusting, over the footwall flate of the Khairi-Murat thrust' (Fig. 1).
Magnetostratigraphy and zircon fission track dating limits the evolution of the triangle zone between 2.1-1.9 Ma (e.g. Raynolds, 1980). Timing of thrusting is important for an insight into the evolution and kinematics of the NPDZ. Previous models with foreland (Fig. 2B) and hinterland (Fig. 2C) translation of a roof sequence and possibility of an upper detachment at the top of the Eocene suggest 40 to 80 km of shortening. Considering subsequent to the deposition of Siwalik strata (Fig. 2D), piggyback thrusting remains an inadmissible model because Siwalik strata are not exposed north of the Khairi-Murat thrust (Fig. l), shown as problem in figure 2A. Alternately, with established Dhurnal backthrust (Fig. l), passive-roof duplex geometry is an admissible solution (Fig. 2E). However, timing of Siwalik sedimentation (13 I to *0* 7), thrusting (prior to the 5 Ma motion along the Salt Range thrust, and sequential balancing suggest sedimentation simultaneous to thrusting Thus, we consider the possibility of a disconformity that has evolved into back thrusting and a triangle zone geometry in the eastern NPDZ. Besides, position of the roof thrust in Tertiary Rawalpindi Group strata will reduce shortening estimates to the half Examining of thrust geometries and timing of thrusting is critical to evaluate migration, accumulation, and entrapment of the hydrocarbons.
Key Words: Structure, hydrocarbons, stratigraphy, foreland, Potwar, Himalaya.

J/21. Jadoon, I.A.K., 1997. Shortening and uplift rates along a blind thrust, eastern Potwar Plateau, northern Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.24.

Key Words: Structure, uplift, Potwar, Himalaya.

J/22. Jadoon, I.A.K., & Frisch, W., 1997. Hinterland-vergent tectonic wedge below the Riwat Thrust, Himalayan foreland, Pakistan; implications for hydrocarbon exploration. American Association of Petroleum Geologists, 81(3), 438-448

The Riwat thrust, with a surface trace of over 50 km, is one of the major faults in the footwall of the main boundary thrust in the Himalayan foreland of Pakistan. Surface geology shows that the Riwat thrust is a foreland-vergent thrust along which lower to middle Siwalik molasse strata are thrust southward over upper Siwalik strata. Seismic reflection interpretation shows that the Riwat thrust developed as a roof thrust of a hinterland-vergent tectonic wedge (triangle zone) underlain by evaporites. The Riwat thrust propagates upsection from a depth of about 4 km at the base of the Siwalik Group. At this depth, it merges into a hinterland-vergent blind thrust that propagates upsection as a ramp from Eocambrian evaporites covering the basement at a depth of about 6 km. Bounded between this set of conjugate faults, a tectonic wedge of Eocambrian (evaporites) to Neogene strata is thrust toward the hinterland to form a triangle zone. The roof thrusts of triangle zones have been widely mapped as backthrusts in deformed mountain fronts. Hinterland motion of tectonic wedges as in the Riwat thrust triangle zone may be a feature of the fold-and-thrust belts underlain by evaporites acting as an extremely weak decollement layer. Their recognition, with a trap-forming geometry below a thrust, is important for interpreting particular fold belts and for hydrocarbon exploration. These structures could be predicted by the surface geology data where hinterland vergence of a fold below a thrust is apparent; however, seismic reflection data appear to be critical in recognizing these structures.
Key Words: Tectonics, Riwat Thrust, Himalaya foreland.

J/23. Jadoon, I.A.K., Frisch, W. & Jaswal, T.M., 1996. Geometry of a latest Pliocene-Pleistocene triangle zone in the Himalayan foreland, North Pakistan. Abstract volume, 11th Himalaya-Karakoram-Tibet Workshop, Flagstaff, Arizona (USA), 72.

Hydrocarbon exploration and magnetostratigraphy from the Himalayan foreland in north Pakistan has provided new surface/subsurface data and informations on the evolution of an overthrust wedge. Surface geology combined with seismic reflection profiles and well data are used to reveal the geometry and

evolution of a latest Pliocene-Pleistocene triangle zone in the eastern North Potwar Deformed Zone (NPDZ). Surface expression of the mountain front is of monocline (Soan) and two thrust faults of opposite vergence (Fig. 1). The steep limb of the monocline is located over the bedding parallel south-dipping Soan backthrust in the Neogene molasse strata. The steep Soan backthrust becomes shallower to the south and dies out at a depth of about to 2 to 4 km. At this depth, it merges into a north-dipping blindthrust that propagates upsection as a ramp from Eocambrian evaporites at a depth of about 8-km and makes a flat along a pelitic horizon in the Miocene molasse strata. The two faults bound a blind, tapered and below the backthrust show the undeformed planar and deformed (flat-ramp and pop-ups) geometry of the core wedge.
We interpret three-dimensional geometry of the triangle with fault tip-line structures as pop-ups and a core wedge of an overall irregular flat-ramp-flat geometry. A major thrust with about of 12 km of shortening lies to the proximal side of the core wedge. Along and across strike variation of shortening has allowed recognizing the evolution of a linked fault system in the triangle zone.
Magnetostratigraphy and zircon fission track dating (e.g. Burbank and Raynolds, 1984; Raynolds and Johnson, 1985; Burbank and Beck, 1991) limits the evolution of the triangle zone between 2.1-1.9 Ma. We present section balancing and calculate horizontal contraction of 4.5 km along the core wedge and variable degree of uplift from about 3.2-6 km along the core wedge and the Soan backthrust respectively. The shortening and uplift (erosion) rates amount to a minimum of 22 mm/year and about 16 mm/yr. Presence of hydrocarbons (Dhurnal Oil Field) in such a young structural trap has important bearings for the exploration of oil and gas in the Himalayan foreland.
Key words: Structure, hydrocarbon, magnetostratigraphy, foreland basin, Pliocene, Pleistocene, Potwar, Himalaya.

J/24. Jadoon, I.A.K., Frisch, W., Jaswal, T.M. & Kemal, A., 1999. Triangle zone in the Himalayan foreland, north Pakistan. In: MacFarlane, A., Sorkhabi, R.B. & Quade, J., (Eds.). Himalaya and Tibet: Mountain root to mountain tops. Geological Society of America, Special Papers 328, 275-286.

Surface geology and seismic reflection profiles reveal the geometry of a triangle zone in the Himalayan foreland of Pakistan. Surface expression of the triangle zone is the Soan syncline (monocline), the northern foreland-dipping steep limb of which is located above a bedding-parallel backthrust in the Tertiary molasse strata. The hinterland-dipping Khairi-Murat thrust is located on the proximal end of the triangle zone. The steep Dhurnal backthrust becomes shallower to the south and dies out at a depth of about 2 to 4 km. At this depth, it merges with a north-dipping blind thrust that propagates upsection as ramp from a layer of Eocambrian evaporites at depth of about 8 km and forms a flat along a pelitic horizon in Miocene molasse strata. The two faults bound a blind, tapered wedge of allocthonous strata (core wedge) inserted below the backthrust. Coherent and discoherent reflections above and below the Dhurnal backthrust show the undeformed planar and deformed (pop-ups) geometry of the footwall and hanging wall outside and inside the wedge.
We interpret the three-dimensional geometry of the triangle zone in terms of a core wedge having flat-ramp-flat geometry and internal as well as external pop-ups. The presence of blind faults of smaller lateral extent (about 10 km) and shortening (about 2 km) indicates the occurrence of more than one hydrocarbon trap in the triangle zone.
Published magnetostratigraphy limits the formation of the triangle zone between 2.1 to 1.9 Ma. On the basis of cross-section balancing, we calculate horizontal contraction of 4.5 km and rock uplift of about 2.8 km along the core wedge. The shortening and rock uplift rates amount to about 22 mm/yr and about 14 ± 2 mm/yr, respectively. The presence of hydrocarbons (the Dhurnal oil field) in such young structural traps in the Salt Range has important bearings for the exploration of oil and gas in the Himalayan foreland.
Key Words: Structure, foreland, Potwar, Himalaya.

J/25. Jadoon, I.A.K., Frisch, W., Kemal, A. & Jaswal, T.M. 1997. Thrust geometries and kinematics in the Himalayan foreland (North Potwar deformed zone), North Pakistan. Geol Rund. 86:120-131

Hydrocarbon exploration and magnetostratigraphy from the Himalayan foreland (Salt Range/ Potwar Plateau) in North Pakistan has provided new surface/subsurface data and information on the tectonic evolution of an overthrust belt. A N-S balanced cross section constrained by seismic reflection and well data across the eastern North Potwar deformed zone (NPDZ) shows a buried thrust front with a triangle zone and ramp and flat structures. The triangle zone is characterized by core wedge of an irregular geometry bounded between a floor thrust in the Eocambrian evaporites and a roof thrust in the Rawalpindi group strata. A blind thrust propagates upsection from a depth of approximately 7 km above the basement and merges in the roof thrust at a depth of approximately 3.7 km. The core wedge is bounded by the Soan back- thrust and the exposed S-verging Khairi-Murat thrust. The Kheiri-Murat thrust soles out in the main decollement and is overlain by a plane-roofed duplex horse over the hanging wall flat of the former structure. Both the Khairi-Murat thrust and the duplex are deformed by out-of-sequence thrusting. The duplex geometry and out-of-sequence thrusting is responsible for the absence of the Siwalik strata and complex deformation north of the Khairi-Murat thrust. Nearly all the seismic lines show a step of approximately 800m in the basement with hanging-wall block down-to-the-north displacement. The basement normal fault seems to provide a buttress for thrusting at the deformation front in the eastern NPDZ.
Timing of Siwalik sedimentation (13.1 - 5.1 Ma) and thrusting (8 - 5 Ma) indicate sedimentation partly simultaneous to thrusting. We consider the possibility of piggyback thrusting and a disconformity prior to the development of a passive-roof duplex with backthrusting and a triangle zone in the eastern NPDZ.
A balanced structural cross section 40 km long is restored to an original length of 81 km. Forty one kilometres of shortening along balanced cross section added to the 14 km along the Golra thrust provides total shortening or approximately 55 km between 8 and 1.9 Ma in the NPDZ. Approximately 49.5 km of shortening has occurred between 8 and 5 Ma. The shortening rate of 16.5 mm/a is roughly 33% of approximately 50mm/a convergence rate between the Indian and Eurasian plates.
Key words: Balanced cross section, hydrocarbons, duplex, thrust geometry, Himalayas.

J/26. Jadoon, I.A.K., Khwaja, A.A. & Awan, M.A., 1987. A study of folded structures west of Hazara Kashmir syntaxial bend, in south eastern Hazara, Southern Himalayas. Kashmir Journal of Geology 5, 155.

Key Words: Structure, Hazara-Kashmir syntaxes, Himalaya.

J/27. Jadoon, I.A.K., Khawaja, A.A. & Jamshed, S.Q., 1995. Thrust geometries and evolution of the eastern North Potwar deformed zone, Pakistan. Geological Bulletin, University of Peshawar 28, 79-96.

The North Potwar Deformed Zone is part of the active Himalayan foreland fold- and thrust- belt in northern Pakistan. Field work have been carried out mostly along a profile in the eastern North Deformed Zone, to gain an insight into this complexly deformed area of hydrocarbon interest. The results show triangle zone geometry and a set of imbricates between the Soan Syncline and the Main Boundary Thrust. The preserved triangle zone below the Soan Syncline is characterized by a floor thrust located at depth of 6 km in the Eocambrian evaporites. The floor thrust propagates upsection and merges in a roof thrust at depth of about 3 km in the Rawalpindi Group strata. The roof thrust has a hinterland vergence similar to backthrusts of the triangle zones in other fold- and thrust belts. Integration of structural and timing data for consideration of kinematics suggests that thrust imbricate north of the preserved triangle zone is exposed due to increasing uplift and erosion of a duplex.
A structural cross-section indicates that approximately 42 km of shortening has occurred across the NPDZ. The rate of shortening is 16 mm/yr considering deformation that has occurred between 4.5 – 1.9 Ma in the North Potwar Deformed Zone.
Key Words: Tectonics, structure, Potwar, Himalaya.

J/28. Jadoon, I.A.K., Lillie, R.J., Humayon, M., Lawrence, R.D., Ali, S.M. & Cheema, A., 1989. Mechanism of deformation and the nature of the crust underneath the

Himalayan foreland and fold-and-thrust belts in Pakistan. EOS, Transaction, Geophysical Union, 70, 1372-1373.

Key Words: Structure, deformation, foreland, Himalayan fold-and-thrust belt.

J/29. Jadoon, Q.K. & Zeb, K., 1999. Geochemical study of illite and montmorillonite-rich clay sequence from an ancient lake in Jehangira area, District Nowshera, N.W.F.P. M.Sc. Thesis, University of Peshawar, 47p.

Key Words: Geochemistry, clay, Nowshera.

J/30. Jadoul, F., Erba, E. & Gaetani, M., 1992. Uppermost Triassic-Middle Jurassic evolution of the upper Hunza sedimentary cover: implications in the Jurassic geodynamic evolution of the North-Karakoram Microplate. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, 115-116.

New data collected during the second Italian expedition in the Chapursan area permit a more detailed reconstruction of the Upper Hunza Jurassic stratigraphy. Two different successions have been recognized. They record, in different ways, the first Cimmerian orogenic episode in the Karakoram. The main stratigraphic characters of the successions, studied in different thrust sheets, are as follows:

a) during the Norian-Rhaetian two different carbonate platforms were present: eastwards a mainly peritidal dolomitized succession (Guhjal type facies); westward and south-westward a calcareous, subtidal platform with Megalodons (Aghil Fm.), passing laterally to bedded, dark gray probably deeper carbonates.

b) In the topmost Triassic-Earliest Jurassic the Aghil platform underwent a tectonic dissection (“flexural stage”) with local drawing of a more subsident area with slope calcarenitic-ruditic facies deriving from a marginal Upper Triassic platform locally emerged (possible “peripheral bulge stage”). In other areas it is probable that an Upper Triassic-Liassic platform was still growing (Aghil with *Lithiotis).* An important tectonic escarpment was certainly present in the Lupghar area as testified by very thick breccias-paraconglomerates (200-300m thick) with prevalent clasts of micritic, recrystallized limestones rich in dark siliceous nodules.

In this time the early differentiation of the Jurassic sequences took place. An A-type succession characterizes the more subsident area with a prevalent fine siliciclastic euxinic basinal facies with also turbiditic sedimentation. The B-type succession represents a more continuous shallow-water sequence.

A-Type succession. In the forming foreland basin the overlying succession is characterized by a sequence with basal black shales passing upwards to a synorogenic turbiditic siltstones and dark quartzose hybrid sandstones. The petrography of the sandstones shows the presence of quartz, pelagic siliceous micrites with radiolarians, vetrophyric basalts, serpentine schists, granitoids and metamorphic rock fragments. The age of this succession has not been assessed; the stratigraphic position suggests an Early Jurassic age.

B-Type succession. Sparse outcrops would suggest that the Aghil carbonate platform or/and open shelf carbonates and mans possibly continue in some area. But the datum is not well constrained.

c) Middle Lias. The B-type succession consists of open shelf dark limestones with many limestones and marls. Fossils, at the top of the succession, are Brachiopods *(Zeilleria* sp., “*Spiriferina”* sp.) followed by Foraminifers *(Haurania* sp.) and calcareous Nannofossils *(Lotharingius hauffii, Mitrolithus jansae, Schizosphaerella punctulata)* that record a Late Domerian-EarlyToarcianage. Upwards there is a shallowing upwards regressive succession with bioclastic-ooidal calcarenites.

Middle Liassic facies have not been recognized in type A succession because of tectonic boundaries or the presence of an erosive unconformity between the synorogenic succession and the overlying basal conglomerates, shales and sandstones of the Yashkuk Fm. The undated shaly and turbiditic synorogenic succession (thickness more than 150 in.) is possibly of Triassic age.

d) The Upper Lias-Lower Dogger is everywhere characterized by the deposition of the Yashkuk Fm. that represents an important orogenic event in the North Karakoram Plate (considered as Middle Lias by Gaetani et al., 1990). The Yashkuk Fm., in the B-type succession, is Toarcian and/or Earliest Aalenian in

age, not very thick and characterized by continental to marine transitional sandstones-siltstones passing upwards to fine siliciclastic and shallow-water marine carbonates that contain bioclastic calcarenites with Forams *(Mesoendothyra* sp.). This unit overlays the Middle Lias without an evident unconformity.
In A-type succession the corresponding Yashkuk Fm. (Gaetani et al., 1990) is not dated and quite different, shows locally an evident unconformity over the shales and turbiditic sandstones. At the base are present carbonate conglomerates with prevalent clasts of Upper Triassic Aghil Fm. passing upwards to a thick (more than 130 m) continental red sandstones-siltstones sequence (Gaetani et al., 1990).
e) The Early Middle Jurassic marine transgressive sequence is well documented only in the B-type succession. Shallow-water carbonates with ooids, stromatolites, bioclastic calcarenites with manly intercalations pass upward to dark gray-bedded limestones with frequent oncoids, ooids and thin manly intercalations. The top of these shelf carbonates has been dated as Late Aalenian (Nannofossil: “small” *Hexalithus magharensis).* In Late Aalenian-Early Bajocian the shelf drowned and pelagic limestones prevail. A decametric intercalation of dark grey fossiliferous mans (Nannofossils: *Hexalithus magharensis,* “small” *Watznaueria manivitae)* documents an anoxic Bajocian event.
In the A-type succession, shallow-water, lagoonal dark grey limestones overlay, in transgression, the thick Yashkuk Fm. At the top of these carbonates a highly tectonized fine ternigenous marine-transitional-evaporitic unit crops out. In intercalated mans we have recognized a Nannofossil (*Watznaueria* cf. *W. communis)* that indicates Bajocian to Cretaceous age for this regressive succession.
The A-type succession is interpreted as a part of the sedimentary accretionary complex in which the dark shales and turbiditic sandstones represent the “starved flysch stage” derived from the erosion of the roof and wallrock of an area. This succession is unconformably channalized by the basal conglomerates, shales and red sandstones of the Yashkuk Fm. Eventually it is transgressed and sealed by the marine late Middle Jurassic fine ternigenous to carbonatic shallow-water sediments.
The B-type succession is considered to represent a more distal or external domain, whose mostly shallow-water environment is temporary, invaded by the terrigenous prism of the Toarcian-Earliest Aalenian Yashkuk red sandstones-siltstones. Both these successions are considered to reflect the first episode of the Cimmenian orogeny. To be noted that presently the A-type succession (accretionary prism) lies at south of the B-type, representing the external domain.
Key words: Sedimentary rocks, Mesozoic, geodynamic, evolution, Hunza.

J/31. Jaffery, S.Q.A., 1974. Geology and petrology of Hero Shah area, Malakand Agency. M.Sc. Thesis, Punjab University, Lahore, 65p.

Key Words: Geology, petrology, Hero Shah.

J/32. Jafery, S.S.A., 1991. Geology of Kahuta and Bhimber area, Azad Kashmir. Geological Survey of Pakistan, Information Release 510.

Key words: Geology, Kahuta, Bhimber, Azad Kashmir.

J/33. Jafery, S.S.A., 1996. Geology and mineral resources of the Collision Zone in Pakistan. Geological Survey of Pakistan, Information Release 444, 22p.

A research project on geology and mineral resources of collision zone in Pakistan under the collaboration of Geological Survey of Pakistan and Geological Survey of Japan was planned in March, 1987.
On behalf of the Director General of Agency of Industrial Science and Technology (AIST) under the ITIT programme, the author visited Japan in February, 89 to carry out the collaborator research, mainly the X-Ray Diffraction and field studies of the geology of Japan at several localities.
The report in general deals with the brief introduction of the geology of Pakistan with specific reference of the collision zones, and related mineral resources with Calc alkaline plutonic bodies intruded into volcanic and volcano-sedimentary rocks which have undergone low to high grade of metamorphism; laboratory examinations of the minerals and rocks of the collision zone using X-Ray Diffraction; and geological field examinations in Japan for comparative type of studies.

All the geological field trip related to the geology of collision zones were for comparative studies between Pakistan and Japan, the zoned pluton of the granite rocks of the Ibaraki (SE of Japan) is much interesting. Here the rocks grade from quartz diorite, granodiorite to adamellite.
The co-magmatic pluton sequences are cocentrally zoned pluton in which relatively magmatic rocks in the margins, composed of high temperature mineral assemblages pass inwards without discontinuities to more felsic rock in the core composed of high temperature. Such type of field studies can be carried out for the study of geological environments and possible mineral resources in Pakistan.
Above all, the studies in Japan provided a better understanding and guideline for the study of the genesis of mineral deposits in the collision zone and its application to the exploration techniques in Pakistan.
Key words: Collision zones, mineral resources, Japan, Pakistan.

J/34. Jaferi, S.S.A. & Rahimuddin, 1997. Contact demarcation using the heavy minerals in the rocks of the Siwalik and Rawalpindi Groups at Ex-Toot Well 7. Abstracts, 3rd GEOSAS Workshop on Siwaliks of South Asia, Islamabad. Geological Survey of Pakistan, Records 109, 48-49.

The rocks of the Siwalik Group and the Rawalpindi Group are mainly sandstones, claystones and shales that are lithologically difficult to demarcate. Toot Well-7 was spudded in the Dhok Pathan formation of the Siwalik Group; and was drilled through a depth of 4612 m down to the Tredian formation of Jurassic age. The three rock formations within the Siwalik Group, i.e., Dhok Pathan, Nagri and Chinji, may be distinguished by the criteria given below.
Dhok pathan Formation: The presence of fresh, whitish, grey to light greenish grey sandstone, with high clay content and appearance of maroon siltstone in the Dhok Pathan formation.
Nagri Formation: Greenish grey, medium hard micaceous sandstone and brown soft silty clays.
Chinji Formation: Brownish clays with thin bands of sandstone. However, the contacts between the formations belonging to the two Groups are not always demarcable at precise levels due to gradations in lithology. In the present case, their heavy mineral contents are, therefore, deployed for more precise determination of the contacts.
The samples from various depths were sieved through 80 mesh size and treated with 15% chloric acid, washed and dried. Bromoform liquid of specific gravity 2.8205 was used to separate the heavy minerals whose percentage in rock samples provided the criteria deployed to mark the contacts as mentioned below.
Contact between Chinji and Nagri Formations: Epidote is more dominant in the Chinji formation than in the overlying Nagri formation. At Toot Well-7, persistent dominance of epidote began at 1615 m.
Contact between Chinji and Kamlial Formations: Epidote is higher in the Chinji formation than in the underlying Kamlial formation of the Rawalpindi Group. At Toot Well-7, there is a distinct increase of tourmaline and decrease of epidote at 3105 in. The contact is assumed at 3110 m because the sampling interval is 10 in contact between Kamlial and Murree Formation: Epidote is more and tourmaline less in the Murree formation than in the Kamlial formation. At the well site, tourmaline shows sharp decline at 3185 m, so the contact is positioned at 3190 m. The foregoing is an example of the use of heavy mineral content of sandstones and shales from flush cutting samples of the ex-toot well-7 in demarcating the contacts amongst rock formations of the Siwalik and Rawalpindi Groups.
Key words: Stratigraphy, lithology, heavy minerals, Siwaliks, Murree.

J/35. Jaffery, S.S.A. & Saleemi, N., 1973. Geology of Malakand area. M.Sc. Thesis, Punjab University, Lahore.

Key Words: Geology, petrology, Malakand.

J/36. Jah, M.A., Wazir, A.K., Shah, M. & Ahmad, N., 1978. Geology of Lambidogi area in relation with the Kakul Hazara Phosphate Project. M.Sc. Thesis, University of Peshawar, 79p.

The writers were assigned the responsibilities of trenching including systematic logging and sampling, petrological study of the rocks and regional and detailed mapping of the area in May, 1976. The trenching, (see fig.7) systematic logging, and sampling was completed in September, 1976. The trenches were grouped according to the Village locations like "A & C" group extends from Kalure to Tiryana Village, "B" group from Lambidogi to Kalure and "D" group from Dakhan to Manga-di-Bandi village, during and before mapping the area was divided into different distinctive rock units. The plane table survey was undertaken from March, 1977 to mid May, 1977. The scale used for plane table survey was 1:500. A self reducing alidade was used as surveying instrument.
The data collected to the field was compiled into report which presents a comprehensive petrological study of south western facies of phosphatic youngest sediments in upper most part of the Sirban Formation which is conformably overlain by the Haziran siltstones. The upper most part is well exposed in the area. It extends from Lambidogi on the Banda Pir Khan Road to the crest of the ridge of Kakul mines. However, the area investigated extends upto Manga-di-Bandi south of the Lambidogi. The change that only occurs between Lumbidogi and Kakul west succession is the "C" unit which is sandy dolomite in thesis area and slabby/flaggy phosphatic dolomite to Kakul west.
Key Words: Geology, Lambidogi, Kakul phosphate.

J/37. Jah, S.M. & Masud, B., 1979. Geological mapping of the Gandaf Irrigation Tunnel area, Right Bank, Tarbela dam, with special emphasis on the Engineering Geology properties of the materials. M. Sc. Thesis, Punjab University, Lahore, 190p.

Key Words: Mapping, irrigation, engineering geology, Tarbela, Gandaf.

J/38. Jamal, A., 1995-96. Structure, stratigraphy, micropaleontology and petrography of Jabri and Bodla areas District Haripur Hazara (NWFP), Pakistan. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 78p.

The Jabri-Bodla area lies in the Attock-Hazara fold-and-thrust belt of the northwestern Himalaya of Pakistan. Precambrian to Cenozoic sedimentary rocks are folded and imbricated during the Tertiary-Himalayan collision.
The oldest exposed stratigraphic unit is the Precambrian Hazara Formation. The formation is composed of slates, shales and phyllites. The presence of ripple marks and graded bedding shows that the Formation is deposited in shallow water turbidity environments. The Middle Jurassic Samana Suk Formation, Late Jurassic to Early Cretaceous Chichali Formation and Early Cretaceous Lumshiwal Formation were deposited in shallow marine conditions. The late Cretaceous Kawagarh Formation was deposited in deep to shallow water shelf environment. The late Cretaceous to Early Paleocene uplift in the area caused the regression of the Tethyan Sea. The Tethyan regression initiated the deposition of ferruginous sandstone of the Hangu Formation.
The lower Tertiary sequence of Early to Late Paleocene Lockhart limestone, Late Paleocene Patala Formation, Early Eocene Margala Hill Limestone and Early to Middle Eocene Chorgali formation mark the complete cycle of transgression and regression of the Tethyan Ocean. The presence of early Paleocene to Late Eocene foraminiferal assemblage like globorotalia, globogorina, lockhartia, assilina and nummulites in the limestones and shales of the Lower Tertiary sequence show the tropical sub-tropical open sea upper slope to outer shelf environments. The Paleocene-Eocene boundary cannot be marked on the basis of microfossils in the area because the Patala Formation lacks microfossils. However, the tentative Paleocene-Eocene boundary between the Patala Formation and the Margala Hill Limestone can be marked at the base of Margala Hill Limestone on the basis of first appearance of Early Eocene microfossils. The structural analysis of the investigated area shows that the Precambrian to Eocene rocks record at least two major events of deformations i.e. D1 and D1 deformation phases. The D1 deformation is divided into D1a and D1b deformation phases. The D1a is associated with the southeast-directed thrusts and southeast vergent F1 folds. The second phase of D1b deformation is related with the backsteeping of the major thrusts and northwest overturning of the major F1 folds. The northwest plunging F2 cross-folds are recognized as D2 deformation phase in the project area. These F2 cross-folds are related with the development of the Hazara-Kashmir syntaxis.

Key Words: Structure, stratigraphy, paleontology, petrography, Haripur, Hazara.

J/39. Jamil, K., Jabeen, N. & Fazal, A., 1983. Petrogenetic study of Malakand Granitic Gneisses and Meta-sedimentary Complex, Malakand Agency. M.Sc. Thesis Geology Department, Peshawar University, 113p.

Key Words: Petrology, granite gneiss, metasediments, Malakand Agency.

J/40. Jamiluddin, S. & Khan, S.N., 1984. Radioactive survey of Kundas–Chamongarh, Hanuchal Burmai area, Gilgit Agency, Pakistan. Geological Survey of Pakistan. Information Release, 209.

Key Words: Radioactivity, Gilgit.

J/41. Jankovic, S., 1986. Metallogeny and mineral potential of Northern Pakistan (North of Indus Suture Zone): A preliminary assessment. Geological Survey of Pakistan, Records, 65, 25p.

Key Words: Metallogeny, mineral potential, plate tectonics, Northern Pakistan.

J/42. Jan, M., Nisar, Z.A. & Pervez, M., 1988. Petrography and Geochemistry of the Sillai Patti complex carbonatite. M.Sc. Thesis, University of Peshawar, 53p.

Key Words: Petrography, geochemistry, carbonatite, Sillai Patti, Malakand agency.

J/43. Jan, M.Q., 1964. Geological report of the Makarwal area. Geological Bulletin, University of Peshawar 1, 19-25.

This report was prepared in Dec.1963, after a seven-day field study of the area, mainly along Miranwal Nala. Mr. Farooqui, a junior Geologist in W.P.I.D.C. guided us at times. The Makarwal area is on the South-Western extremity of the Surghar-Range. (Sur----Pashto word for “Red” and Ghar for “mountain”; since the general, colour of these mountains is reddish). The Surghar Range is included in the famous Salt Range series of West Pakistan, on the trans-Indus side between longitudes 71'-72 E and latitudes 3 1 ' 3 2 ~ N. The place is in South-West of Kalabagh at a distance of about 32 miles. The area is on the Western extreme of Mianwali District. The top of these mountains is the boundary between the Distts. of Kohat and Mianwali. Makarwal exposures are located on the East-scrap, slope of the mountain chain of Surghar Range. The place is connected with Kalabagh-Bannu Railway and cemented lorry road which are the side branches of road & railway, separating from main line at Kamar Mashani. The formations at Makarwal have been an important source of Coal in the Western part of Indo-Pak subcontinent for the last 60 years.
Key Words: Geology, coal, Makarwal.

J/44. Jan, M.Q., 1968a. Petrography of the emerald-bearing rocks of Mingora (Swat State) and Prang Ghar (Mohmand Agency) West Pakistan. Geological Bulletin, University of Peshawar 3, 10-11.

Emerald-bearing rocks are present near Mingora in Swat State, and Prang Ghar in Mohmand Agency. Rock containing fuchsite in addition to calcite and /or siderite are perhaps the most favorable for emerald, though some pegmatite and greenschists may also have emerald. The emerald and chrome-mica (fuchsite) probably have some genetic bearing on the chrome-bearing ultramafic intrusions of the two areas.
Key Words: Petrography, gemstone, emerald, Swat.

J/45. Jan, M.Q., 1968b. Pleistocene sandstone. Geological Bulletin, University of Peshawar 3, 34.

Pleistocene sediments are exposed on the northern slope of the Cherat Range, about 1 ½ miles south east of Jalozai village. The beds dip gently to the south, making an angular unconformity with the older rocks. The base of these sediments is composed of sandstone, which is overlain by friable shale, which in turn is overlain by grit stone. This note is written with the intention to introduce the sandstone that has interesting mineralogy, which shed some light on the provenance.
Key Words: Pleistocene, sandstone, Cherat Range.

J/46. Jan, M.Q., 1969. Preliminary geology of the Shilman area, Khyber Agency, with notes on a Copper-bearing Gabbro. Geological Bulletin, University of Peshawar 4, 92-93.

Reconnaissance geological work was carried out in Shilman, Khyber Agency, and traverses were made along roads and major streams. Low-grade metamorphic rocks, striking northeast and dipping northwest, occur in the northwest of the area. The rocks are generally of a grayish color, the phyllitic rocks having well-developed cleavages. Some rocks are greenish-gray to dark gray and contain carbonaceous material. The rocks are cut by abundant quartz veins and also by some basic and a few granitic intrusions. The intrusions in the phyllitic rocks are mostly small, concordant bodies, not more than a few tens of feet thick. The basic rocks are dark colored, medium-grained gabbros and dolorites. The gabbro near Bar Kili is composed of Plagioclase, abundant dark minerals and a little quartz. The gabbro contains various copper minerals – Chalcopyrite, bornite, cuprite, malachite, etc. either disseminated, in a pockets, or as incrustations, in a ten foot-thick brecciated zone along the contact.
Key Words: Reconnaissance, geology, metamorphism, Shilman, Khyber Agency.

J/47. Jan, M.Q., 1970. Petrography of the upper part of Kohistan and southwestern Gilgit Agency along the Indus and Kandia Rivers. Geological Bulletin, University of Peshawar 5, 27-48.

This paper presents a petrographic account of the common rocks of the previously unmapped area of Indus Kohistan and southwestern Gilgit Agency. The study is based on field observations and thin section of 55 rocks selected from over 200 samples quickly collected along the Indus Valley Road and Kandia River. The major rocks of the area are amphibolites (gneissose metaigneous; some banded ? metasedimentary) and norites-diorites (the former also having a clinopyroxene), and minor (?) alpine peridotites, granitic rocks, pegmatites, and low grade regionally metamorphosed schists in the Kandia valley. The norites-diorites are abundant in the north, the amphibolites in the south. Tentative ages have been assigned to the rocks; the various igneous rocks are considered to be related to the Himalayan orogeny and emplaced between Middle/Late Cretaceous and Early Tertiary.
Comparison of the rocks from various parts of the northern West Pakistan shows that the Hornblendic Group of Martin et al. (1962) extending from Chilas in Gilgit Agency to at least Western Dir – a distance over 160 miles. There is a probability that the group may be extending in the adjacent eastern Afghanistan, which is covered by the Hindukush Range. North to south, the group may occupy a territory as wide as 60 miles.
Key Words: Petrography, amphibolites, norite, diorite, Indus valley, Kandia River, Kohistan.

J/48. Jan, M.Q., 1973. Topaz occurrence in Mardan, N.W.F.P. Abstracts, 24th Pakistan Science Conference, Islamabad, p. H-2.

Consult Jan, 1979.
Key words: Gemstones, topaz, Mardan.

J/49. Jan, M.Q., 1975. Notes on the igneous rocks of Spinkai and adjacent areas of Tirah, Khyber Agency. Geological Bulletin, University of Peshawar 7 & 8, 73-78.

A brief petrographic account of the most common igneous rocks of the Spinkai area (Tirah) is presented in this note. Reconnaissance survey reveals that like the adjacent Kohat district, much of the Tirah Tribal territory is free of igneous and metamorphic rocks. Traverses in Spinkai area indicate that crystalline rocks, mainly igneous, are confined to a narrow strip of country (only a few miles broad) extending along Afghanistan-Pakistan border. The country rocks on the southern contact are Paleozoic in age (Tahirkheli, et al., 1971). Tertiary and Mesozoic sedimentary rocks are exposed further south and east. This leads to think that in this part of the Safed Koh Range, the intrusive activity was either confined to the central part of the range, or that the main activity was older than the Tertiary (and even Mesozoic). Dolerite intrusions of probable Permian age (Tahirkheli, Personal Communication) are common to the northeast between Torkham and Jamrud. Ahmad et al., (1969) have also reported basic and acid igneous rocks of Late Mesozoic to Early Tertiary age from the Warsak area, farther northeast.
Key Words: Reconnaissance, petrography, Spinkai, Tirah, Khyber Agency.

J/50. Jan, M.Q., 1977a. The Mineralogy, Petrology and Geochemistry of Swat Kohistan, NW Pakistan. Ph.D. Thesis, University of London, 349p.

This is the first detailed petrological description of the southern part of the Kohistan island arc, supported by hundreds of whole rock and mineral chemical analyses. It describes the petrological aspects of the ultramafic rocks and garnet granulites of the Jijal complex sitting on the Indus suture, the southern amphibolites, gabbronorites of the now called Chilas complex, and quartz diorites to the south of Kalam. It is shown that the amphibolites and gabbronorites extend from Swat towards Chilas. Mineralogical aspects of pyroxenes, amphiboles, garnets and other minerals are elaborated.
Key Words: Mineralogy, petrology, geochemistry, amphibolites, gabbronorites, diorites, Jijal complex, Swat Kohistan.

J/51. Jan, M.Q., 1977b. The Kohistan basic complex: A summary based on recent petrological research. Geological Bulletin, University of Peshawar 9&10, 36-42.

The central part of the Kohistan basic complex in the Swat district has been studied in detail petrographically and geochemically. The main rocks of the area–amphibolites, noritic rocks, and quartz diorites – do not appear to be directly related mutually or to the rocks of the Jijal complex (garnet granulites and alpine-type ultramafic rocks). Temperature pressure estimates suggest that the various metamorphic rocks of the area were formed under different geothermal gradients. It is recommended that the noritic rocks be henceforth called pyroxene granulites.
Key Words: Petrography, petrology, geochemistry, Swat Kohistan.

J/52. Jan, M.Q., 1979a. Petrography of the Jijal complex, Kohistan. Geological Bulletin, University of Peshawar 11, 31-49.

This paper presents a detailed petrography of the garnet granulites and garnet-free ultramafic rocks which constitute a > 150 sq. km tectonic block at Jijal, Indus Kohistan. The granulites are classified into 1) those with essential plagioclase, and 2) those with little or no plagioclase; the two types are a consequence of bulk chemical rather than environmental differences (Jan and Howie, in prep.). A total of 17 mineral assemblages have been identified, with garnet + clinopyroxene + plagioclase + quartz + rutile ± hornblende ± epidote being the most widespread. The plagioclase-free granulites are generally composed of two or three of the minerals garnet, clinopyroxene, hornblende, and orthopyroxene or epidote. The granulites were produced by high-pressure metamorphism of a series of hypersthene gabbros with some more and some less silicic rocks.
The ultramafic rocks have alpine-type features but, unlike most alpine-type ultramafic rocks, they are dominated by diopsidites (with or without olivine); dunite, harzburgites and websterites together make less

than 50 % of the > 40 km slab. The granulites and ultramafic rocks are considered to have originated in the Tethyan lower crust-upper mantle before they were metamorphosed during the collision of the Indian-Asian masses. The granulites were intruded in the granulites as plastic material after the main metamorphism but before the two were tectonically brought in their present surroundings.
Key Words: Petrography, garnet granulite, ultramafic rocks, Jijal, Kohistan.

J/53. Jan, M.Q., 1979b. Petrography of the amphibolites of Swat and Kohistan. Geological Bulletin, University of Peshawar 11, 51-64.

The amphibolites of Swat and Kohistan are mainly found in two belts. Those forming the southern belt are the prograde metamorphic products of basic to intermediate rocks, which were intruded into tuffs, with some volcanic flows; the tuffs now represented by banded amphibolites. The rocks are locally migmatitic and are essentially composed of hornblende, plagioclase and or/clino-epidote, with garnet and/or quartz in some places. Opaque minerals, rutile and/or sphene are the common accessory minerals, while white and dark micas, clinopyroxene, carbonate, k-feldspar, margarite, corundum, cummingtonite, zoisite, green spinel and staurolite are locally present. The amphibolites of the granulite belt are retrograde products of the pyroxene granulites, mainly due to an influx of water, and are essentially composed of hornblende and plagioclase.
Key Words: Petrography, amphibolite, Swat, Kohistan.

J/54. Jan, M.Q., 1979c. Petrography of pyroxene granulites from northern Swat and Kohistan. Geological Bulletin, University of Peshawar 11, 65-87.

The pyroxene granulites of Swat and Kohistan, formerly called norites, form a part of an extensive belt stretching between Nanga Parbat and central Dir. They are relatively uniform in composition and usually represented by leucocratic rocks essentially composed of plagioclase, orthopyroxene and clino-pyroxene, with subordinate amounts of quartz, opaque mineral(s), apatite, amphibole, biotite and, locally, garnet; but some of the rocks contain a higher proportion of amphibole and biotite. The proportion of quartz increases towards the intermediate members, which may also have essential K-feldspar. The rocks are gneissose (foliated) and layered/banded, with some of the layers being pyroxenitic or anorthositic. Some of the bands are due to metamorphic segregation whilst others are relict igneous layers modified by metamorphism.
This paper presents a detailed account of the petrography of the rocks together with a discussion on the nature of the foliation, layering, and other aspects (xenoliths, hornblende-pegmatite, etc), and details of the plagioclase in the granulite. Many of the features can be better explained by invoking metamorphism. It appears that the rocks crystallized plutonically from an andesitic basalt magma in an island arc or a continental margin, were metamorphosed (800ºC, 7-8 kb) and finally intruded, as crystalline material capable of plastic flow, in the country rocks which were passing through amphibolite facies metamorphism.
Key Words: Petrography, gabbronorites, pyroxene granulite, Swat, Kohistan.

J/55. Jan, M.Q., 1979d. Petrography of quartz diorites to the south of Kalam, Swat. Geological Bulletin, University of Peshawar 11, 89-97.

The quartz diorites of Swat Kohistan appear to be partial melting products of more mafic rocks during the collision of Asian-Indian landmasses and the Himalayan orogenic-metamorphic episodes. On the basis of texture and type of principal mafic mineral(s), at least four types of quartz diorites can be recognized in the area to the south of Kalam. One of these, with strongly pleochroic hypersthene relics, appears to be a retrograde type after pyroxene granulites. It is not clear whether or not the other types are a product of differentiation from a single parent magma; however, it is likely that they represent independent pulses of diorite (andesite) magma produced over a considerable length of time (Late Cretaceous to Middle Tertiary), the earlier ones having been metamorphosed.
Key words: Petrography, quartz diorites, Kalam, Swat

J/56. Jan, M.Q., 1979e. Topaz occurrence in Mardan, North West Pakistan. Mineralogical Magazine 43, 175-176.

Colouless, purple, and pink topaz and transparent quartz crystals have been found in calcite veins (with or without milky quartz) in calcareous rocks near Katlang (34 ~ 24' N, 72 ~ 6' E), Mardan. The veins do not contain any fluorite nor the country rocks any topaz. The topaz and transparent quartz crystals are mostly broken and perfectly euhedral outlines are very rare. Refractive indices, 2V, specific gravity, and the fluorine (determined) and H20 + (calculated) contents of two topaz crystals are suggestive of their high I00 OH/(OH+F) ratios (> 25). Rather than being derived, the topaz may have formed in situ by hydrothermal/pneumatolytic activity, followed by tectonic movements that fractured the crystals and resulted in their incorporation in later-formed vein calcite.
Key words: Gemstone, topaz, Mardan.

J/57. Jan, M.Q., 1980. Petrology of the obducted mafic and ultramafic metamorphites from the southern part of the Kohistan island arc sequence. Geological Bulletin, University of Peshawar 13, 95-107.

The ~ 36,000-km2 Kohistan region is a well-defined tectonic zone with unusual lithology when compared to the neighboring regions. It is occupied mostly by plutonic and volcanic igneous rocks ranging from ultramafic to silicic. A few authors have suggested that some or the entire Kohistan zone represents a fossil island arc. Based on over 250 rock and minerals analyses, mainly from Swat, a petrological account of the mafic and ultramafic rocks of Kohistan is presented below, together with comments on their tectonic environments, metamorphism, and the duration of the presumed island arc.
The basic rocks occur in two NE-trending belts of amphibolite and pyroxene granulite stretching from Nanga Parbat to eastern Afghanistan, and in the wedge-like tectonically-emplaced Jijal complex (~ 200 sq. km) which comprises garnet granulites and alpine ultramafics. It is suggested here that most of the southern amphibolites (and the overlying metasediments of the Kalam group) represent the Tethyan oceanic crust and the alpine ultramafics the underlying upper mantle. The pyroxene granulites, some amphibolites and, probably, Jijal garnet granulites have been derived from a high alumina tholeiite (calc-alkaline) magma that was intruded into the oceanic crust during the early phases of arc-building.
Key words: Petrology, mafic-ultramafic rocks, amphibolite, Kohistan Island Arc.

J/58. Jan, M.Q., 1982. Chemical changes accompanying the granulite to amphibolite transition in Swat Kohistan, North West Pakistan. In: Sinha, A.K. (ed.), Contemporary Geoscientific Researches in Himalaya 2, 49-52. Singh, Dehra Dun, India.

In southern Kohistan, gabbros and norites (granulite facies) show retrogression to amphibolites on local as well as wide scale. This is a chemical study of the phenomenon. The transition is accompanied by fall in Ti and Fe2+, and rise inFe3+, alkalies, H_2O, Ba, Cu, Ni, and Y.
Key words: Geochemistry, granulite, amphibolite, Swat Kohistan.

J/59. Jan, M.Q. 1983. Further Data on ortho- and clinopyroxenes from the pyroxene granulites of Swat-Kohistan, northern Pakistan. Geological Bulletin, University of Peshawar 16, 55-64.

Microprobe analyses of pyroxenes from the pyroxene granulites of Swat-Kohistan are similar to their wet chemical analysis and the two sets of analysis yield similar temperature estimates. The pyroxenes are exsolved, but the exsolved pyroxene is similar in chemistry to its corresponding principal pyroxene, suggesting the attainment of physico-chemical equilibrium. The Mg /(Mg+Fe″) ratios for the coexisting pyroxenes have been plotted and the implications of granulite facies metamorphosed noritic lenses in the amphibolite belt of Kohistan discussed.
Key words: Pyroxene, pyroxene granulite, Swat-Kohistan.

J/60. Jan, M.Q., 1984a. Chromian andradite and olivine-chromite relations in chromite layer from the Jijal complex. Abstracts, First Pakistan Geological Congress, Lahore, p.56.

Green chromian andradite associated with chrysolite occurs in a chromitite layer within dunite of the Jijal complex. The garnet contains over 10% Cr_2O_3 and has the formula $Ca_{6.13}$ Cr_{137} $Fe^{+3}{}_{2.53}$ $Si_{5.94}$ O_{24}. The garnet formed during retrograde greenschist facies metamorphism of the Jijal complex. Analyses of chromite in the dunite and chromite, layers resemble those of high Cr-chromite but their total Fe is a little higher. In contrast, the olivine is highly magnesian, with a ratio 100 Mg/ (Mg + Fe^{2+}) of about 96%. These features appear to have been caused by Fe ↔ Mg exchange between the two minerals down to a blocking temperature of about 800ºC.
Key words: Andradite, ultramafics, Jijal complex, Kohistan.

J/61. Jan, M.Q., 1984b. Some K/Ar ages from the Chilas complex in Swat. Geological Bulletin, University of Peshawar 17, 171-173.

K/ Ar dates (64-79 Ma) have been obtained on four samples from the Chilas complex in Swat Kohistan. Field studies and petrography suggest that hornblende in SH 37 grew secondarily at the expense of pyroxene mainly, whereas the pegmatite bodies have formed by metasomatic processes. The age of hornblend in SH 37 is younger than that of the whole rock but the two ages would not be significantly different at the 95 % confidence level if the error in potassium determination were in fact 2 %. Surprising is the younger age of the granulite (US14) sample compared to others. It can be attributed to a number of factors such as argon loss from the non-retentive sites in the whole rock sample, to overprinting caused by a later tectonic, intrusive or magmatic activity.
It has been noted by a number of workers that K/Ar ages of rocks that have gone through polyphase metamorphism and deformation usually record younger periods than the actual age of formation (cf. Le Fort et al., 1983). It seems that the four K /Ar determinations from Swat record cooling and uplift ages after the rocks had passed through pyroxene granulite facies metamorphism. Similar ages (70-80 m.y., according to Shams, 1980, and Maluski and Matte, 1983) were obtained on Shangla blueschists of the Indus suture zone. Hence Bard (1983) suggested that the high-P metamorphism may have taken place during obduction.
Key words: Geochronology, Chilas complex, Kohistan.

J/62. Jan, M.Q., 1985. High-P rocks along the suture zones around Indo-Pakistan plate and phase chemistry of blueschists form eastern Ladakh. Geological Bulletin, University of Peshawar 18, 1-40.

The Indo-Zangbo suture zone (IZS), the Indoburman suture zone and the Chaman Fault are the traces of major collisional boundaries between the Indo-Pakistan plate and Eurasian block, Gondwanic micro-continents or island arcs. These suture zones are characterized in several places by ophiolites and tectonic melanges. High-P metamorphic rocks, generally belonging to blueschist facies, have recently been discovered along the suture zones in Naga hills, southern Tibet, eastern and western Ladakh, Swat and Afghanistan. The high-P metamorphism probably occurred during the Late Cretaceous / Paleocene. In the IZS it is complemented by low- to medium-P metamorphism to the north, suggesting a northward dip for the subduction zone. Along the southern margin of the Kohistan arc near Jijal, immediately N of IZS, gabbroic rocks were metamorphosed to high-P garnet granulite at a depth of > 40 km about 100 m.y. ago.
Detailed investigations, based on whole rock and 188 point analyses in three sections, suggest that metabasites in the eastern Ladakh ophiolites melange are ocean floor basalts metamorphosed under blueschist facies conditions. They are mineralogically similar to high-grade blueschists of other areas and contain sodic, sodic-calcic and calcic amphiboles, epidote, chlorite, albite, phengite, paragonite, garnet, quartz, rutile, calcite, and magnetite. The PT trajectory suggests that the metamorphic conditions culminated around 370-4800C, 7-8 k-bar and subsequent retrogression, possibly during uplift, took place at similar temperature but lower (6-4) pressure.
Key words: Collision boundaries, phase chemistry, blueschists, Swat, Naga hills, Ladakh.

J/63. Jan, M.Q., 1986a. Composition of the pluton core of the Kohistan island arc, NW Himalaya, Pakistan. Geological Society of America, Annual Meeting, Abstracts with Program 18, p.645.

Consult the following.
Key words: Plutons, Chilas, Jijal, Kohistan arc.

J/64. Jan, M.Q., 1986b. Composition of the pluton core of the Kohistan island arc in NW Himalaya, Pakistan. Abstracts, Symposium/Workshop on Plate Tectonics and Crust of Pakistan. Institute of Geology, Punjab University, Lahore, 19-20.

The Kohistan island arc covers about 36,000 km2 of N. Pakistan. It formed as an intra-oceanic arc in response to northward subduction of Neotethyan lithosphere during Late Jurassic-Cretaceous, and consists of arc volcanics, amphibolites, diorite-tonalite-granite plutons and minor sedimentary rocks. The base consists of the stratiform Chilas complex which stretches for >300 km with a width of about 40 km in the middle. It is composed of mildly layered gabbronorites with subordinate Qz-Hyp diorites, pyroxenites and anorthosites of calcalkaline affinity. These contain variable amounts of Pg (An64-43), Opx (En66-51), Cpx (Fs12-22, Wo 43-48), Mt, Il ±Qz ± K-spar ± Hbl ± Bio ± rare Scapolite. In the central part of the complex there are small (up to 5 sq. Kin), seemingly intrusive bodies of dunite-peridotite-pyroxenite-troctolite gabbronorite-anorthosite. -ol/pxn pegmatite association displaying excellent layering, graded bedding, slump breccia and syn-depositional faults. These rocks may be derived from a picritic melt or may be remobilized deeper-level cumulates. This association contains 01 (Fo85-73), Opx (En83-66), Cpx (Fs5.4-12.5, Wo 45-49), Pg (An98-83), Chr or Cr-Sp, Hbl and vermicular pleonaste. Association of other arc-related rocks, absence of oceanic rocks, and the chemical and mineralogical features suggest that the Chilas complex is not an ophiolite. It is similar to plutonic rocks from deeper parts of island arcs and analogous to the Border Ranges complex, Alaska. It was re-equilibrated under pyroxene granulite facies conditions (750o-850oCm 5-6.5 kb) about 110 mybp. A portion of this complex, subducted to >40 km along the Indus suture was metamorphosed to garnet granulite facies 104 mybp.
Key words: Plutons, Chilas, Jijal, Kohistan arc.

J/65. Jan, M.Q., 1988a. Relative abundance of minor and trace elements in mafic phases from the southern part of the Kohistan arc. Geological Bulletin, University of Peshawar 21, 15-25.

Many pyroxenes, garnet, hornblende, epidote, biotite, and one each of olivine and chromite from amphibolites, gabbronorites and ultramafic rocks were analysed for up to 21 minor and trace elements. Like major elements, many of these also are systematically distributed between the coexisting mineral pairs and trios. Orthopyroxene contains higher amounts of MnO, Co, Ni, Zn, and lower TiO2, Na2O, Li, Pb, Cr, V, Zr, Sr, Ba, Y, Nd and La as compared to clinopyroxene. Biotite contains more Cr, Cu, Li, Pb, and Ni than pyroxenes and hornblende. The amounts of TiO2, Na2O, K2O, Fe2O3 and Ni are higher in hornblende than in pyroxenes and garnet. Garnet is impoverished in Li, Ni, V and Zn as compared to clinopyroxene and hornblende.
Key words: Geochemistry, ultramafics, mafic phases, Kohistan arc.

J/66. Jan, M.Q., 1988b. Geochemistry of amphibolites from the southern part of the Kohistan arc, N. Pakistan. Mineralogical Magazine 52, 147-159.

The southern part of the Cretaceous Kohistan island arc is occupied by an extensive belt dominantly comprised of amphibolites. These include banded amphibolites of partly meta-volcanic parentage, and non-banded amphibolites derived from intrusive rock. In addition to being relict, banding has also been produced by shear deformation, metamorphic/metasomatic segregation and, possibly, by lit-par-lit injection of plagiogranitic material. Non-banded amphibolites also occur as retrograde products of noritic granulites forming the lopolithic Chilas complex. The chemistry of 37 rocks has been compared with those of known

tectonic environments. The amphibolites have chemical characteristics similar to volcanic rocks found in island arcs and most of the analyses apparently support affinity with the calc-alkaline series. The amphibolites consist essentially of hornblende, plagioclase and/or epidote. Garnet and clinopyroxene have developed locally in rocks of appropriate bulk composition. Metamorphism may have taken place during the mid-Cretaceous under conditions of 550 to 680 ~ and 4.5 to 6.5 kbar pH2O. The metamorphic grade appears to increase from the centre of the southern belt toward the Chilas complex to the north and Indus-Zangbo suture (IZS) to the south. In the vicinity of the IZS, garnet-clinopyroxene + amphibole assemblage developed locally in response to high P-T.
Key Words: Metamorphic rocks, amphibolites, Kohistan arc.

J/67. Jan, M.Q., 1990. Petrology and geochemistry of the southern amphibolites of the Kohistan arc, N. Pakistan. Physics and Chemistry of the Earth 17, 71-92.

The southern part of the Cretaceous Kohistan island arc is made up of amphibolites and a variety of other rocks. These constitute a more than 350 km long belt extending from eastern Afghanistan to Nanga Parbat. The amphibolites can be divided into banded and non-banded varieties. Despite a minor quantity of associated metasediments, the banded amphibolites are not metasedimentary themselves; they were derived from volcanic and plutonic precursors, whereas the non-banded amphibolites are after plutonic rocks. In addition to being relict, banding was produced by shear deformation, lit-per-lit injection of trondhjemitic material and possibly, other processes discussed in the paper. The amphibolites consist essentially of hornblende, intermediate plagioclase and/or epidote ± quartz. Almandine-rich garnet developed preferentially in rocks with low Mg/Fe ratios and diopside-salite in those with high CaO. Metamorphism took place before late Cretaceous at 550-680 ^{0}C 4.5-6.5 kbar pH2O. Locally, however, higher PT conditions operated and the two minerals grew more abundantly over a wider range of rock composition. Metamorphic conditions were locally suitable for extraction of trondhjemitic and granitic melts from the amphibolites. The chemical characteristics of the amphibolites are similar to volcanic rocks found in island arcs and most of the analyses apparently support affinity with the calc-alkaline series.
Key words: Petrology, geochemistry, amphibolites, Kohistan Island Arc.

J/68. Jan, M.Q., 1991. High-P metamorphic rocks from the Himalaya and their tectonic implication - a review. Physics and Chemistry of the Earth 18, 329-343.

The suture zones bordering the Indian subcontinent on the E, N and W are characterized in several places by the occurrence of ophiolitic complexes and tectonic melanges. High-P metamorphic rocks have recently been discovered in the melanges in Burma, Naga Hills, southern Tibet, eastern and western Ladakh, Kohistan (Jijal, Allai, Shangla) and Khost (Afghanistan). The development of these rocks has an important bearing on the plate tectonics of the Himalaya.
The High-P metamorphic rocks belong to prehnite-pumpellyite, blueschist and high-P greenschist facies but extensive garnet-granulites have developed at 35 km depth in Jijal. In the Indus-Zangbo suture zone (IZS) the high-P metamorphism is complemented to the N by low- or medium-P metamorphism and calc-alkaline magmatism in Tibet, Ladakh as well as Kohistan. High-P metamorphism in Jijal has been dated at 104 Ma, in Shangla at 70-100 Ma and in western Ladakh during mid-Cretaceous. Elsewhere, the timing of the high-P metamorphism is not known but a Cretaceous age is inferred. Since collision along the IZS occurred during Eocene, the high-P metamorphism is therefore related to the northwards subduction of the neo-Tethyan lithosphere under Tibet or late Mesozoic magmatic arcs. The timing of high-P metamorphism coincides with the breakup of India from Gondwanaland and its rapid northwards movement, whereas the tectonic melanges may principally have formed during Eocene collision and obduction.
Key words: High-P metamorphism, blueschists, greenschists, garnet-granulites, Himalaya.

J/69. Jan. M.Q., 1992. Highly aluminous hornblende-cummingtonite coronas in gabbronorites of the southern amphibolite belt, Kohistan. Geological Bulletin, University of Peshawar 25, 127-131.

The gabbronorites of the Chilas complex and southern amphibolites belt locally contain thin (<0.2 mm) amphibole coronas around pyroxene. These consist of an inner shell of fibrous, colourless to pale cummingtonite, and an outer shell of bluish green alumino-tschermakite, with or without a discrete growth of epidote + vermicular quartz on the edges of the plagioclase. The coronas represent the initial stage of amphibolite facies metamorphism, which prevailed in the southern part of the Kohistan arc during mid Cretaceous. The tschermakite, with 19.2 % Al_2O_3, is one of the most aluminous calcic amphiboles thus far reported. The primary amphibole in the gabbronorites is brown ferroan pargasite containing much higher Ti and K than the coronitic tschermakite.
Key words: Hornblend, Chilas complex, Kohistan arc.

J/70. Jan, M.Q., 1995. An inventory data base (Presentation by Group 1 in report on the regional workshop "Landslide Hazard Management and Control in the Hindu Kush-Himalayas" Chalise, S.R. & Karki, S., (Eds.), International Centre for the Integrated Mountain Development, Kathmandu, p20.

The Chairperson for this session was Professor A. Herrmann the presentations in this session were made by the chairpersons of the three working groups after extensive discussions in each group. Presentation by Group I on an Inventory Database including Socioeconomic Aspects and institutional Collaboration for National, Regional and International Levels) Professor Qasim Jan, Chairperson of Group I, presented the recommendation on "Inventory Database including Socioeconomic Aspects and institutional Collaboration for National, Regional and International Levels"
Key words: Landslide, hazard.

J/71. Jan, M.Q., 1998. 13th Himalaya-Karakoram-Tibet International Workshop (Conference Report). Episodes 21, p.106.

This workshop was held at the National Centre of Excellence in Geology, University of Peshawar from April 20-22,1998. It was convened by M. A. Khan and M. Q. Jan, and was attended by more than 160 participants, 89 of them from l3 countries outside Pakistan. The workshop consisted of two field excursions and paper presentation.
The workshop was preceded by a field excursion (April l7-19) to the sedimentary sequence of the Himalayan foothills, covering the Islamabad-Salt Range-Kohat-Peshawar section.
The workshop was followed by a week-long excursion along the KKH (April 23-29). The KKH joins China with Pakistan and follows the course of the Hunza and Indus rivers before splitting at Besham into a westerly branch (passing through Swat to Peshawar and an easterly branch (through Hazara to Islamabad). The excursion followed the westerly route on the way up and ended in Islamabad via Hazara. This trip provides a wonderful opportunity of examining a section across the NW Himalaya, Kohistan arc, and central Karakoram and the suture zones between them. Unfortunately, due to unexpected rain storm and landslides, the trip was terminated at the Shyok Suture southwest of Hunza and not much of the Karakoram section could be examined. Each of the 70 participants was supplied a 131 -page field guide edited by R D Lawrence and M A Khan.
There was a brief inaugural session chaired by RAK Tahirkheli, It consisted of introductory remarks, note of thanks, and a summary of the major contributions to the geology of the Himalaya-Karakoram region of Pakistan during the last 50 years by the Chief Guest (S H Gauhar, Geol. Surv. Pakistan).
Technical papers consisted of over 50 poster; and 80 oral presentations, covering eleven sessions:
l) NW Himalaya (Chairman: M P Searle, UK).
2) Karakoram and Hindukush (M Gaetani, Italy),
3) Suture zones and ophiolites (J P Burg, Switzerland),
4) Western Himalaya (J DiPietro, LISA),
5) Central Himalaya (B Grasemann, Austria).
6) Eastern Himalaya and Tibet (K Arita, Japan),
7) Tibet (Xian: Xuchang, China).
8) Foreland basins (V C Thakur, India),
'9) Kohistan (P Le Fort, France),

l0) Neotectonics and Quaternary (E Appel. Germany),
I l) Applied geology (M E Brookfield, Canada),
Key words: 13th HKT workshop report.

J/72. Jan, M.Q., Ahmad, I. & DiPietro, J.A., 1999. Mineralogy of a carbonatite-related fenite in Lower Swat, Northern Pakistan. Geological Bulletin, University of Peshawar 32, 71-75.

The Precambrian-Cambrian Manglaur formation contains several small bodies of carbonatite and fenite to the SE of Mingora. Their composition and close association with late Paleozoic granitic rocks is similar to these of the Naranji Kandao area in Buner. The entire suite may be related to Late Paleozoic rifting. The carbonatite is sugary sovite comprising calcite and clinopyroxene, with minor amounts of primary (?) clinozoisite, cancrinite- vishevite, apatite, sphene, opaques and zircon. The fenite consists of pure albite (abundant) calcite, biotite with > 3 % MgO and minor magnetite.
Key words: Mineralogy, carbonatite, fenite, Manglaur Formation, Swat.

J/73. Jan, M.Q. & Arif, M., 1996. Chemistry of chromite in the ophiolite complexes of Pakistan. Abstracts, 30th International Geological Congress, Beijing, p.662.

The northwestern boundary of the Indian plate in Pakistan is demarcated by a series of ophiolitic complexes and, locally, high-pressure rocks. The Indus suture in northern Pakistan contains, from east to west, Sapat, Jijal, Shangla, and Skhakot-Qila complexes, of which the latter two occur in tectonic melange zones. In addition, a lopolithic body of mafic-ultramafic rocks – the Chilas complex - also occurs in a Cretaceous magmatic arc to the north of the Indus suture. The suture on the western margin of the Indian plate contains, from north to south, the Waziristan, Zhob valley and Bela ophiolites, the latter extending for about 400 km from the coast of the Arabian sea northwards. These three are examples of megamelanges; in Bela, blocks measuring more than 100 km have been reported. The tectonic settings of these complexes have been the subject debate, mainly because of a lack of sufficient geological data.
Ultramafic and mafic plutonic rocks, ranging from residual peridotites to cumulate peridotites and gabbros, constitute large parts of these complexes. Disseminated and segregated chromite (in some economically exploitable) occurs in these complexes, and displays field and textural features similar to those reported from other parts of the world. Chemical data on composition of the chromite is available from all the eight occurrences. On the basis of chromium number [Cr # =100Cr/(Cr+A1)], the complexes can be divided into three groups: (1) the Sapat, Jijal and Waziristan complexes contain high Cr chromites with Cr # >60; (2) the Shangla, Skhakot-Qila, Zhob and Bela rocks contain chromite which displays a wide range of composition with Cr # varying from 15 to 90; and (3) rocks of the Chilas complex are characterized by low Cr chromites (Cr # <65). The petrogenetic importance of chromite chemistry has been discussed by several authors. It is interesting to note that the chromite compositions from Pakistan appear to indicate different tectonic settings for the origin of the complexes under consideration. Those with high Cr chromite have been regarded to represent island arc type origin. Opinion differs on the origin of group (2) chromite-bearing complexes; they may well be of complex origin with components which originated in different tectonic settings. The Chilas complex of group (3) containing low Cr chromite has been considered to have formed in a rift-related set up (intra-arc rifting or back arc basin). The present compilation lays emphasis on the importance of detailed mineral-chemical data to understanding the petrogenesis of ophiolite complexes.
Key words: Chromite, chemistry, ophiolites.

J/74. Jan, M.Q., & Arif, M., 1997. Comparison of chromite chemistry from the Pakistani Ophiolites. Abstract volume, 12th Himalaya-Karakorum-Tibet International Workshop, Rome, Italy.

Consult Jan and Arif, 1996.
Key words: Chromite, chemistry, ophiolites.

J/75. Jan, M.Q. & Arif, M., 1997. Comparison of chromite chemistry from the Pakistani ophiolite. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, 26-27.

Consult Jan and Arif, 1996.
Key words: Chromite, chemistry, ophiolites.

J/76. Jan, M.Q. & Asif, M., 1981. A speculative tectonic model for the evolution of NW Himalaya and Karakoram. Geological Bulletin, University of Peshawar 14, 199-201.

The Himalaya are commonly considered to be the product of collision between the Asiatic and Indo-Pakistan plates. A number of plate tectonic models have recently been proposed for the NW Himalayas. Tahirkheli et al. (1979), Klootwijk et al. (1979), and Virdi (1981) suggested the formation of Kohistan Ladakh Island arc between the two plates. Coward et al. (in press, 1982) found that the structure of the Kohistan zone is much complex for such a simple interpretation. Complicated models, involving north- and south- facing subduction zones have been envisaged by Andrews-Speed and Brookfield (1982) and Windley (pers. Comm.).
We present here a model supported by new radiometric ages. The major sequence of events during the evolution of NW Himalaya and Karakoram of Pakistan and Kashmir is tentatively proposed here to be as follow:
Early to Mid Cretaceous: N-facing subduction of the Neo-Tethyan oceanic crust to produce volcanic and plutonic rocks (Dras, Chalt, Shyoke, Kohistan amphibolites) resulting in the formation of the Kohistan – Ladakh Island arc.
Late Cretaceous: Intrusion of the Chilas, Jijal, Kargil basic complex(es); and development of bluschists.
Paleocene to very Early Eocene: Collision of the Island arc with India (Powell, 1979); obduction of ophiolites and blueschist; simultaneous N- and S- facing subduction of the oceanic crust intervening between a Gondwanic microcontinent and the Island arc to produce the earlier phases in the Karakoram- and Kohistan-Ladakh granitic belts, regional metamorphism. Eocene to Early Miocene: Eruption of Eocene Kalam volcanic; younger intrusions (some derived from continental crustal material?) in the two granitic belts (Jan et al., 1981). Post-Early Miocene: Crustal thickening and production of the youngest granitic rocks in the Karakoram belt. The tectonic position of the Khunjerab-Tirich Mir granitic belt (115-84 m. y.) is not clear to us. These rocks might be a product of N-facing subduction N of the microcontinent (? Reshun Fault or Chitral- Upper Hunza Fault of Desio, 1979, however no ophiolitic rocks have so far been found in this area. An alternative of this is to think that the granites are of Late Cimmerian tectonic phase (Desio, 1979), related to Wakhan and Pamir granites and produced by a S- facing subduction zone further north.
Key words: Tectonics, evolution, Himalaya.

J/77. Jan, M.Q. & Asif, M. 1983. Geochemistry of tonalites and quartz diorites of the Kohistan-Ladakh (Trans Himalayan) granitic belt in Swat, N. Pakistan. In: Sham F.A. (ed.), Granites of Himalayan, Karakorum and Hindu Kush. Institute of Geology, Punjab University, Lahore, 355-376.

The Transhimalayan Kohistan-Ladakh granitic belt in the Swat district, NW Pakistan, is mostly represented by plutons of intermediate composition; granites are less abundant while basic bodies are rare. This paper presents a brief account of the petrography and a detailed discussion of the geochemistry of 38 tonalites, (quartz) diorites and related rocks, analysed for up to 25 elements. The chemistry suggests that the rocks ire principally calc-alkaline in nature, many of those having island arc affinities. However, chemical variation for some elements is considerable and erratic. It is concluded that the rocks are the product of independent pulses of magma, generated by partial melting of subducted crust or the overlying upper mantle wedge over a long period from Middle Cretaceous to post-Eocene.
Key words: Geochemistry, tonalite, quartz diorite, granites, Kohistan, Ladakh.

J/78. Jan, M.Q., Asif, M. & Tahirkheli, T., 1981. The geology and petrography of the Tarbela “alkaline” complex. Geological Bulletin, University of Peshawar 14, 1-28.

The Tarbela complex comprises gabbroic rocks (oldest), dolerites, melteigites, albitites, normal and sodic granites, albite-carbonate rocks / breccia, and carbonatites (youngest), together covering an area of about 4 sq. km. The rocks have been intruded along a fault zone between the Salkhala and Tanawal formation. Some of the gabbroic intrusions display in situ differentiation with one intrusion grading from pyroxenitic outer margin in leucogabbroic/dioritic interior with a core of intrusive albitites.
Amongst typical alkaline minerals, sodic pyroboles are restricted to the sodic granite, and nepheline to the melteigite. However, trace elements in albite-carbonate rocks, the high quantity of albite ± carbonate along with consistent presence of zircon, and rutile / sphene in most albitites are indicative of their alkaline affinity. The gabbroic rocks might also be alkaline, as suggested by the abundance of amphiboles (hornblende, kaersutite, hastingsite), low An-content of plagioclase, clinopyroxene composition, the general absence of primary quartz and the possibly high Ti-content reflected in amphibole, sphene and ilmenite. These observations, coupled with the close field association point towards an overall alkaline nature of the complex. The rocks show a considerable degree of alteration (autometasomatism) with widespread development of scapolite, carbonate, amphibole, mica, sphene, rutile, etc. The country rocks have been metasomatised in the vicinity of the intrusion and scapolite, albite, carbonate, ? quartz, pyrite have been produced. Some of the albitized sedimentary rocks resemble adinoles. This paper presents a detailed account of the petrography of the complex together with optical details of the minerals and a geological map. The petrogenesis of the complex is yet not clearly understood and hypothetical schemes based on differentiation under variable PCO2 and liquid immiscibility are presented.
Key words: Petrography, alkaline complex, Tarbela.

J/79. Jan, M.Q., Asif, M., Tahirkheli, T. & Kamal, M. 1981. Tectonic subdivision of granitic rocks of north Pakistan. Geological Bulletin, University of Peshawar 14, 159-182.

The granitic rocks of north Pakistan can be divided into five types on the basis of available radiometric, petrographic, geochemical, tectonic and geographic data. (The granitic gneisses in the Nanga Parbat, Mansehra, and Swat areas are Late Precambrian (?) to Cambrian, S-type and possibly related to the Pan-African orogeny. The peralkaline to alkaline granites of Tarbela, Shewa-Shahbazgarhi, Ambela, Malakand proper, and Warsak were originated in extensional environments (rift / graben-related) during Eocene (50 to 40 m. y. ago). Dominantly calc-alkaline, Creto-Tertiary granitic rocks constitute three, several hundred kilometer long belts in the Himalaya-Karakoram- Hindukush region.
The Khunjerab-Tirich Mir belt is the oldest (~ 115 to 86 m. y.) of the three and produced in continental margin environment in response to the subduction of the Paleotethys during the Cretaceous. Radiometric ages in the Karakoram granitic belt (continental margin) ranges from 65 to 5 m. y. whilst those in the Ladakh-Kohistan granitic belt (continental margin or island arc) from 63 to 19 m.y. It is possible that both these belts are a product of simultaneous subduction along the MMT and (?) MKT. It is likely that the more basic plutons in these two belts were produced by the partial melting of a predominantly oceanic crust, whilst in the rest of the rocks of the two belts both oceanic and continental crust contributed to the magma formation.
Key words: Tectonics, granitic rocks, Himalaya, Karakoram, Hindukush.

J/80. Jan, M.Q., Banaras, M., Ghani, A. & Asif, M. 1983. The Tora Tigga ultramafic complex, southern Dir District. Geological Bulletin, University of Peshawar 16, 11-29.

The ultramafic rocks of Tora Tigga near Munda are emplaced in amphibolites of the Kohistan tectonic zone along the Main Mantle Thrust. The amphibolites are represented by metamorphosed gabbros and norites of the Chilas layered complex, and garnet-bearing mafic to intermediate plutons. The ultramafic include dunites and a variety of peridotites, pyroxenites, and hornblendites. The hornblendites are the most abundant of these, are coarse-grained to pegmatite, and contain deformed felsic dykes and veins. The origin

of the olivine- and pyroxene ultramafics is not clear; they might be alpine-type or, more probably, cumulates of the Chilas complex and related to the metamorphosed gabbros and norites. Field relations and textural features suggest that the hornblendites have formed by metasomatism of the various rocks in the area.
Key words: Ultramafic complexes, Tora Tigga, MMT.

J/81. Jan, M.Q., Colback, P.S.B. & Ahmad, M. 1985. Low-temperature secondary minerals form Tarbela. Geological Bulletin, University of Peshawar 18, 189-197.

Several types of sulfates and other minerals, believed to have formed at low temperatures, were found in a remedial excavation site overlooking Tunnel 3 and 4 on the right bank of the Tarbela Dam. Indentified with the help of optical properties, XRD and chemical analyses, these include gypsum, pickeringite, potassium alum, hydrated iron sulphate, epsomite, locontite, natroalunite, buntite, halloysite, (?) leonite and (?) starkeyite. Optical and chemical data for most of the samples studied are presented in the paper. The sulphates are thought to have formed in connection with the weathering and alteration of pyrite commonly present in the metasediments of the host Salkhala formation. The huntite has formed by the action of ground water on dolomitic rocks, or gabbros and pyroxene / hornblende peridotites, and the halloysite form alkali feldspar-rich intrusive rocks of the Tarbela "alkaline" complex compressive phases. It seems more plausible that the two sets of fractures and faults represent a conjugate set of wrench faults with a maximum stress axis of roughly E-W orientation. This also coincides with the orientation suggested by the folding (Durrani, 1980). I would like to bring the author's attention to the fact that the major faults also show a substantial amount of dip slip (normal) component (Durrani, 1980). This normal component of the faults and the gentle nature of the folds suggest that the compressional phase responsible for the folding and presumably coeval wrench faults was followed by a tensional phase. This tensional phase caused reactivation of earlier faults, now with dip slip movements, and was also responsible for the gentleness (partial unfolding) of early tighter folds. Discordance of the strike of the strata (N-S trend from the rest of the axial belt (roughly NE-SW trend) suggests that these tensional structures are probably related to some sort of rotation of the Indian craton causing subsequently tensional regime. In the light of above it is suggested that the tectonic history of the Dilband area occurred in following steps:
Folding and faulting due to compression (E-W trend).
Reactivation and dip-slip movements of the pre-existing faults and flattening of the original tighter folds due to tensional forces.
The fluorspar deposits are lacking elsewhere, including the type locality of the Chiltan Limestone (near Quetta). It seems that fluorspar deposits formed by late stage hydrothermal activity (Schcheglov, 1969), more likely in a tensional regime. Further study on the morphology and petrology of veins and, especially, new techniques in the field of fluid inclusions have substantial scope to determine the genesis of fluorspar deposits of Dilband area.
Key words: Sulfates, geochemistry, Tarbela.

J/82. Jan, M.Q. & Howie, R.A., 1980. Ortho-and clinopyroxenes from pyroxene granulites of Swat Kohistan, northern Pakistan. Mineralogical Magazine 43, 715-726.

This paper presents wet chemical analyses of forty-one pyroxenes (thirty-nine of them new) from pyroxene granulites and a few neighbouring rocks from Swat Kohistan and the adjoining Indus Valley. The granulites, considered to be derived from plutonic norites of an island arc tholeiitic nature, constitute one of the most extensive belts of its kind in the world. The pyroxenes are not unusual in any respect but they bear a closer resemblance to metamorphic than to igneous pyroxenes crystallized from deep-seated tholeiitic magmas. The distribution of Mg, Fe, and Mn (average $K^{MgFe}{}_{D} = 0.57$) and the tie-line intersections on the Wo-En join (generally from Woso.5 to Wov6.5) between the coexisting eighteen pyroxene pairs from the granulites are discussed. Based on eight different methods of geothermometry and other considerations, it is concluded that the pyroxene granulites were metamorphosed at around 800 ^{0}C and 7 to 8 kbar.
Key words: Pyroxene granulite, Swat Kohistan.

J/83. Jan, M.Q. & Howie, R.A., 1981a. The mineralogy and geochemistry of the metamorphosed basic and ultrabasic rocks of the Jijal complex, Kohistan, NW Pakistan. Journal of Petrology 22, 85-126.

The Jijal complex, covering more than 150 sq. km in the extreme north of Pakistan, is a tectonic wedge of garnet granulites intruded in the south by a 10 × 4 km slab of ultramafic rocks. The granulites are divisible into plagioclase-bearing (basic to intermediate) and plagioclase-free (ultrabasic to basic) types, the two types reflecting differences in bulk chemistry. Garnet + plagioclase + clinopyroxene + quartz + rutile ± hornblende ± epidote is the most common assemblage. The plagioclase-free rocks are composed mainly of two or three of the minerals garnet, amphibole, clinopyroxene and epidote. Orthopyroxene occurs in websteritic rocks devoid of epidote. Much of the amphibole and some epidote appear to be prograde products. Although variation diagrams do not reveal a genetic link between the two types of granulite, it is considered that they are comagmatic rather than the products of two or more unrelated magmas. The compositions of garnet ($Py_{28–46}$ Alm $_{27–43}Gro_{16–28}$), clinopyroxene ($Mg_{44–34}Fe_{5–17}Ca_{51–49}$, Al_2O_3 3·0–9·9 per cent), orthopyroxene (with up to 5·5 per cent Al_2O_3), amphibole (with up to 16·3 per cent Al_2O_3 and high Al^{vi}/Al^{iv}), and the abundance of garnet suggest a high-pressure origin for the granulites. The rocks appear to have differentiated from a tholeiitic magma of oceanic affinity or they may be genetically related to the pyroxene granulites of Swat considered to have originally crystallized from a calc-alkaline magma of island arc or continental margin affinity. They probably crystallized in the ancient Tethyan crust/upper mantle (or less likely in a continental margin), later to be metamorphosed to granulites (670–790 °C, 12–14 kb) during the collision of the Indian-Asian landmasses, and carried upwards during later Himalayan orogenic episodes. The ultramafic rocks are alpine-type in nature and devoid of garnet. They are dominated by diopsidites; dunites, peridotites, and harzburgites together form <50 per cent of the area of outcrop. The chemistry of the rocks, and their olivines ($Fo_{92–89}$) and clinopyroxenes ($Mg_{49.5–48}Fe_{2.8–5.2}Ca_{47.4–46.8}$) are similar to those of alpine complexes of the harzburgite subtype. It is not clear whether they represent a faulted slab of suboceanic crust/upper mantle, mantle diapirs in deep orogenic roots, or dismembered ultramafic rocks differentiated from a basaltic magma. They seem to have a complex history; their present mineralogy is suggestive of high grade metamorphism (800–850 °C, 8–12 kb). They are magmatically unrelated to the garnet granulites and were probably intruded into the latter as plastic crystalline material after both had been independently metamorphosed, but before the entire complex was carried tectonically into its present surroundings. The abundances of the diopsidites is in marked contrast to other alpine-type complexes and the possibility of Ca and Si metasomatism during or before their metamorphism should not be totally ruled out.
Key words: Mineralogy, geochemistry, basic rocks, ultrabasic rocks, Jijal complex, Kohistan.

J/84. Jan, M.Q. & Howie, R.A., 1981b. Petrology of minor olivine gabbros and ultramafic rocks from upper Swat, N.W. Pakistan. Geological Bulletin, University of Punjab 16, 1-10.

Small bodies of ultramafic and olivine gabbroic rocks have been reported from a number of places in the amphiboles and pyroxene granulites of Swat. Most of these rocks are inconsistent in texture, mineralogy, chemistry and the extent of metamorphism. They have probably been emplaced at different times and do not seem to be directly related mutually or to their host rocks. As an illustration, the petrography and chemistry of two olivine gabbros, two pyroxenites, one bahiaite, and a two-pyroxene-two amphibole-olivine-plagioclase-spinel rocks is presented, together with comments on the relationship between various rock types of the area.
Key words: Petrology, ultramafic rocks, Swat.

J/85. Jan, M.Q. & Howie, R.A., 1982. Hornblendic amphiboles from basic and intermediate rocks of Swat-Kohistan, northwest Pakistan. American Mineralogist 67, 1155-1178.

Chemical analyses for 21 elements together with physical data are presented for 38 amphiboles (34 of them new) from garnet granulites, pyroxene granulites, amphibolites, and quartz diorites constituting the southern half of the Kohistan Cretaceous-early Tertiary arc. The metamorphic hornblendes are rich in alumina and some of them have high Al^{vi} /Al^{iv} ratios. The influence of metamorphic conditions is not important except on A-site occupancy and, possibly, on Ti and Mn contents. Refractive indices, birefringence, and density display a systematic increase (and 2V a decrease) with decrease in the ratio (Mg + Al^{vi})(Mg + Al^{iv} + Al^{vi} + Ti + Fe^{3+}) + Fe (super 2+) + Mn). Pleochroic colors and amount of absorption are controlled by Fe (super 3+) , Ti, Fe (super 3+) /Ti, and Mg/Fe (super 2+) , while Z:c appears to increase with Fe.3+) + Ca.--Modified journal abstract.
Key words: Amphiboles, basic rocks, Intermediate rocks, Swat Kohistan.

J/86. Jan, M.Q. & Howie, R.A., 1987. Some garnets, epidotes, biotite, micas and feldspars from the southern part of Kohistan, NW Pakistan. Acta Mineralogica Pakistanica 3, 5-25.

Partial or complete analyses of 52 mineral (with trace elements for 22) from amphibolitic rocks, mafic granulites and quartz diorites are presented. Garnet development in the amphibolite belt is sporadic and controlled by bulk chemistry, especially low Mg/Fe, but in Lilauni area of the amphibolite belt and in the garnet granulites of Jijal, abundant garnet has developed in response to high pressures. The amphibolite facies garnets are distinctly richer in almandine+spessartine and poorer in pyrope and grossular components as compared to the high-pressure granulite. The epidote is mostly monoclinic with Ps content ranging from 0 to 32-mole %. Epidote composition is controlled by the Fe3+/Al ratios of the environment and by fO2 but other factors might also exert some influence. No obvious difference is seen in the epidote compositions from the amphibolites and Jijal granulites.
The biotites in granulites generally have higher Ti, and lower Mn, Al and Na than those in amphibolites and diorites, which are considered to have equilibrated at lower temperatures than the granulites. Four of the biotites are altered to varying extent and show a loss in K (and Si) and gain in H2O+ and to a lesser extent, in Ca. The feldspar analyses in some cases have excess Si and Al over Ca and alkalis. The plagioclase in a calc-silicate rock within the amphibolite terrain is albitic, it’s abnormally low An content reflecting the peculiar bulk chemical and mineralogical composition of this rock.
Key words: Garnets, epidotes, biotite, micas, feldspars, Kohistan.

J/87. Jan, M.Q. & Jabeen, N., 1990. A review of mafic-ultramafic plutonic complexes in the Indus suture zone of Pakistan. Physics and Chemistry of the Earth 17, 93-117.

Several small to large bodies of mafic-ultramafic rocks have recently been studied in the Indus Suture Zone of Northern Pakistan. These occur in tectonic melanges along the suture, as klippe over-riding the Indian plate, and as cumulate/intrusive bodies in the Kohistan arc sequence. In this paper we present the salient petrological features of six well studied and prominent complexes. The Jijal (granulite), Chilas and Tora Tigga complexes are closely associated with rocks of the Kohistan arc and have petrographic and chemical features similar to plutonic rocks from deeper levels of island arcs. The Jijal, Dargai, Shangla and Allai ultramafic bodies are found along the Indus suture. The Shangla serpentinized peridotites and Dargai klippe represent segments of the Neotethyan oceanic crust/upper mantle. The Jijal and Allai Kohistan dunite-peridotite-diopsidite association appears to have complex origin.
Key words: Mafic-ultramafic complexes, Indus suture.

J/88. Jan, M.Q., Kamal, M. & Khan. M.I. 1979. Tectonic control over emerald mineralization in Swat. Geological Bulletin, University of Peshawar 14, 101-109.

Emerald and chromian tourmaline occur in carbonate-talc / serpentine / chlorite rocks, carbonate-bearing talc schists, and associated quartz veins near Mingora, Charbagh, and Shangla. The rocks are altered ultramafics found in a discontinuous belt of volcanic, volcano-sedimentary, and sedimentary rocks that have undergone high P – low T metamorphism. The belt is a thrust slice overlying Gondwanic sialic metasediments and underlying the Kohistan (? oceanic) amphibolites both of which display Barrovian metamorphism in the almandine amphibolite facies. It appears that the emerald-bearing belt represents a marginal basin or trench rocks of (?) Mesozoic age with tectonically incorporated lenses of ultramafic rocks from the upper mantle.

Key words: Emerald, tourmaline, talc schists, tectonics, MMT.

J/89. Jan, M.Q., Kamal, M. & Qureshi, A.A., 1981. Petrography of the Loe Shilman carbonatite complex, Khyber Agency. Geological Bulletin, University of Peshawar 14, 29-43.

The Shilman complex comprises sill-form bodies emplaced along a fault zone in Palaeozoic to Precambrian metasedimentary rocks. The largest outcrop is 2.5 Km long with a width of 170m in the central part. The rock-type of the complex include altered (meta) gabbros / dolerite, followed by amphibole-apatite-, biotite / phlogopite-, and dolomitic carbonatites, syenites and lamprophyric rocks, and Fe-rich hydrothermal veins. The syenitic rocks have locally been intruded and brecciated by light-coloured sovitic veins. It is suggested that the basic rocks might be related to the rest of the complex.

The country rocks (slates, phyllites, mica schist, recrystallized limestone and quartzite) have been regionally metamorphosed up to the biotite zone of Barrovian. They display, locally, considerable fenitization with development of alkali pyroboles, phlogopite and alkali feldspars. The complex is westward extension of the over 200km arcuate belt of alkaline complexes found around the northern half of the Peshawar plain and intruded during Early Tertiary along faults resulting due to the collision of the Indo-Pak plate with Eurasia.

Key words: Petrography, carbonatite, Khyber agency.

J/90. Jan, M.Q. & Karim, A., 1990a. Continental magmatism related to Late Paleozoic-Early Mesozoic rifting in northern Pakistan and Kashmir. Abstracts, 2nd Pakistan Geological Congress, University of Peshawar, 22-23.

For details consult the following account.

Key words: Continental magmatism, Paleozoic, Mesozoic, rifting, northern Pakistan, Kashmir.

J/91. Jan, M.Q. & Karim, A., 1990b. Continental magmatism related to Late Paleozoic-Early Mesozoic rifting in northern Pakistan and Kashmir Geological Bulletin, University of Peshawar 23, 1-25.

During the Late Paleozoic and very Early Mesozoic, three groups of igneous rocks originated in the present day northwestern part of the Indo-Pakistani subcontinental landmass: 1) The Peshawar plain alkaline igneous province (PAIP), 2) The Panjal volcanics and associated intrusive rocks of Kashmir and Kaghan, and 3) The dolerite dykes in Peshawar, Hazara and Kashmir regions. The PAIP comprises the Tarbela complex (gabbros, albitites, granites), the batholithic Ambela granitic complex (AGC: granites, syenites, carbonatite, dolerites), the Shewa-Shahbazgarhi and the Warsak granites (some alkaline), gabbros and dolerite, the Malakand granite, and the carbonatite complexes of Sillai Patti (Malakand) and Loe Shilman (Khyber). The Panjal volcanics consist of flows (basalt, andesite, rhyolite and alkaline types), agglomerates and tuffs, dolerites, gabbros and norites. The Panjal igneous activity spans from Carboniferous to Triassic, but it were most extensive and voluminous during Permian. Dolerite dykes of the Peshawar, Hazara and Kashmir regions are quartz-hypersthene normative in character and have a Permian stratigraphic age.

Reliable age data are lacking for most of the PAIP, but the Koga alkaline rocks within the AGC have Rb-Sr isochron ages of 297-315 Ma, the U-Pb systematics of zircon in the Malakand granite suggest a Carboniferous age, and the Shahbazgarhi porphyries have a Carboniferous stratigraphic age. The Panjal volcanics and the dolerite dykes have similar (essentially Permo-Carboniferous) stratigraphic ages. Based on the available geochemical data in combination with the ages of the three groups of rocks, it is suggested that the present day northwestern margin of the Indo-Pakistani landmass experienced a major episode of swelling and rifting, with associated magmatism which culminated during Late Carboniferous to Early Triassic.

Key words: Continental magmatism, Paleozoic, Mesozoic, rifting, Northern Pakistan, Kashmir.

J/92. Jan, M.Q. & Karim, A., 1992. High-pressure veins in corona gabbros of Khwaza Khela Kohistan. Geological Bulletin, University of Peshawar 25, 47-50.

Gabbroic rocks of Khwaza Khela in the southern amphibolite belt of the Kohistan island arc pressure a record of thermal history from magmatic crystallization to high-pressure vein formation. The rocks formed from arc-related magma at about 1000 ^{0}C, 3-4kb, probably during the Early Cretaceous, subsequently calcic plagioclase and olivine reacted to from orthopyroxene + clinopyroxene + spinel ± tschermakite coronas at 800 ^{0}C, 6-8kb. The corona formation may have occurred in the early stages of the closure of the arc with the Karakoram plate (~ 95-102 Ma ago). Finally the rocks were subjected to high-pressure metamorphism, which is reflected in thin quartzofeldspathic veins containing garnet, zoisite, paragonite and kyanite were formed at 500-600^{0}C, 10-12 kb. This paper presents petrography of these rocks and discusses the tectonic implications of the coronas and high-pressure veins, which developed in response to cooling and crustal thickening.
Key words: Gabbros, amphibolite belt, Khwaza Khela, Kohistan.

J/93. Jan, M.Q. & Karim, A., 1994. Crustal thickening observed through Coronas and high-P veins in metagabbros of Kohistan island arc, N. Pakistan. Journal of Nepal Geological Society 10, Abstract Volume, 9th Himalaya-Karakoram-Tibet Workshop, Kathmandu, Nepal, 70.

The southern margin of the E-W trending Kohistan magmatic arc in the NW Himalaya-Karakoram ranges is made up of amphibolites and a variety of other lithologies ranging from peridotite to granite. The amphibolites are derived from volcanic and plutonic rocks of Early Cretaceous age. Gabbroic relics in the amphibolites are common both in Swat and Indus valleys. They display calc-alkaline character and their mineralogy is similar to low-pressure island arc plutonic rocks. During cooling and crustal thickening, olivine and anorthite in the gabbroic relics near Khwaza Khela (Swat) reacted to produce coronas consisting of two pyroxenes+pleonaste+tschermakitic hornblende at about 800oC, 5.5-7.5 kbar. Later these rocks were locally traversed by veins containing high-P assemblages: garnet, kyanite, zoisite, paragonite, corundum, chlorite, plagioclase and quartz. These formed in the range of 510-600oC, 10-12 kbar, either due to India-Kohistan collision in Eocene or earlier. This paper presents microprobe data on the minerals and discusses the tectonic implications of the coronitic and vein assemblages in the gabbros, which appear to have formed during cooling and crustal thickening.
Key words: High-P veins, metagabbros, Kohistan island arc.

J/94. Jan, M.Q. & Karim, A., 1995. Coronas and high-P veins in metagabbros of the Kohistan island arc, northern Pakistan: evidence for crustal thickening during cooling. Journal of Metamorphic Geology 13, 357-366.

The E-W-trending Kohistan terrane in the NW Himalaya is a sandwich of a magmatic arc between the collided Karakoram (Asian) and Indian plates. The southern part of the Kohistan arc is principally made up of amphibolites derived from volcanic and plutonic rocks of Early Cretaceous age. Gabbroic relics in the amphibolites display calc-alkaline character, and their mineralogy is similar to low-P plutonic rocks reported from modern and ancient island arcs. The largest of these relics, occurring along the southern margin of the amphibolite belt near Khwaza Khela, is subcircular in outline and is about 1 km across. It consists of cumulate gabbros and related rocks displaying a record of cooling and crustal thickening. Primary olivine and anorthite reacted to produce coronas consisting of two pyroxenes +Mg-Fe^{2+}-Al spinel ± tschermakitic hornblende at about 800° C, 5.5–7.5 kbar. This thermotectonic event is of regional extent and may be related to the overthrusting of the Karakoram plate onto the Kohistan arc some 85 Ma ago, or even earlier. Later the gabbros were locally traversed by veins containing high-P assemblages: garnet, kyanite, zoisite, paragonite, oligoclase, calcite, scapolite and quartz ° Chlorite ° Corundum ± diopside. Formed in the range 510–600° C, and 10–12 kbar, these suggest further thickening and cooling of the crust

before its uplift during the Tertiary. This paper presents microprobe data on the minerals, and discusses the tectonic implications of the coronitic and vein assemblages in the gabbros.
Key words: High-P metamorphism, Kohistan island arc, P-T path.

J/95. Jan, M.Q. & Kempe, D.R.C., 1970a. Recent researches in the geology of Northwest West Pakistan. Geological Bulletin, University of Peshawar 5, 62-89.

The northwest part of the West Pakistan has seen detailed geological investigation in several areas during the past ten years. In this paper, an attempt has been made to give a brief account of the research work (much of which has already been published) carried out in Peshawar and Malakand Divisions, and Gilgit Agency since 1974. A summary of economic investigations is given and a detailed account of the bibliography has been presented in the end to provide an easy source of references for future workers.
The important conclusion that the authors have reached from this work is that many of the more or less regionally metamorphosed rocks, previously considered Precambrian, are mainly Siluro-Devonian, to a lesser extent, Carboniferous in age, with a relative abundance of reef complexes. Many of these rocks were intruded by various types of igneous (mainly granites), mostly during the Late Cretaceous and Early Tertiary periods.
Key words: Geology, bibliography.

J/96. Jan, M.Q. & Kempe, D.R.C., 1970b. Contributions of the Department of Geology, University of Peshawar, to the geology of the N.W.F.P. Geozine, University of Peshawar, 26-31.

The Department of geology has been active in research, especially field mapping in Kohistan and Dir, and the area between the Khyber Hills and Attock, during recent years. In this paper these activities are summarized.
Key words: Field mapping, Khyber Hills, Attock, Kohistan, Dir.

J/97. Jan, M.Q. & Kempe, D.R.C., 1973. The petrology of the basic and intermediate rocks of Upper Swat, Pakistan. Geological Magazine 110, 285-300.

A series of metamorphosed (amphibolite facies) basic and intermediate igneous rocks from upper Swat, Pakistan, is described, with seven chemical analyses. The rocks intrude ?Palaeozoic metasediments and are partially bordered by other, later, intrusive and volcanic rocks. The group, now represented by, from S–N, epidote amphibolites, amphibolites, noritic and hypersthene gabbros, and quartz diorites, is considered to be derived from a series of plagioclase hypersthenites, norites, hypersthene gabbros, and hypersthene diorites. Variation diagrams are used to show that the series forms a differentiated sequence; FMA and lime-alkali diagrams suggest that it is similar to the rocks of the Garabal Hill–Loch Fyne area of Scotland. Some of the mineralogy of the group is briefly discussed, with five chemical analyses. A K/Ar age determination gives 67 Ma; thus the rocks probably derive from an early Himalayan (Alpine) tholeiitic basalt magma.
Key words: Petrology, basic rocks, intermediate rocks, Swat.

J/98. Jan, M.Q., Kempe, D.R.C & Symes, R.F., 1971. A green chrome-tourmaline from Swat, West Pakistan. Abstracts, 23rd Pakistan Science Conference, Peshawar, p.3.

Traces of a green, chrome-tourmaline occur in calcareous rock in contact with serpentinite, near Alpurai, Swat. The mineral is thought to be produced by silica-rich hydrothermal solutions, which have crystallized as thin quartz veins in the calcareous rocks. The petrography of the rock, and the optical properties of tourmaline along with its chemistry paragenesis and comparison with other such tourmaline occurrences is presented. Beside other constituents the Alpurai tourmaline has about 7.3 per cent Cr_2O_3 and 0.2 per cent V_2O_3 as revealed by electron microprobe analysis.
Key words: Tourmaline, Swat.

J/99. Jan, M.Q., Kempe, D.R.C & Symes, R.F., 1972. A green chromian tourmaline from Swat, West Pakistan. Mineralogical Magazine 38, 756-759.

Traces of a green chromian tourmaline occur in calcareous rocks in contact with serpentinite near Alpurai, Swat, West Pakistan. The petrography of the rocks and the optical properties of the tourmaline are presented along with its chemistry (it contains over 8 % Cr_20_3 and about 0.2 % V_20_3). The mineral is compared with other chromian tourmalines and its paragenesis discussed: it is thought to have been produced by silica-rich hydrothermal (or gaseous) solutions, which have crystallized as thin quartz veins in the calcareous rocks, introducing boron and other constituents.
Key words: Tourmaline, Swat.

J/100. Jan, M.Q., Kempe, D.R.C. & Tahirkheli, R.A.K., 1969. The geology of the corundum-bearing and related rocks around Timurgara, Dir. Geological Bulletin, University of Peshawar 4, 83-89.

The geology of the Timurgara, Dir area has been mapped, largely because of the occurrence of ruby corundum associated with some ultramafic bodies intruding the regional hornblende gneisses, quartzo-feldspathic gneisses, and minor phyllites.
The most abundant intrusive rocks are diorites, themselves intruded by granites. The ultramafic bodies include serpentinites, pyroxenites and the corundum-bearing amphibolites. The relationship of the other intrusive rocks is not clear.
Key words: Mapping, geology, ultramafics, ruby, corundum, Dir.

J/101. Jan, M.Q., Kempe, D.R.C. & Tahirkheli, R.A.K., 1971. Corundum, altering to margarite, in amphibolites from Dir, Pakistan. Mineralogical Magazine 38, 106-109.

Pink to pale purplish corundum crystals, generally less than 15 mm but occasionally reaching 6 cm in length, sometimes idiomorphic, are found sparsely disseminated in a dark grey tremolite rock (amphibolite) associated with small ultrabasic intrusions (?sills) at Timurgara, Dir, West Pakistan (34' 48º N., 71’ 50' E.). The corundum bearing amphibolites form bands in contact with pyroxenites and serpentinites intruded into banded hornblende gneisses (Jan et al., t969); rarely, the amphibolites themselves have a gneissose texture. The banded gneisses are composed of plagioclase, hornblende, epidote (up to 50 % in some rocks), garnet, and minor quantities of iron ore and rutile. The rocks are veined, wedged, and tongued, and are mainly metasedimentary in origin. Other intrusions of granite and, most commonly, dioritic and noritic rocks are found in the area. The latter are composed of plagioclase, bronzite, clinopyroxene, hornblende, quartz, biotite, iron ore, and apatite; such rocks are abundant to the north-east of the area in upper Swat.
Key words: Corundum, amphibolite, Timurgara, Dir.

J/102. Jan, M.Q., Khan, A. & Windley, B.F., 1983. The Waziristan ophiolite complex: Chemistry of chromites and some other minerals. Proceedings, 2nd National Seminar on Development of Mineral Resources, Peshawar 1, 16p.

The Waziristan complex covering over 500 sq. km area, was tectonically emplaced during Paleocene - Early Eocene. It consists of ultramafics, gabbros, sheeted dykes, pillow lavas and pelagic sediments rock constituting type ophiolite complexes. However, a complete sequence with all the members intact does not occur in any single locality due to dismemberment and tectonic slicing. This paper presents an account of the petrography of the complex and the mineral chemistry of the podiform chromitites. The chromites consists of aluminochromite (Cr_2O_3 = 49_6l-%) with subordinate chromian chlorite and/or chromian serpentine+ magnetite / on Cr-Al--Fe3+ + Ti diagram the chromites plot in the area of alpine chromite but on the other conventional diagram they occupy the overlapping fields of those from alpine and stratiform complexes. Many of the chromites are zoned with ferrit-chromite margin richer in the Cr/(Cr+Al) and poorer in Mg/(Mg+Fe) ratio than the unaltered cores. The chlorites are generally rich in. SiO_2 and MgO

and poor in Al_2O_3 . It is suggested that during greenschist-facies metamorphism diffusion of Mg, Al and some Cr from the chromite margins towards the silicate matrix resulted in the development of ferrit chromite and chlorite.
Key words: Ophiolites, chromite, chemistry, Waziristan.

J/103. Jan, M.Q., & Khan, M.A., 1991. Petrologic evaluation of the mafic-ultramafic complexes in the lower levels of the Kohistan magmatic arc. Abstracts, 1st Postgraduate Training Course in Plate Tectonics, Punjab University, Lahore, p.6.

Synthesis of petrographic and geochemical data presented in the past three decades suggests that the Indian and Asiatic (Karakorum) Plates in northern Pakistan are separated from each other by a sandwich of an island arc. This, subduction related Cretaceous arc, consists predominantly of igneous rocks showing various degrees of metamorphism. Our detailed investigations on three mafic-ultramafic complexes from Kohistan not only coroborate the idea of the arc but also throw light on the growth of the lower crust.
The Chilas complex is a huge mass, lore than 200 km in length and up to 40 km in width. It consists of a gabbronorites into which are emplaced small bodies of ultramafic-mafic –anorthosite rocks showing excellent layering. Mineralogical and geochemical data support a subduction-related origin for the complex which has remarkable similarities with plutonic rocks of the island arc. The complex may have developed from a mantle diaper during early arc rifting or it may represent the plutonic base for the arc volcanics.
The Jijal complex is a 100 km block of ultramafic rocks and garnet granulites along the MMT. The ultramafic rocks range from pyroxenite through peridotite to dunite with chromite segregations. The granulites range from plagioclase + Garnet + clinopyroxene + quartz + rutile + hornblend + epidote assemblage to those consisting of granulites, hornblendites, pyroxenites and epidotites (meta-anorthosites). These rocks have preserved magmatic layers despite high-pressure granulite facies metamorphism. Geochemical and mineralogical data suggest that the complex represents arc cumulates metamorphosed at 8000C, l0 kbar about 100 m.y. ago.
The small (5 km2) Tora Tigga Complex is emplaced in amphibolites just north of the suture in southern Dir. It consists of hornblendites, olivine-rich and pyroxene-rich ultramafic rocks, and plagiogranite closely associated with metagabbroic rocks probably belonging to the Chilas Complex. These rocks have calc-alkaline magmatic signatures and may be cumulates to hydrous arc magma.
Key words: Petrology, mafic-ultramafics, Kohistan magmatic rocks.

J/104. Jan, M.Q., & Khan, M.A., 1995. Potential for ruby mineralization in upper Kaghan, NW Himalaya. Geological Bulletin, University of Peshawar 28, 1-7.

The Precambrian to Early Paleozoic basement of the upper Kaghan has a cover of metamorphosed sedimentary and volcanic rocks of Late Paleozoic-? Early Triassic age. About 3 km NE of Naran, the cover rocks contain a few tens of meters thick marbles containing thin (mostly <1 cm) micaceous bands one of which hosts tiny (up to a millimeter) grains of pinkish red corundum. The occurrence of the ruby corundum is similar to the Hunza and Azad Kashmir ruby deposits, thereby necessitating further search in the area.
The marbles consist of calcite + muscovite + biotite & quartz + pyrite. The micaceous bands consist of the two mica + pyrite I- opaque oxide + calcite ± rutile ± quartz plagioclase ± chlorite ± garnet. Microprobe analyses are presented for the common phases. Petrography and preliminary geothermobarometry suggest that the marbles were metamorphosed at 450-5OO^{0}C, 6 kbar , followed by a lower temperature (~280 ^{0}C) overprinting of chlorite-epidote grade during retrogression. Considerable inter- and intra-granular variations in the Cr content of peen mica and ruby suggest a lack of mobility of Cr during metamorphism. The abundance of micaceous minerals and pyrite, and local occurrence of garnet and corundum suggest that the thin bands associated with the marbles were highly aluminous and iron-rich (?lateritic), and that reducing environments prevailed during their diagenesis.
Key words: Ruby, metamorphism, Precambrian, Paleozoic, Kaghan.

J/105. Jan, M.Q. & Khan, M.A., 1996. Petrology of gem peridote from Sapat mafic-ultramafic complex, Kohistan, NW Himalaya. Geological Bulletin, University of Peshawar 29, 17-26.

A large quantity of peridot has recently been marketed from the Parla Sapat area to the NE of Nara. The peridot occurs in pockets and veins located in shear zones in partially serpentinized dunitic host rocks. The latter constitute basal cumulates of the Kohistan magmatic arc thrust onto the Indian plate during Early Paleocene. The peridot is associated with serpentine (essentially chrysotile), minor magnetite, and local magnesite and talc. It is mostly yellowish green, takes good polish, and suitable specimens are faceted into brilliant stones of highest quality. It occurs in euhedral to subhedral crystals, but most stones are broken due to crude methods of recovery. The stones are mostly <3 cm in length, but up to 15 cm long crystals weighing 2 kg have been recovered. The largest faceted stone is reported to measure about 310ct.
The peridot is pleochroic from pale green (α=γ) to yellowish green or olive in greenish yellow variety (β=Z). Refractive indices (α = 1.644 to 1.653, γ = 1.682 to 1.684 ± 0.003), density (3.26 to 3.44) and EPMA data suggest that most specimens range in composition from Fo89 to Fo92, but some are more magnesian (up to Fo97). The depth of color increase form light green to yellowish green with increase in the Fe content, but the greenish yellow color may partly be related to a higher Ti content. Some peridot contains tiny inclusions of magnetite and hairy to acicular, brownish black ludwigite [(Ti0.011 Cr0.041 Fe^{3+}0.947) (Mg 1.085 Fe^{2+}0.897 Mn0.004 Ni0.013) BO5]. The paragnessis may be related to hydrothermal activity with also introduced CO2 and B. The undeformed nature of the peridot suggests that the solutions may be related to the late phases of Himalayan metamorphism or leucogranites of the underlying Indian plate, both of which are of Eocene age.
Key words: Petrology, gems, peridot, ultramafics, Sapat, Kohistan, NW Himalaya.

J/106. Jan, M.Q. & Khan, M.A., 1997a. Mineralogy of gem olivine (peridot) from Kohistan-Kaghan watershed. Abstracts, National Symposium on Economic Geology of Pakistan, Islamabad 2 p.

A large quantity of peridot has recently been marketed from Parla Sapat area to the NE of Naras. The peridot occurs in pockets and veins located in shear zones in partially serpentinized dunitic host rocks. The latter constitute basal cumulates of the Kohistan magmatic arc thrust onto the Indian plate during the Early' Paleocene. The peridot is associated with serpentine (essentially chrysotile), minor magnetite and local magnesite and talc.
Physical constants and chemical composition oh the peridot were studied in detail during the present investigation, It is mostly yellowish green takes a good polish and suitable specimens arc faceted into brilliant stones oh highest quality. The mineral occurs in euhedral to subhedral crystals but most stones are broken due to crude methods of recovery. The stones are mostly < 3 cm in length, but larger stone have been recovered including a 10-15 cm long crystal weighing 2 kg. The largest faceted stone is reported to measure about 310 ct.
The peridot is pleochroic from pale green (a =γ) to yellowish green or olive in greenish yellow variety (β= Z). Refractive indices range from a= 1.644 to 1.653 and γ=1.682 to 1 .684 ± 0.003, and density from 3.26 to 3.44. The refractive indices and electron microprobe analyses suggest that most peridot ranges in composition from Fo89 to Fo92 but some compositions are more magnesian (up to Fo97). The depth of colour increases from light green to yellowish green with increase in the Fe content, but the greenish yellow colour may partly' he related to higher Ti content.
Some peridot contains tiny inclusions of magnetite and hairy to acicular inclusions of a brownish black substance, locally forming mats. XRD and probe data suggest that later to he ludwigite (Ti0.011 Cr0.041 Fe3+0.097) (Mg1.085 Fe2+0.897 Mn0.004 Ni0.013) BO6 a mineral not reported previously in peridot. It is thought that the paragenesis developed along shear zones and is related to hydrothermal activity, which also introduced CO_2 and B. The undeformed nature of the peridot suggests that the solutions may he related to the late phases of regional metamorphism or leucogranites of the underlying Indian plate, both of which are of Eocene age.
Key words: Mineralogy, gems, peridot, ultramafics, Kaghan, Kohistan, NW Himalaya.

J/107. Jan, M. Q., Khan, M.A., 1997b. A review of the geology and tectonics of N. Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, 1-2.

North Pakistan is significant for its geographical position at the junction of world's three major mountain ranges; Hindukush, Karakoram and Himalayas. Several lines of evidence based on diverse geological studies including lithological and structural mapping, petrography, geochemistry, fossil findings and radiometric age determinations, have led to realization that N. Pakistan comprises three, previously discrete and distant apart, plates named Karakoram, Kohistan and India. These plates accreted to Eurasia during Jurassic-Early Tertiary to form the present-day landmass of south-central Asia.

The Karakoram plate incorporates much of the Karakoram-Hindukush ranges and adjacent areas of south-central Asia. Northern Baltistan (including K2) and upper reaches of the Hunza, Ishkuman, Yasin, Yarkhun and Chitral valleys are parts of northern Pakistan which occur in the Karakoram plate. The plate is divisible into three tectonic units; (1) a metamorphic complex, comprising metapelites with subordinate marbles of probable Precambrian-Palaeozoic age in the south. (2) an Andean-type batholith (granodiorites, diorites and granites) of Late Cretaceous-Tertiary age in the middle and (3) a succession of intact stratigraphy (predominantly carbonates ad pelites with subordinate sandstones and conglomerates) from Ordovician to Triassic in the north with rare remnants of a Precambrian basement (metapelites) near the Baroghil Pass. A series of discontinuous plutons of Late Cretaceous age, stretching from Wakhan-Trich Mir to Khunjerab and beyond, intrude this tectonic unit. The Karakoram plate is a lateral equivalent of the Lahasa block in the east, and the Afghanistan and Iran microcontinents in the west. All these microplates are Gondwanic in their faunal affinity and are considered to have been separated from the Gondwana during Permian. The paleotethys closed to the north of these microplates in Jurassic (150-145 Ma) at the site of the Rushan-Pashart-Bangong-Nujiang Suture Zone, accreting these microplates with Eurasia. The southern contact of the Karakoram plate is with the Kohistan island arc terrane at the site of the Shyok suture.

The Kohistan terrane in north Pakistan is a fossil island arc of Cretaceous-Early Eocene age. This is an east-west trending belt of 30-60 km width, encompassing the Kohistan region of north Pakistan, i.e., middle Indus, Swat and Dir valleys. It was formed in an intraoceanic setting in the Neotethys. Basalts, gabbros and ultramafic rocks predominate the early phases of arc growth giving way to the intermediate to felsic (mainly granitic) igneous rocks in the later states. The earliest rocks.in the Kohistan terrane are about l20Ma old-. This coincides with the age of the separation and northward drift of the Indian plate from the eastern Gondwana independently deduced from the ocean-floor magnetic anomaly data. The Kohistan terrane suffered two collisions; firstly it collided with the southern margin of previously accreted Karakoram-Eurasia at about 90-80 Ma (Chalt suture), when it became an Andean-type continental margin. Finally the terrane was sandwiched when the Indian plate collided with its southern margin during Early Tertiary at the site of the Main Mantle Thrust or Indus Suture. These multiple tectonic events have exposed the deepest parts of the arc crust, including Moho, attracting considerable attention from petrologists for the study of deep-arc crustal structures and composition.

The Himalayas, in essence, represent the deformed northern part of the Indian plate involved in continent-continent collision. They are regionally divisible into internal (or hinterland) and external (or foreland) zones. The internal zone occurs immediately to the south of the MMT. It comprises crystalline rocks tectonically stacked in such a way that deep-crustal (hence higher grade) rocks occur on the top of shallower, lower-grade rocks successively in the south. Polyphase deformation and metamorphism, accompanied by partial melting and granite gneisses, are characteristic of the internal zone. The external zone, which in essence, is a type foreland thrust-fold belt, comprises successions of stratified sedimentary rocks of Hill Ranges (e.g., Margala, Kalachita and Kohat), Potwar-Kohat plateau, and Salt Ranges. The classical division of the Himalayas into Tethyan, higher, lesser and sub Himalayas is not strictly applicable to the west of the Nanga Parbat Syntaxis, roughly, the Internal zone includes higher and inner part of the lesser Himalaya, while the outer part of the lesser Himalaya and sub-Himalaya occur in the external zone.

A simplistic scenario of the origin of Himalaya includes (1) subduction of the leading oceanic part of the Indian plate form about 120 Ma to about 65 Ma in the north-west, and up to 50 Ma elsewhere, (2) partial subduction of the basal parts of the Indian-plate continental crust leading to Eocene peak metamorphism including the high-P metamorphism responsible for the 49 + 5 Ma eclogites in the upper Kaghan valley, (3) rapid uplift and shifting of deformation front from the MMT successively southwards to the thrusts in the interiors of the Indian plate; Shontargali and Batal Shears at about 40 Ma, Main Boundary Thrust (MBT) at about 10 Ma and Main Frontal Thrust at the Salt Range in geologically recent past, (4) north-verging

folding of the Himalayan thrust sheets into dome and basin structures (e.g., Hazara-Kashmir, Besham, Indus and Nanga Parbat syntaxial bends and Hazara and Swat arc). Whereas the youngest of these structures are still active (e.g. Raikot fault at the western limb of the Nanga Parbat syntaxis), the older structure (e.g. MBT) have been frequently reactivated.
Key words: Tectonics, Karakoram, Kohistan arc, Himalaya.

J/108. Jan, M.Q. & Khan, M.A., 2000. A Petrological overview of the Kohistan magmatic arc, NW Himalaya, N Pakistan. Abstract Volume, 15th Himalaya-Karakoram-Tibet Workshop, (Chengdu) China, 5-6.

The Kohistan Terrane in N. Pakistan occupies the suture zone between the collided Indian and Asian Plate. It formed primarily as an intra-oceanic crust between 125 and 90 Ma prior to its accretion with the Asian plate along the Shyok Suture. The final obduction of the Kohistan onto the Indian plate in Early Eocene ensued the principal phase of the Himalayan orogeny.
A two-fold subdivision of the rocks forming the Kohistan crust is now well established. Much of the ultramafic-mafic component of the arc crust developed in the intraoceanic setting prior to collision with Asia. Mafic-ultramafic plutonic complexes (Jijal and Sapat), together with gabbroic-basaltic amphibolites (Kamila belt), at base of the arc crust, and basaltic-boninitic volcanics (the Chalt Formation) and Jaglot-Yasin metasediments, in the upper arc crust are representative lithologies of this tectonic setting. Post Shyok suture lithologies include ca.80~45 Ma Kohistan Batholith, Early Eocene utror-Shamaran volcanics and sedimentary rocks deposited in Early Eocene Dir and Drosh basins in Andean-type setting. The Chilas gabbronorite-ultramafic complex was magmatically emplaced in the waning stages of intraoceanic phase but preceded the onset of the Andean-type magmatism.
Earlier models suggested that Kohistan is a simple island arc tilted on an end with its base at the Indus suture and top at the Shyok Suture. Later, more detailed studies reported several complexities including large-scale folding of the arc crust, existence of Kamila shear zone and metamorphic ages spanning 95~85Ma. Most tectonic models fro the Kohistan Terrane Indus Suture. But several aspects of the terrane are still under discussion and need further investigations. These include: (1) Nature and extent of the oceanic basin consumed at the Shyok Suture and the palaeolatitude position of Kohistan in Late Early Cretaceous; (2) Existence and polarity of subduction zone at the site of the Shyok Suture and facing direction of Kohistan in terms of location of the fore-, and back-arc basins; (3) Timing of emplacement for the Chilas Complex, i.e., pre- or post Shyok Suture; (4) Nature of the Kamila Amphibolite belt, i.e., a stack of gabbroic-ultramafic magma chambers or a metabasalt basement with intrusive gabbroic plutons, both metamorphosed to amphibolites; (5) Nature of the mafic plutonic rocks in the Jijal Complex; garnet granulites, garnet gabbros, or both; (6) Nature of the ultramafic rocks in Jijal and Chilas Complexes: mantle peridotites, or cumulates at the base of an island arc crust or ophiolite.
Lack of rocks in Kohistan crust with a clear continental basement affinity negates possibility of its origin as a continental margins offshore the Karakoram plate. This implies that models suggesting a Sea of Japan type origin for the Shyok Ocean are invalid. Several pieces of evidence, including isotope systematics, palaeomagnetic studies and laterization favor an equatorial palaeolatitude position for Kohistan in Late Early Cretaceous. This implies that the Shyok ocean was a sizeable entity, which closed at the site of the Shyok suture after producing subduction-related 110~90 Ma Karakoram Batholith. The Suggestion that the Shyok ocean was additionally bounded by a subduction zone to its south with southerly dips that gave birth to intraoceanic Kohistan island arc is currently under debate. But the presence of boninites in Chalt Volcanics at the northern margin of the terrane certainly lends supports to this model. The mid-crust levels Chilas intrudes the interface between the Kamila amphibolites and overlying metasediments of the Jaglot group. A lower state of deformation in the Chilas Complex compared to the host Kamila Amphibolite and the Jaglot metasediments and a U-Pb zircon age of 84Ma indicates a post- or syn-Shyok Suture origin for the Chilas Complex. The 110Ma Rb-Sr whole-rocks age contradicts this interpretation warranting further geological and geochrononological investigations.
The Kamila Amphibolite belt is composite in nature. It consists of predominantly pillowed metabasalts (both MORB and arc) together with metagabbros. Burial of the Kamila pillowed metabasalts from a surface level to that of lower crust is attributed to (1) mid-crustal magmatic overloading y the Chilas Complex and (2) tectonic burial beneath the folded Chilas Complex and Jaglot Group along the Kamila shear zone. This highlights role of combined tectonics and magmatism in crustal growth in island arc.

The Jijal Complex, exposed at the base of the Kohistan Crust directly above the Indus Suture, is the most studied yet least understood unit in the Kohistan. Workers in the recent past have preferred to place petrological MOHO directly at the Indus Suture implying that the overlying 4-km thick ultramafic unit, together with garnet gabbros/granulites constituted cumulates at the base of the Kohistan Island Arc Crust. Alternatively, petrological MOHO is placed at the contact between the ultramafic and the gabbroic units implying that the ultramafic unit in the Jijal Complex is part of the infra-arc mantle. Another controversy relates with the garnetiferrous mafic rocks in the Jijal Complex. These have been interpreted to have directly crystallized as such are a product of high pressure metamorphism imprinted on what were originally gabbroic rocks or pyroxene granulites. Coherently in continuous magmatic layering with both in the ultramafic and garnet gabbros preclude Jijal Complex is a part of mantle. The structure ascribed to upper mantle can equally commonly in ultramafic cumulates. A mineral chemical data of a large number of samples, both from Chilas and Jijal do not favor a mantle nature for the ultramafic rocks of these two complexes.
Key words: Kohistan arc, orogeny, Himalaya.

J/109. Jan, M.Q., Khan, M. A. & Qazi, M.S. 1992. The Sapatgali mafic-ultramafic complex, Kohistan arc, N Pakistan. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, 44.

The Sapatgali complex is one of the several mafic-ultramafic complexes occupying the bottom of the Cretaceous Kohistan island arc. It occurs in the immediate hangingwall of the Indus suture zone along the drainage divide between the Kohistan and Kaghan terrains. Previously undescribed, much of the complex Consists of gabbroic rocks, but in the central part, there are basal ultramafic cumulates emplaced onto the Indian plate. It displays well developed layering which may be disrupted, folded, pinched and swelled. The basal ultramafics, attaining a maximum width of 1.5-km, extend for 15-km. In the central part, these can be divided into the following zones, from base to top:
Homogeneous serpentinized dunites (350 m thick), dunites with thin chromite layers (350 m), thinly layered dunites-pyroxenites (30 m), Layered dunites-pyroxenites-gabbros (170 m) with chromite layers in the lower part, and gabbros. The gabbroic rocks may be amphibolitised and consist of a variety of lithologies ranging from troctolites to anorthosites, with local pyroxenite (± olivine) layers and horizons of olivine-rich ultramafics. These rocks are at places cut by pyroxene-rich pegmatites containing upto 45 cm long pyroxene crystals.
Preliminary microprobe studies on the ultramafic rocks show that the clinopyroxene is Mg-Ca-rich diopside, and olivine has a forsterite content of 92 to 78, but in rare cases >95. The chromite displays high Cr# (75-67) and low Fe3+/R3+ (<10). These data, especially the chromite analyses, are akin to those of ultramafic rocks of island arcs, including the Jijal Complex, 80 km to the west. The huge Chilas complex, which occurs in the central part of the Kohistan arc, contains Cr-oxides with Cr# typically <60.
Key words: Ultramafics, Sapat Complex, Kohistan arc.

J/110. Jan, M.Q., Khan, M. A. & Qazi, M.S. 1993. The Spat mafic-ultramafic complex, Kohistan arc, north Pakistan. In: Treloar, P.J. & Searle, M.P. (Eds.), Himalayan Tectonics. Geological Society, London, Special Publications 74, 113-121.

The Sapat layered complex occupying the tectonic base of the Cretaceous Kohistan island arc, occurs in the immediate hanging wall of the Indus suture zone north of the Kaghan valley. Previously undescribed, much of the complex consists of gabbroic rocks, but in the basal part there are ultramafic cumulates (l5 x < 2 km) in direct tectonic contact with the Indian plate. In the central part, the complex can be divided into five zones. From the base these are: (1) homogeneous serpentinized dunites (350 m thick), (2) dunites with thin chromite layers (100 m), (3) thinly layered dunites-pyroxenites (30m), (4) layered dunites-pyroxenites-gabbros (170 m) with chromite layers in the lower part, and (5) gabbros. The gabbroic rocks are amphibolitized and consist of a variety of lithologies ranging from troctolites to anorthosites, with local pyroxenite (+ olivine) layers and horizons of olivine-rich ultramafics. These rocks are locally cut by pyroxene-rich pegmatites containing up to 45 cm long pyroxene crystals. Preliminary microprobe studies on the ultramafic- rocks show that the clinopyroxene is Mg-Ca-rich diopside, and olivine has a forsterite

content of 92 to 78, but in rare cases > 95. The chromite displays high Cr No. (75 to 67) and low Fer3+/R3+ (<10). These data, especially the chromite analyses, are akin to those of ultramafic rocks of island arcs, including the Jijal complex, 80 km to the west. We suggest that the, Sapat complex formed the basal part of the Kohistan terrain and is related to arc magmatism. It has been metamorphosed under epidote amphibolite facies conditions.
Key words: Ultramafics, Sapat Complex, Kohistan arc.

J/111. Jan, M.Q., Khan, M.A. & Windley, B.F., 1989. Mineral chemistry of the Chilas mafic–ultramafic complex, Kohistan island arc, N. Pakistan: oxide phases. Geological Bulletin, University of Peshawar 22, 217-239.

The Chilas Complex contains a great variety of Fe^{3+}, Al, Cr, and Ti oxide phases. The principal gabbronorite association (PGA), which forms much of the complex, and the amphibolite dykes which represent a younger magmatic event in the Chilas Complex, contain magnetite-ilmenite pair exsolved from an initially single phase; no Cr-Al spinel occurs in these rocks. The ultramafic-mafic-anorthosite association (UMAA) of rocks, which appears to be emplaced in the PGA, contains oxides covering the entire range from pleonaste through Al-Cr-Fe^{3+} spinel (with a maximum of 39 wt. % Cr_2O_3) to magnetite. These display complete ranges for Cr / (Cr + Al) and Fe^{3+} / R^{3+} ratio which decrease with increase in Mg / (Mg+Fe^{2+}) ratio (0.7 to 0.0). The composition of the UMAA spinel varies form one to another samples and in some cases from grain to grain within a single specimen. The variations are attributed to subsolidus re-equilibration with adjacent silicate grains and to exsolution. The exsolved pairs define a complete solvus similar in shape to those reported elsewhere. The UMAA also contains pleonaste formed in reaction coronas between calcic plagioclase and olivine, and in few cases, ilmenite formed during exsolution of Cr-Al-Fe^{3+}spinel. Exsolved oxide phases in both the associations of rocks have re-equilibrated under low oxygen fugacity during cooling of the complex at temperature ranging form >800 to 500^0C. The detailed microprobe analytical data for the oxide phases discussed in this paper support our earlier view that the Chilas Complex is related to the Kohistan arc probably formed during intra-arc rifting in initial stages of development of a back-arc basin.
Key words: Ultramafics, Spinels, Chilas Complex, Kohistan arc.

J/112. Jan, M.Q., Khan, M.A. & Windley, B.F. 1992. Exsolution in Al-Cr-Fe3+ spinels from the Chilas mafic-ultramafic complex, Pakistan. American Mineralogists 77, 1074-1079.

The Chilas complex contains accessory and segregated spinels that display a complete range from Cr-poor pleonaste through Al-Fe3+ -rich chromite to Cr-poor magnetite. Microprobe data reveal complete ranges for the Cr(Cr + Al) and Fe3+/R3+ ratios, whereas the Mg/(Mg + Fe2+) ratio ranges from 0.7 to 0.0; the former two ratios increase as the latter decreases. Grain to grain compositional variation within a thin section is common.
It is particularly drastic in tiny spinel grains and is mainly because of subsolidus reequilibration with adjacent grains of olivine, pyroxenes, and amphibole. Many samples also contain aluminum chromium spinel with blebs and lamellae of exsolved Fe3+-rich spinel.
The exsolved grains define a complete solvus, the shape of which is similar to those of other documented examples of exsolved spinels in the system (Mg-Fe,)$Fe^{3+}{}_2O_4$-(Mg- Fe^{2+})Cr_2O_4-(Mg-Fe^{2+})Al_2O_4. Exsolution probably took place during cooling at <600 ^{0}C.
Key words: Ultramafics, spinels, Chilas Complex, Kohistan arc.

J/113. Jan, M.Q. & Khan, M.J., 1992. Precambrian sequence of Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, 17-18.

Precambrian rocks in NW Pakistan can be classified into a basement (Salkhala Group) and overlying slates (Hazara, Attock Formations), quartzite (Tanawal Formation) and conglomerate (Tanaki Formation). The Salkhala Group consists of metamorphosed pelites with significant graphitic, quartzitic and carbonate

components, and associated gneisses, pegmatites and dolerite dykes at many places. There is a general increase in the grade of metamorphism towards north, with varying types of schists, migmatites and paragneisses. Radiometric studies in the Nanga Parbat Haramosh area and Besham suggest that the oldest rocks are at least 1850.1950 M.Y. in age.
The slate sequence is overlain by the Tanawal Formation and comprises quartzite, quartzitic schist, phyllite and some conglomerate. It is intruded by granitic rocks. Major pluton intruding these quartzites is the Mansehra Granite, with Rb/Sr isochron age of 516±16 MY. The upper most part of Precambrian sequence in NW Pakistan is formed by a conglomeratic unit, the Tanaki Formation.
Key words: Precambrian, Pakistan.

J/114. Jan, M.Q., Khan, M.J. & Hamidullah, S. (eds.), 1989. Tectonic Evaluation of Collision Zones between Gondwanic and Eurasian Blocks. Special Issue Geological Bulletin, University of Peshawar 22, 239p.

Key words: Tectonics, collision zones, Gondwana, Eurasia.

J/115. Jan, M.Q. & Khattak, M.U.K., 1983. Petrology of a hornblende-rich pegmatite and host amphibolites near Matta, upper Swat. Geological Bulletin, University of Peshawar 16, 31-41.

The 500 × 30m pegmatite near Matta consists of hornblende + epidote + garnet lithology and hornblendite, with a small proportion of leucocratic, deformed dykes and veins. It is hosted by epidote amphibolites derived from gabbroic rocks and belonging to the southern amphibolite belt of the Kohistan zone. The hornblende-epidote lithology of the pegmatite is chemically identical to the amphibolites and is, therefore, neither a younger intrusion in nor a metasomatic product of the amphibolites. The coarse-grained fabric of the pegmatite may have developed locally in response to a higher concentration of fluid phase, mainly water but some fluorine. The hornblendite, which is coarser grained (with up to 35 cm long crystals) and may cut the hornblende-epidote lithology, may be a product of metamorphic differentiation or, more likely, metasomatism. The amphibolites are tholeiitic in affinity and probably represent the Tethyan oceanic crust.
Key words: Petrology, pegmatite, amphibolite, Swat.

J/116. Jan, M.Q., Khattak, M.U.K., Parvez, M.K. & Windley, B.F. 1984. The Chilas stratifrom complex: field and mineralogical aspects. Geological Bulletin, University of Peshawar 17, 153-169.

The Chilas complex in northern Pakistan stretches for about 300 km from Astor to western Dir and attains a width of 40 km in the middle. It was probably emplaced during the early stages of development of the Cretaceous Kohistan island arc. Field observations, supported by petrography and mineral chemistry, suggest that the complex is composed of two groups of rocks. Group A consists predominantly of noritic rocks with subordinate pyroxenites, anorthosites and hypersthene–quartz diorites. These cover most of the complex, are generally strongly foliated and display some layering. The mineral composition of these rocks varies as follows: orthopyroxeneEn75 En51; clinopyroxene Mg=43 to 27, Fe=9 to 22, Ca= 42 to 50; plagioclase An62 to An43.
Group B rocks occur in the form of lenses (upto 5 km2) and smaller bodies showing complex contact relations, ranging from concordant to discordant, with their host (group A) rocks. These comprise dunite, peridotites, pyroxenites, troctolites, norite, anorthosite, and pyroxene pegmatites; of these the former two are the most abundant. The principal outcrops of these rocks are found in Chilas area but isolated, small bodies occur as far to the west as Swat. The range in the mineral composition of these rocks is: olivine Fo88 to An77; orthopyroxene En90 to En62; clinopyroxene Mg=46 to 37; Fe= 5 to 17, Ca= 49 to 45; plagioclase An98 to An77. Characteristic features of this group of rocks are the development of excellent layering and corona structure.
The group A association may have evolved from a high-alumina basaltic (calc-alkaline) magma. It is not clear whether the group B rocks represent magmatic cumulates of this magma or younger intrusions of a

more basic (picritic) magma. Both groups were probably metamorphosed under pyroxene granulitic facies, to be followed by amphibolite dykes and hornblend-plagioclase pegmatites.
Key words: Petrology, chemistry, Chilas, Kohistan.

J/117. Jan, M.Q., Khattak, M.U.K. & Tahirkheli, R.A.K. 1983. A comparison of chemistry of chromites from Zhob valley, Harichand and Waziristan ophiolite complexes of Pakistan. Proceedings, National Seminar on Development of Mineral Resources, Peshawar 3, 13p.

Chromian spinels from Zhob, Harichand and Waziristan are essentially alumino-chromites generally rich in Cr_2O_3. Different variation diagrams have been used to compare the chemistry of chromites on the basis of 73 analyses from Zhob (15 of them new), 27 from Harichand and 9 new analyses from Waziristan. On Mg/(Mg+Fe2+) vs Cr/(Cr/Cr+Al) and Fe3+/(Cr+Al+Fe3+) and Cr_2O_3 vs. total FeO and mol % Al_2O_3 /(Cr_2O_3 + Al_2O_3 +Fe_2O_3) diagrams they generally plot in the overlapping fields of chromites from stratiform and alpine complexes.
Their alpine (or ophiolitic) nature is not obvious on TiO2 vs. Fe2+/Mg diagram either, although the Waziristan chromites plot only in the alpine field on this diagram. However, on Cr-Al-Fe^{3+} +Ti diagram chromite analyses from a1l the three complexes are restricted to the field of those from alpine complexes.
The Zhob chromites display a greater range in composition due probably to a higher number of analyses from this area. In general, the Zhob chromites have a higher range in the ratio Mg/(Mg+Fe^{2+}) and Fe^{3+}/(Cr+Al+Fe^{3+}) whilst the Harichand ones have a higher range in the ratio Cr/(Cr+Al).
Key words: Ophiolites, chemistry, chromite, Zhob, Harichand, Waziristan.

J/118. Jan, M.Q., Malik, R.H. & Ahmad, K.H., 1995. Gem garnet in pegmatites from Neelum valley, Azad Kashmir. Geological Bulletin, University of Peshawar 28, 9-14.

The upper Neelum valley is occupied by a group of basement rocks of Precambrian to early Paleozoic age and a cover of younger rocks. Both the basement and cover contain Late Paleozoic (?) mafic sheets. There are at least two sets of pegmatites, one we-dating and the other post-dating the mafic sheets. A few of these contain green tourmaline, pink beryl, and colourless topaz, one of the pegmatites near the village of Phullawaii contains bluish green tourmaline and gem garnet. The garnet is well-formed and reaches up to 30 gin weight. 1 t is clear, transparent, takes a good polish, and ranges from yellowish red to tangerine and crimson red. Many spots analysed in two tiny (~ 0. 5 cm^2) grains are uniform in composition. The garnet is rich in spessartine (79.9 mole %), with small amounts of almandine (15.3 mole %) and grossular (4.4 mole %) components.
Key words: Gems, garnet, pegmatites, Azad Kashmir.

J/119. Jan, M.Q., & Mian, I., 1971. Preliminary geology and petrography of Swat, Kohistan. Geological Bulletin, University of Peshawar 6, 1-32.

Regional survey, covering 1400 square miles of area, was carried out in Swat Kohistan to prepare a preliminary geological map and investigate the structure, petrography and economic geology of the region.
The area is covered by various types of plutonic and a lesser quantity of sedimentary and volcanic rocks. Quartzite, siliceous schist, phyllite, siltstone/shale, and limestone of the Kalam Group (Carboniferous to? Siluro-Devonian) are exposed in the Matiltan-Kalam area. Norites, diorites, and the associated rocks of the Kohistan Basic Complex (Late Cretaceous) cover a large area to the south of Kalam. They form a northeast trending belt that extends to the east in Indus Kohistan and to the west in dir. To the northwest, the Kalam Group is overlain by a thick sequence of silicic to intermediate lavas, tuffs and agglomerates (the Utror Volcanic Rocks) of probable Creto-Eocene age. These, and the sedimentary rocks, have been cut by various types of plutonic rocks, mainly quartz diorites and granites, in Gabral and Ushu Valleys. The Plutons are thought to be emplaced during Early to Middle Tertiary period. Quaternary alluvium and glacial deposits occur in small quantity in all parts of the region.
Key words: Mapping, geology, Swat Kohistan.

J/120. Jan, M.Q., Parvez, M. K. & Khattak, M.U.K., 1984. Coronites from the Chilas and Jijal-Patan complexes of Kohistan. Geological Bulletin, University of Peshawar 17, 75-85.

This paper describes coronites from the Jijal-Patan and Chilas complexes of northern Pakistan. In Jijal, plagioclase and orthopyroxene reacted under high P - high T metamorphic conditions (~ 8500C, 12-14 Kbar) to produce garnet + clinopyroxene coronas. These rocks occur along the MMT suture zone and were metamorphosed at > 40 km depth due to subduction / sinking. In the Chilas complex, orthopyroxene / clinopyroxene / hornblende + spinel coronas developed due to reactions between highly calcic plagioclase and mafic minerals under medium P- high T conditions (750-8500C, 5-7 kbar). These coronas may have formed due to slow cooling, either during uplift or pyroxene granulite facies metamorphism of feldspathic peridotites, troctolites, olivine gabbros, and related rocks. At higher levels during uplift, when the Chilas complex had access to water, labradorite-andesine reacted with mafic minerals to produce thin amphibole and epidote ± quartz coronas in noritic granulites. These medium to low P - low T epidote amphibolite facies coronas are mostly very thin but quite common. In rare cases the rocks are more severely affected, thus bridging the gap to epidote amphibolites.
Key words: Carbonates, High P-T metamorphism, Jijal-Pattan complex, Chilas complex, Kohistan.

J/121. Jan, M.Q. & Rafiq, M., 1999. Highly unusual chloritoid-ilmenite-rich rocks in the Indus suture melange north of Peshawar, North West Pakistan. Terra Nostra 99 (Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany), 75-76.

The Indus suture to the north of Peshawar, along which are juxtaposed the Indian plate and the Kohistan magmatic arc, is characterized by a tectonic melange. It consists of ophiolitic ultramafic rocks, greenstone, and a variety of sedimentary rocks: metamorphosed under greenschist facies conditions (up to garnet grade) (Hussain et al., 1984). The component lithologies in the mélange may extend for tens of kilometers. Within the greenstone, there occur spare, up to 200 m long and 1 to 3.5 m thick, lenticular bodies consisting of abundant chloritoid (31 to 59 modal per cent), ilmenite + subordinate, oxidized pyrite (12 to 25 %), quartz (8 to 31%), variable amounts of white mica (up to 3.9 Wt % FeO), and chlorite (pseudothuringite to ripidolite).
The analyses of these rocks consist essentially of Si02, Ti02, Al_20_3 and iron oxide. Such compositions have neither been reported for igneous nor sedimentary rocks. Although extremely rare, similar compositions have, however, been proposed for weathered and lateritized basaltic rocks and their metamorphosed equivalents (Liou and Chen, 1978; Singer, 1975; La Tour et al., 1980). Major, trace and rare-earth element analyses of three greenstone samples show some transition towards the chloritoid-ilmenite rocks. This, coupled with the presence of local chloritoid in the greenstone, and the close association of the chloritoid-ilmenite rich rocks with greenstone suggest a common parentage for the two. The greenstone analyses contain high Ti02, Fe203, and P205. They show an enrichment in light REE and depletion in heavy REE, a negative Eu and positive Yb anomaly, and their chondrite normalized patterns resemble those of basaltic rocks from some island arcs and oceanic islands (Kay, 1984). Their Hf-Th-Ta (Wood, 1980), Ti-Zr-Y (Pearce and Cann, 1973), and Nb-Zr-Y (Meschede, 1986) relations suggest that the greenstone may be derived from oceanic islands alkali basalt.
Due to inaccessibility of the area, detailed field studies have not been performed to work out the relations of the chloritoid-ilmenite-rich rocks with their host greenstone. The former may represent shear zones in the basaltic precursors of the greenstone along which extensive alteration took place due to passage of water. More likely, the chloritoid-rich rocks may be weathered/lateritized soils whose relations with their host basalt (greenstone) have been exacerbated during melange formation, metamorphism and emplacement during the Paleocene.
Key words: Chloritoid-ilmenite rock, Indus suture, Tectonics.

J/122. Jan, M.Q. & Shah, M.T., 1987. Ni, Cr, Cu, Zn, Co, Ag and Au content of some Talc-carbonate rocks from NWFP, Pakistan. Geological Bulletin, University of Peshawar 20, 215-216.

The principal ophiolite complexes of northern Pakistan (i.e., Waziristan, Skhakot Qila, Jijal, Shangla-Mingora) are characterized by the occurrences of talc-carbonate rocks (± quartz, chlorite, serpentine, fuchsite, epidote, oxide and sparingly, emerald and Cr-tourmaline). These rocks occur along the margins of and in shear zones, within ultramafic rocks and have been considered as the product of alteration. In the southern part of the Malakand pass, there are several small lenses of talc-carbonate-quartz rocks in greenschist facies metapelites. Carbonate-bearing ultramafic rocks bordering alpine-type peridotites may contain various mineralization such as Hg, As, Co-Ni arsenides; several occurrences of gold have also been reported. The carbonate-bearing rocks, termed listwaenite, are light grey-green rocks consisting mainly of carbonates with accessory quartz, talc, serpentine, chlorite, fuchsite, hematite, magnetite, pyrite, and Cr-spinel. These grade into serpentinized peridotite through a talc-carbonate zone.
Key words: Ophiolites, talc-carbonates, Malakand.

J/123. Jan, M.Q. & Symes, R.F., 1977. Piemontite schists form upper Swat, northwest Pakistan. Mineralogical Magazine 41, 537-540.

The piemontite schist is a fine grained rock with a distinct purplish colour and a silver-grey lustre associated with the schistosity. In thin section it is composed of quartz, albite, muscovite, margarite, tourmaline, piemontite, spessartine garnet, a Mn-rich chlorite (MnO = 2.24%), rutile, and magnetite. A crude segregation of quartz and albite from the muscovite, piemontite, tourmaline laminae occurs in the plane of the schistosity. The quartz grains are anhedral, interlocking and of even grain-size up to 0.25 mm in diameter and constitute modally 40 % of the rock. They commonly contain inclusions of small euhedral piemontite and magnetite crystals. Albite occurs as broadly twinned poikilitic patches up to I mm across and containing abundant inclusions of the associated minerals, which form a distinctly crenulated schistose fabric. The albite poikioblasts often show rotational features suggestive of syntectonic growth. Muscovite occurs as bundles of colourless or slightly rose-coloured grains. Margarite and the manganese-rich chlorite both occur in blebs of small colourless, radiating brushes.
Both the piemontite and the tourmaline occur as euhedral, elongated crystals subparallel to the dominant schistosity, the former being strongly pleochroic whereas the latter is colourless, or a very dull yellow dravite, showing some pleochroism in shades of pink. In the quartz-poor areas of the schistose fabric piemontite constitutes up to 15 % of the rock, some crystals being elongated up to 0.4 mm in length and 0.1 mm broad. The piemontite grains almost always carry tiny magnetite inclusions concentrated in their cores. Spessartine garnet is not common but forms occasional idioblastic crystals the habit of which seemingly indicates a late metamorphic growth, enclosing piemontite and tourmaline. Microprobe studies show that the disseminated magnetite is often intimately associated poikioblastically with minute rutile grains. The piemontite crystals in orientation suitable for optical examination consist mainly of 0.05-0.1 mm prisms elongated along [010]. Twinning on {100) was only rarely observed. However, two crystals twinned on {100) and lying parallel to the optic plane (010) were measured for *u, y,* and for the extinction angles. Dispersion of the indicatrix is strong and values are for NaD only: *CY* 1.748, canary yellow, /1 1.770, amethystine pink, y 1.795, deep rose pink, *?-a* 0.047, 2Vy calc = 87" 29'.
An XRF analysis of the whole rock, using pressed-powder discs, was carried out for major, minor, and a range of trace elements. H20+ was determined by the Penfield method and FeO by Wilson's method. Accuracy should be within f 2% of the amounts present for the major elements. The values quoted in Table I for Co, Ga, Y, and Zr are expected to be correct to within I 5 ppm, Cr, Ni, and Sr to within 20 ppm, and those for Ra, Cu, and Zn within 40 ppm. Owing to the over-all small grain-size and presence of magnetite inclusions the piemontite was not separated for chemical analysis, but analysed by electron-microprobe. The reported analysis of the piemontite is the average of three homogeneous grains free of inclusions and large enough to allow ten spot counts per grain. Total Mn has been expressed as Mn203 and total Fe as Fe203 following Deer *et* al. The analysis shown in Table I is expected to be accurate to ±2 % of the amounts present for the major elements.
Compared to an average Palaeozoic shale, from which the piemontite schist is probably formed (Clarke, 1924), the rock has higher SO_2, MgO, CaO, and K_20 and lower Ti02, Na_20, and P_20_5. The values for Ba, Cr, Ga, and Zr are lower, and those for the other trace elements higher than those given for an average shale by Turekian and Wedepohl (1961). The significant difference of the Swat rock from the average values is in its nickel (2 x the average content), copper (> 11 times that of the average), and especially Mn (20 x).

The high manganese value reflects special circumstances, which precipitated abundant manganese at the time of the deposition of the shale horizon. Local volcanic or hydrothermal activity may have been the contributory factor.
The manganese content of the piemontite (Mn_20_3= 12.55%) is high for this mineral although Bilgrami (1956) has reported up to 17.78 % Mn203 from a piemontite in a pegmatite from Chikla, India. The analysis has been recalculated on the basis of twelve oxygens in Table I. From this it appears that all the Mn3+ and Fe3+ are in octahedral co-ordination. However, a survey of the analysed epidote group minerals in the literature suggests that the Mn occurs in different oxidation states, most of it being octahedral but some also occupying some of the large cation sites (Hutton, 1942; Bilgrami, 1956; Cooper, 1971; Marmo et al., 1959; Short, 1933). This also seems to be the case of the Swat piemontite, if the formula is recalculated on the basis of 13 (O, OH) after adding 1.84% H, O to the analysis to give I (OH) in the formula($Ca_{1.4}Mg_{0.01}Mn_{0.16}K_{0.01}$) ($Al_{1.88}$ $Fe_{0.50}$M~0.62)$Si_{3.00012}(OH)_{1.00}$. In this formula Mn is about four times as abundant in the octahedral site as in the large cation site and is in accordance with most of the earliest piemontite analyses (see Short, 1933). Cooper (1971) argues that bulk chemistry (especially oxidation state) rather than the metamorphic conditions controls the occurrence of piemontite. Further determinations of Mn_20_3 and MnO contents of the piemontite-bearing rocks are needed to verify this, because, as pointed out by Cooper, most metamorphic occurrences of piemontite are in high-pressure or in high-pressure to intermediate-facies series terrains. The Swat rock seems also to have formed under high-pressure conditions. Apart from its closeness to the thrust fault and the glaucophane schist it occurs in a belt of schists that in places contain chloritoid, garnet, staurolite, and kyanite.
Key words: Peimontite, mineralogy, Upper Swat.

J/124. Jan, M.Q. & Tahirkheli, R.A.K., 1969. The geology of the lower part of Indus Kohistan (Swat), West Pakistan. Geological Bulletin, University of Peshawar 4, 1-13.

An area of over 450 square miles in Indus Kohistan, Swat, has been mapped and the detailed petrography of the rocks is presented. The area investigated is bounded by latitudes 350 15′ to the north, and 340 45′ to the south, by the Indus River to the east, and by the drainage divide of the Indus and Swat Rivers to the west. The predominant rocks in the southeast and south belong to the Lower Swat-Buner Schistose Group (Siluro-Devonian or possibly Ordovician). The Schistose Group is commonly represented by low grade quartzite, quartz-mica schists, amphibolites, marbles, calcareous schists, phyllitic schists, graphitic schists, and greenschists. These were intruded by ultramafic rocks (pyroxenites and dunites near Jijal; serpentinites near Alpurai, Jijal etc.) during the earlier phases of the Himalayan orogeny (middle to late Cretaceous). During later orogenic phases (early Tertiary), the area was intruded by the abundant Swat Granites and Granite Gneisses (generally leucocratic, two feldspar-bearing rocks) and pegmatite, and major gneissic granodiorites near Shang and Dubair. These events were followed by overthrusting of the (?Precambrian) Upper Swat Hornblendic Group which covers the northern and northwestern part of the investigated area. The Hornblendic Group is represented mostly by diorites, metadiorites, hypersthene gabbros, and garnet-amphibole gneisses.
Key words: Geology, mapping, Indus Kohistan.

J/125. Jan, M.Q. & Tahirkheli, A.Z., 1990. The Tora Tigga complex, southern Dir, NW Pakistan; an example of mafic-ultramafic rocks in the bottom of an Island arc. Geological Bulletin, University of Peshawar 23, 231-251.

The Tora Tigga complex comprises dunite, peridotites, pyroxenites, hornblendites, metagabbros and plagiogranite covering over 6 km area. It is located in the north of the Indus-Zangbo suture, in an extensive terrain of amphibolites that form the southern part of the Cretaceous Kohistan island arc. The ultramafic rocks are closer to those found in stratifrom complexes than to oceanic peridotites and the metagabbros are calc-alkaline island arc-type. Chemical variation suggests that the rocks are magmatically related. They probably represent amphibolites facies metamorphosed cumulates in a magma chamber of the Kohistan arc. The hornblendites are medium-grained to pegmatitic, and range from small dykes, patches and pools to large bodies over 2.5 km in length. There are gradational lithologies to pyroxenites and peridotites in which

hornblende is replacive in texture; however, chemical data do not support a metasomatic origin for such rocks and the hornblendites.
Key words: Ultramafics, Island Arc, Tora Tigga, Dir, Kohistan.

J/126. Jan, M.Q., Weaver, B.L. & Windley, B.F., 1997a. Summarized petrology of the garnet granulites of the Jijal complex, Kohistan Himalaya. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, 28-29.

For more details consult the following account.
Key words: Petrology, garnet granulites, Jijal, Kohistan.

J/127. Jan, M.Q., Weaver, B.L. & Windley, B.F., 1997b. General petrology of the garnet granulites of the Jijal complex, Kohistan Himalaya, Pakistan. Abstract volume, 12th Himalaya-Karakorum-Tibet International Workshop, Rome, Italy, 75-76.

The Indus Suture in northern Pakistan is the trace of the collisional boundary between Indian Plate and the Cretaceous Kohistan magmatic arc. A series of mafic-ultramafic rocks occurs in the hanging wall of the Suture. Of these, the Jijal complex (73°E, 35°N) is unique in several ways. This 150 km2 tectonic block consists of a wide range of ultramafic to mafic rocks. The southern part of the complex is occupied by a 10x4 km slab comprising chromite-bearing dunite, peridotites and pyroxenites that are layered in many places. To the northeast of these, the main mass of the complex consists of garnet granulites derived from gabbros, tractolites, pyroxenites and anorthosites that too are locally well-layered. The mineral assemblages in these record granulite facies conditions at 10-15 Kbar, which may be, related to subduction of the complex some 105 Ma ago.
The garnet granulites display many assemblages, of which the most abundant is Grt-Cpx-Pl-Qtz-Rt±Hbl±Ep. Other include hornblendites (commonly with garnet±Cpx), garnetites (±Cpx±Hbl±Pl), garnet pyroxenites (±Hbl), garnet anorthosites (±Cpx±Scp), and retrograde assemblages some of which contain Zo+Ky+Pg. Thousands of mineral analyses have been performed with EPMA. In the ultramafic rocks, the olivine is Fo98-83, orthopyroxene is En91-78, clinopyroxene is diopside with low Al and Na, and chromite has a Cr/(Cr+Al)>0.6[1]. In the granulites, the phases show a wide variation, reflecting variation bulk chemistry.
Garnet consists of 14 to 68 mole% Prp, 23 to 58% Alm, 15 to 45% Grs, and low Adr (<5%) and Sps (<1.5%). Clinopyroxene ranges from $Mg50Fe_2Ca48$ to Mg32Fe17Ca51, with up to 11.3 wt% Al2O3 and <2.5% Na2O. Plagioclase ranges from An50-22, but a few more calcic compositions (up to An87) may be pre-metamorphic. Olivine (Fo85-75) and orthopyroxene (En86-67) occur in a few ultramafic members. Hornblendic amphibole contains 14-20% Al_2O_3, moderate Na_2O (typically 2 to 3%), and low TiO_2 (mostly <1%). Paragonite ranges from P99-87, Epidote from Ps0-33, and scapolite from Me72-62.
Major and trace-element analyses of many dozen garnet granulites have been performed. A mantle-normalized multi-element diagram for some of the mafic members shows positive anomalies for Ba, Sr, P and Ti, and negative for Nb, Ce and Zr. These characteristics, especially the Nb and Sr contents and the overall shape of the spidergram, are typical of the subduction-related magmas. The peak and small Ce trough may be reflection some crustal input to the mantle derived magmas. The granulites display rather complex REE pattern but all show a positive Eu anomaly against chondrite. The mutual relationship of the ultramafic rocks and garnet granulites has not been deciphered as yet, but both display layering and probably represent cumulates related to the Kohistan arc.
In the upper structural levels near Patan, the granulites contain blocks of gabbro-norites apparently equilibrated in hornblende granulite facies (Pl-Opx-C0x-Hb). The blocks are traversed by dyke-like bodies of garnet granulite; however, the two lithologies show a gradual passage within a couple of centimeters. There is a perfect match in the major and trace element contents of the and we regard the gabbronorite as precursor of the garnet granulite. It appears that the development of the garnet granulites due to increased pressure in lower crust accompanied the loss of H_2O (and addition of CO_2) along fractures.
Key words: Petrology, garnet granulites, Jijal, Kohistan.

J/128. Jan, M.Q., Wilson, R.N. & Windley, B.F., 1982. Paragonite paragenesis from the garnet granulites of the Jijal complex, Kohistan, N. Pakistan. Mineralogical Magazine 45, 73-77.

Chemistry of six white micas from the high-pressure garnet granulites of Jijal is presented, together with trace elements, refractive indices, and 2V, for one. The micas are rich in the paragonite component (over 93%), with one analysis having the highest 100 Na/(Na + K) ratio (98.5) so far reported. The paragonite is not a stable mineral of the granulites but was overprinted on the granulites at about 505-540 ~ and 8-9 kbar (suggesting a depth of 30 km).
Key words: Garnet granulites, Jijal, Kohistan.

J/129. Jan, M.Q. & Windley, B.F., 1990. Chromian spinal-silicate chemistry in ultramafic rocks of the Jijal complex Northwest Pakistan. Journal of Petrology 31, 667-715.

The approximately 150 km^2 Jijal complex occupies a deep-level section of the Cretaceous Kohistan are obducted along the Indus suture. The complex consists of mafic garnet granulites, and a > 10 km × 4 km slab of pyroxenites (diopsidite > websterite; ± olivine), dunite, and subordinate peridotite, all of which are devoid of plagioclase. These contain chromite either in lenses, layers, and veins or as disseminated grains. The chromite is mostly medium grained, subhedral to euhedral, shows pull-apart texture, and may contain inclusions of associated silicates. Chromite grains within thin sections of chromitite are generally homogeneous in composition, but dunite and pyroxenite samples commonly contain chromite grains of variable composition. The segregated chromite has higher Cr_2O_3 wt%, *cr*-number, and mg-number, and lower *fe*'-number than the accessory chromite. These variations are mainly attributed to subsolidus exchange of Mg and Fe between chromite and associated olivine or pyroxene, and to inheritance from a magmatic source, but other factors may also be responsible. In general, the chromite grains are altered along margins and fractures to ferritchromit that is enriched in *cr*-number (and generally Fe^{3+}, Mn, and Ti) and impoverished in *mg*-number compared with the parent grains. Chromian chlorite (clinochlore, penninite, with up to 7·3 wt.% Cr_2O_3) is commonly associated with the alteration, as is serpentine in most silicate rocks and some chromitites. The chlorite shows considerable compositional variation from grain to grain and in some cases within a single grain. Clinopyroxene is low-Al, -Na and high-Ca diopside. Orthopyroxene ranges from En_{91} to En_{82} and olivine from Fo_{98} to Fo_{84} (ignoring one analysis each). The *mg*-number of these minerals is higher in chromitites than in dunites and pyroxenites. Several aspects of the petrogenesis of the ultramafic rocks (e.g., the abundance of diopsidite) are not clear, but they seem to have passed through a complex history. The high *cr*-numbers (>60) in the chromite indicate that the rocks may have originated from some form of oceanic lithosphere-island are interaction. Petrography and mineral compositional data suggest that the rocks are ultramafic cumulates derived from an arc-related (?primitive) high-Mg tholeiitic magma, possibly at pressures in excess of 8 kb. There also are small ultramafic bodies in the form of conformable layers and emplaced masses within the garnet granulites. These contain magnetite and pleonaste with < 10 wt.% Cr_2O_3, and less magnesian olivine and pyroxene than the principal ultramafic mass. These also have the characteristics of island are plutonic rocks, but it is not clear whether the garnet granulites constitute a continuous sequence of are cumulates with the principal ultramafic mass or the two are produced from different source magmas.
Key words: Ultramafics, chromite, spinels, Jijal, Kohistan.

J/130. Jan, M.Q., Windley, B.F. & Khan, A**.** 1985. The Waziristan ophiolite, Pakistan, general geology and chemistry of chromite and associated phases. Economic Geology 80, 294-306.

The Waziristan complex, covering over 500 km^2, was tectonically emplaced during the Paleocene to early Eocene. It consists of ultramafic rocks, gabbros, sheeted dikes, pillow lavas, and pelagic sediments--a typical ophiolite suite. However, a complete sequence does not occur in any single locality due to tectonic dismemberment. The podiform chromitites consist of aluminochromite (Cr_2O_3 :49-61%) with subordinate

chromian chlorite and/or chromian serpentine + magnetite. In Cr-Al-Fe (super +3) + Ti space the chromites plot in the area of alpine chromites, but on other diagrams they overlap the fields of chromites from alpine and stratiform complexes. Many chromites are zoned with "ferrit-chromit" margins richer in Cr/(Cr + Al) and poorer in Mg/(Mg + Fe^{+2})) than the unaltered cores. The chlorites are generally rich in SiO_2 and MgO and poor in Al_2O_3. It appears that during greenschist facies metamorphism (or alteration) diffusion of Mg, Al, and some Cr from the chromite margins toward the silicate matrix resulted in the development of ferrit-chromit and chlorite.
Key words: Ophiolites, chemistry, chromite, Waziristan.

J/131. Jan, M.Q., Windley, B.F. & Wilson, R.N. 1984a. Chromian andradite and associated phases in a chromitite layer in dunite from the Jijal Complex. Abstracts, First Geological Congress, Lahore, p.55.

Green chromian andradite associated with chrysolite occurs in a chromitite layer within dunite of the Jijal complex. The garnet contains over 10 % Cr2O3 and has the formula Ca 6.13 Cr1.37 Fe3+2.53 Si 5.94 O24. The garnet formed during retrograde greenschist facies metamorphism of the Jijal complex. Analyses of chromite in the dunite and chromitite layers resemble those of high Cr chromite but their total Fe is a little higher. In contrast, the olivine is highly magnesian, with a ratio 100 Mg/ (Mg + Fe^{2+}) of about 96%. These features appear to have been caused by Fe - Mg exchange between the two minerals down to a blocking temperature of about 800^0 C.
Key words: Chromite, dunite, Jijal, Kohistan.

J/132. Jan, M.Q., Windley, B.F. & Wilson, R.N. 1984b. Chromian andradite and olivine-chromite relations in a chromitite layer from the Jijal Complex, NW Pakistan. Canadian Mineralogist 22, 341-345.

Green chromian andradite occurs associated with chrysotile in a chromitite layer within the dunite of the Jijal alpine ultramafic complex (northern Pakistan). The garnet contains on average 10.1 wt. % Cr_2O_3 (range 9.2-11.6%) and has a formula $Ca_{3.04}$ ($Cr_{0.67}$ $Fe^{3+}_{1.29}$ $Al_{0.02}$) $Si_{2.9}$ O_{l2}. The garnet formed during retrograde greenschist-facies metamorphism of the Jijal complex.
Keywords: Chromian andradite, dunite, retrograde metamorphism, Jijal complex.

J/133. Jankovic, S., 1984. Metallogeny and mineral potential of northern Pakistan (North of Indus Suture Zone), A preliminary assessment. Geological Survey of Pakistan, Record 65, 25p.

The area of northern Pakistan situated north of the Indus Suture zone 9the Main Mantle Thrust – Tahirkheli, 1980) is a part of a global metallogenic belt - the Tethyan Eurasian Metallogenic Belt, formed at the southern margin of the Eurasian plate (Jankovic, 1976).
Owing to its remoteness and inaccessibility, the ore mineralization of Northern Pakistan has not so far been systematically investigated, either from a geological or a specifically metallogenic viewpoint. A previous tentative assessment of the mineral potential of the Northern Pakistan, predominantly south of the main Mantle Thrust, did not consider this part of Pakistan as particularly promising. 9Sillitoe, 1978). But recent discoveries of very significant lithium deposits of pegmatite type in Afghanistan, very close to the Pakistani border and tin and boron deposits (skarn type) in southern Pamir, USSR, as well as a regional metallogenic analysis, clearly indicates that the mineral potential of Northern Pakistan may be very promising.
The aim of this brief report is to draw attention to and emphasize the importance which Northern Pakistan, north of the Main Mantle Thrust, may have as a potential source of Li, Ta, Nb, Sn, W, Mn and Be as well as base metals and gold, and to point out the need and justification for a detailed and systematic investigation of this part of Pakistan.
Key words: Metallogeny, tectonics, economic geology, Indus Suture.

J/134. Jaswal, T., 1990. Structure and evolution of the Dhurnal oil field, Northern Potwar Deformed Zone, Pakistan. M.Sc. Thesis, Oregon State University, Corvallis, 62p.

Key words: Structure, hydrocarbon, Potwar, Dhurnal.

J/135. Jaswal, T.M., Lillie, R.J. & Lawrence, R.D., 1997a. Structure and evolution of the Northern Potwar Deformed Zone, Pakistan. American Association of Petroleum Geologists Bulletin 81, 308-328.

The northern Potwar deformed zone (NPDZ) is part of the active foreland fold and thrust belt of the Salt Range and Potwar Plateau in northern Pakistan. About 500 km of seismic reflection profiles are integrated with surface geologic and drilling data to examine the deformation style and structure of the NPDZ with particular emphasis on history of deformation of the Dhurnal oil field. The seismic lines suggest that the overall structure of the eastern NPDZ is a duplex structure developed beneath a passive roof thrust. The roof thrust is generated from a tipline in the Miocene Murree Formation, and the sole thrust is initiated from the same Eocambrian evaporite zone that extends 80 km southward beneath the Soan syncline and Salt Range. The Dhurnal oil field structure is a pop-up at the southern margin of the NPDZ, and developed beneath the passive roof thrust. The passive roof thrust crops out just north of Dhurnal on the steep, northern limb of the Soan syncline. An overstep passive roof thrust (Sakhwal fault) is interpreted west of Dhurnal; this fault developed due to southward progression of the deformation front beneath the earlier passive roof thrust.
Very gentle basement dip and almost zero topographic slope in the NPDZ suggest that the Eocambrian salt provides effective decoupling at the present position of the NPDZ. The strong deformation in the NPDZ appears to have developed farther north, in an area where the evaporites may be lacking. Since 2 Ma, the NPDZ moved farther south over the evaporites without further deformation, whereas erosion removed any former topographic slope. Restoring a balanced cross section suggests that the minimum shortening across the NPDZ is more than 55 km. Assuming that this shortening occurred between 5.1 and 2 Ma, the shortening rate is about 18 mm/yr.
Key words: Structure, seismic reflection, Potwar, Himalaya.

J/136. Jaswal, T.M., Lillie, R.J. & Lawrence, R.D., 1997b. Triangle zone geometry and blind thrusting along the southern margin of the northern Potwar Deformed Zone, Pakistan. Abstracts, 3rd Pakistan Geological Congress, University of Peshawar, p.30.

Key words: Structure, Potwar, Himalaya.

J/137. Jaume, S.C., 1986. The Salt Range-Potwar Plateau, Pakistan: quantitative and qualitative aspect of a fold-and-thrust belt underlain by evaporates. M.S. Thesis, Oregon State University Corvallis.

Consult the following account
Key words: Structure, topography, MBT, Salt Range, Potwar, Himalaya.

J/138. Jaume, S.C. & Lillie, R.J., 1988. Mechanics of the Salt Range-Potwar Plateau, Pakistan: a fold and thrust belt underlain by evaporates. Tectonics 7, 57-71.

The Salt Range and Potwar Plateau are part of the active foreland fold-and-thrust belt of the Himalaya in northern Pakistan. In this region the distance from the Main Boundary Thrust (MBT) to the front of the fold-and-thrust belt is very wide (100-150 km) because a thick evaporate sequence forms the zone of decollement. Recent studies have combined seismic reflection profiles, petroleum exploration wells, Bouguer gravity anomalies, and surface geology to construct cross sections in the eastern, central, and

western Salt Range-Potwar Plateau areas. In this study the sections are compared with a model that considers the mechanics of a fold-and-thrust belt to be analogous to that of a wedge of snow or soil pushed in front of a bulldozer (Chapple, 1978; Davis et al., 1983; Dahlen et al., 1984; Dahlen, 1984). Models which include the effects of evaporites at the base (Chapple, 1978; Davis and Engelder, 1985) suggest that these thrust belts will have (1) narrow (< 1º) cross-sectional tapers, (2) larger widths than areas not underlain by evaporites. (3) Symmetrical structures, and (4) changes in deformational style at the edge of the evaporite basin. The section across the eastern Potwar Plateau most closely resembles this latter model, having (1) a taper of 0.8º ± 0.1º, (2) a width of 100-150 km, (3) thrust faults that verge both to the north and south, and (4) structures rotated 30º counterclockwise with respect to the Salt Range. From the observed taper and pore fluid pressures of the eastern Potwar Plateau, estimates of the values for the yield strength of the evaporites (τ_o) and the coefficient of internal friction of the overlying wedge (μ) are caleuraed as τo = 1.33-1.50 MPa and μ = 0.95-1.04, which are then applied to the other cross sections. In the central and western sections, a basement uplift, the Sargodha High, interferes with the front of the fold-and-thrust belt. This feature causes the ramping of the Salt Range Thrust end produces a relatively steep basement slope (2º-4º) beneath the Potwar Plateau. This dip, in the presence of the weak evaporite decollement, is sufficient to provide critical taper; no topographic slope is necessary, and the thrust wedge of the southern Potwar Plateau is pushed over the decollement without significant internal deformation.
The northern Potwar Plateau is strongly folded and faulted, yet the topographic slope remains flat. Although the deformation suggests that evaporites are not present there, the observed taper in the northern Potwar Plateau is best fitted by the model with evaporites at the decollement. Combining this with published paleomagnetic and geologic constraints, a model for the evolution of the northern Potwar Plateau suggests that the area deformed as a steeply tapered (3.5º-5.5º) thrust wedge until approximately 2 million years ago, when the southward propagating decollement encountered the evaporites. Between 2 Ma and the present the northern Potwar Plateau has been pushed along the salt decollement without deformation, and erosion has reduced its original steep topographic slope to a nearly level surface.
Key words: Structure, MBT, topography, Salt Range, Potwar, Himalaya.

J/139. Javaid, A.R., 1984-86. The geology and mapping of Muzaffarabad area from Chehla Bandi to Chattar Kalas with special emphasis on building settlement and consolidation in Muzaffarabad City. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan, 63p.

Nearly 100 sq. km area has been mapped mainly East and East--West of Muzaffarabad (A.K.), at the scale of 1:10,000. This thesis is prepared with the aim to study the area in detail and to explore the reasons of building settlement and consolidation in Muzaffarabad. The stratigraphic succession has been established, lithological and structural discontinuities are marked. Structurally the area is complex. Since the area is on the core of Hazara-Kashmir syntaxis, some units of the rocks have been separated due to major thrust faults, among these Jhelum fault (between Hazara Formation and Murree Formation) and Muzaffarabad fault (between Abbottabad Formation and Murree Formation) are the biggest. An attempt has been made to evaluate and put forth the generalized idea about the bearing capacity on different terraces of Muzaffarabad city. The samples of different localities are taken for laboratory tests. The purpose of laboratory test is to evaluate the strength parameters which are responsible for settlement and consolidation. In this report, an attempt is made to explore the reasons of settlement in the area as well as remedial measures were suggested.
Key words: Mapping, geology, Muzaffarabad, Azad Kashmir.

J/140. Javaid, M., 1992-94. Geology of Dubran Area, District Haripur with microfacies study of Langrial algal limestone. M.Sc. Thesis, Punjab University, Lahore, 131p.

Geological mapping of some 64 sq. Km area around Dubran in District Haripur has been carried out at the scale 1: 12500. The geomorphology, stratigraphy, structure, palynology and micropaleontology have been described. Stratigraphically a Mesozoic Tertiary sedimentary cover is overlying a Precambrian to Eo-cambrian basement of Hazara group now metamorphosed in the lower green schist facies. Numerous faults, high angle, reverse and normal have now disrupted the sequence. High angle north dipping Nathia Gali

Thrust is the main fault that passes through the area and has thrusted the Precambrian Hazara Slates over the younger sedimentary sequence. Dubran syncline lying on top of a major anticlinorium makes an interesting structure.
Key words: Microfacies, limestone, structure, Haripur, Hazara.

J/141. Javed, H.J., 1985-87. Litho-structural mapping and Geology of Baragali-Kundla Area, District Abbottabad, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 183p.

This report gives an account of geological studies and lithostructural mapping carried out in Kundla-Bara Gali area. The prescribed area lies on both side of the road leading from Murree to Abbottabad. It is a mountainous region with fairly high relief. Litho-structural mapping of approximately 29 km^2 was carried out. The stratigraphic succession ranges from Hazara Formation (Precambrian) to Kuldana Formation (Eocene) with absence of Cambrian to Jurassic rocks. The lithology is mainly limestone, sandstone and shale. Extensive sampling was carried out and micro structural studies along with petrography of various rock units under the microscope from thin section of certain rock samples was also carried out in the laboratory.
A geological map is prepared on a scale of 1:7060 and tow cross sections (AA' and BB') were drawn in order to interpret the regional structure and tectonic history of the area. The report also included the brief study of the rock units exposed in the project area. Major structures (folds and faults) lies in the project area are also discussed. Finally there is a general discussion about the source rocks, reservoir rocks (Hydrocarbon) and the economic importance of the rock units present in the project area.
Key words: Mapping, geology, Baragali, Abbottabad.

J/142. Javed, K., 1983-85. Litho-Structure studies of Fini-Bhirina-Paniali and Haddo Bandi Area, District Mansehra. M.Sc. Thesis, Punjab University, Lahore, 162p.

There is a specific relationship between the geological structures, landforms and the climate. This relationship can be worked out by qualitative as well as quantitative analysis of the topographic map. The most commonly exposed lithologies in the project area, are schist from chlorite to garnet grade, Susalgali granite gneiss, Mansehra granite, quartzites and hornfelses. The rocks of the project area have been classified into nine lithologic units for the sake of mapping purposes at a scale of 9.2 cm to km on 5.8 inch to a mile.
The area is deformed by different deformation phases, among which three are recognize on mesoscopic as well as microscopic scale and area is characterized by heterogeneous deformation. The rocks have been folded isoclinally and later being refolded into open folds.
The area lies in the zone of brittle deformation and show extensive fracturing instead of folding. Mesoscopic and microscopic deformational features are well developed in the area. The rocks exhibit effects of polymetamorphism. The thermal metamorphism is superimposed on the regional metamorphism.
Key words: Structure, landform, climate, Mansehra.

J/143. Javed, M., Haq, A. & Faruqi, F.A., 1964. Investigation on West Pakistan feldspars. Science and Industry, Lahore, 2, 27-36.

Key words: Minerals, feldspar.

J/144. Javed, M.Y., Akhtar, S. & Humayun, M., 1981-82. Geology and petrography of Samana Suk and Chichali Formations near Gumkol Sharif, northwest of Kohat, North West Frontier Province. M.Sc. Thesis, University of Peshawar, 96p.

Key words: Petrography, Samana Suk Formation, Chichali Formation, Kohat.

J/145. Jawaid, A., Javed, A. & Pervaiz, M., 1983. Mineralogy petrology & economic geology with emphasis on mineral deposits of Besham-Lahor area Swat Kohistan. Kashmir Journal of Geology 1, 120.

Igneous and metamorphic rocks of the project area (longitude (E) 720 50' to 720 54' latitude (N) 340 54' to 340 58') represent the leading edge of the Indian continent underthrusting the Kohistan Island Arc? The mineralization described in this work are related to igneous and metamorphic rocks. Granite/pegmatite complex are of Pre-Cambrian age. Metamorphics of the area are correlated with Salkhala Formation, Tanawal Formation and poorly defined Thakot metasediments. In mapped area metamorphism of pelitic rocks ranges from chlorite to biotite grade, and rocks are named as biotite-chlorite-graphite schist, while quartzite and amphibolites are also present. They are folded metasediments and uplifted due to stresses during Himalayan orogenies. Sequences of folded metasediments was followed by the intrusion of Lahor granite/pegmatite. The Lahor granite/pegmatite has been assigned a mixed origin and is result of the processes of intrusion, anatexis and palingenesis of the country rock. The formation of this granite involves more than one phase of magmatic activity and granatization of the country rocks.
Oxides (magnetite, haematite) and sulphides (galena, sphalerite, molydbenite, pyrits) mineralization are associated with Lahor granite/pegmatite complex and metasediments. Oxides occur in skarns which were originated by the igneous/metamorphic activity (metasomatism). Late stage hydrothermal activity formed disseminated and vein mineralization of sulphides. The study covers the petrographic and ore-microscopic aspects. The evaluation of petrographic and ore-microscopic data of Besham Lahor area, shows its economic importance.
Key words: Mineralogy, petrology, mineral deposits, skarns, magnetite, Lahor, Besham.

J/146. Jehan, K., Khan, A.H., Allahuddin, M. & Akhtar, M., 1975. Some bleaching clays deposits of Campbellpur District, Pakistan. Acta Geologica Hungaria 19, 257-264.

Key words: Clays, mineral deposits, Campbellpur, Attock.

J/147. Jehan, N., 1983. Geology of the part of the Shewa–Shahbaz Garhi Complex, Mardan. M.Sc. Thesis. Geology Department, Peshawar University.

Key words: Geology, granites, Mardan.

J/148. Jehan, N., 1997. Geology, economics and environmental impacts of asbestos from Mohmand and Malakand agencies and district Charsadda, NWFP, Pakistan. M.Phil. Thesis, University of Peshawar, 127p.

Asbestos is associated with ultramafic rocks of the Mohmand and Malakand Agencies. There are a number of places where it is extracted commercially, although not on a huge scale. The geology of these deposits and their economic potential are described in this thesis, along with the environmental and health hazard related to its exploitation.
Key words: Environmental impact, asbestos deposits, Mohmand, Malakand, Charsadda.

J/149. Jehan, N. & Hamidullah, S., 1997. Physical and chemical characteristics of asbestos from North Pakistan and its significance in the promotion of asbestosis. In: Hanif, J. & Hanif, M.I. (Eds.), Environmental Pollution. Proceedings, 3rd National Symposium in Contemporary Chemistry, PAEC, Islamabad, 1997, 139-146.

Key words: Chemistry, asbestos, asbestosis, Pakistan.

J/150. Jehan, N. & Hamidullah, S., 1999a. Lung fibrosis and asbestosis in Northern Pakistan. Terra Nostra 99, Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, p.76.

The lives of millions of people in most parts of the developing world remain at risk due to ruthless mining practices. Pakistan is not an exception. Asbestos occurs in association with talc and magnesite in the dunites and serpentinites of the of the Main Mantle Thrust (MMT) melange north of Peshawar Basin, in Mohmand and Malakand agencies and District Charsadda (longitude 71º35' to 71º55'E and latitude 34º25' to 34º30'N; Noor Jehan, 1996). It has formed as a result of metamorphic transformation of olivine in the presence of CO2 (Hamidullah, 1984). It is mined, transported and crushed in the local crushing plants and sold as pure asbestos or as powder for the production of talcum powder and other industrial products to industries through out the country. In the primitive crushing plants, asbestos is crushed in the same or the nearby (5 feet away) grinder used for grinding grains for flour (Fig. 1).
A variety of studies were carried out on the geology, mineral chemistry, fibre size economics and environmental impacts of this asbestos and related minerals and rocks in the study area and its surroundings. Electron microprobe data (Si02=51.69%, Mg045%, Al2O3=1.33%, FeO=1.33%, CaO=0.06%), XRD data (Table 1) and petrographic observations classify these asbestos minerals as chrysotile, antigorite and tremolite, with the former as the dominant type, and highly carcinogenic. The diameter (<0.3 micrometer) and length (>0.8 micrometer) of individual fibers also indicate these to be carrying sufficient inhalation properties. Enhanced occurrences of allergies of lungs, eyes and skin have been noted in the surroundings of the local mines and relevant industries in the area. Worker in these crushing plants are at the highest risk. Little or no precautionary measure are taken (Fig. 1). More than 200 patients were suspected for asbestos-related lung fibrosis in the Government Lady Reading Hospital, Peshawar. Among these, 50 were followed up and confirmed as suffering from malignant mesothelioma (99% due to asbestos). Several are dead now. Sixty seven percent of these patients belong to northern districts of the province from where asbestos comes (Dr. Arshad Javed, Personell Communication). We still have to sort out relationship between these patient and the local asbestoses.
The asbestos-bearing zone (MMT) extends west across the boarder to Afghanistan. Fine quality asbestos is found at Logar in Afghanistan. The MMT also extends east, through Pakistan and across the border through India (as the Indus Tzangbu Suture Zone), ending at Nepal. Thus the problem is regional and if not well taken care of in time, Afghanistan, Pakistan and India may be engulfed by the epidemic of asbestos related diseases in the near future. Some of the important recommendations suggested for mitigation of asbestosis and other related ailments in the light of the data obtained are: adoption of ventilation and water spraying procedures in all processes of mining, transportation and industrial use of asbestos; personal protection of labor and skilled worker; restriction on use of asbestos in the manufacturing of talcum powder; awareness, training and health and safety monitoring cf the employees; implementation of international compensation laws and ultimately abandoning asbestos mining and industrial uses in the region.
Key words: Fibrosis, asbestosis.

J/151. Jehan, N. & Hamidullah, S., 1999b. Chemical and physical properties of asbestos from Northern Pakistan. Souvenir and Abstracts, 4th Biennial International Conference on chest disease and tuberculoses, p.34.

Key words: Chemistry, physical characteristics, asbestose, asbestosis, Pakistan.

J/152. Jehan, N. & Hamidullah, S., 1999c. Comparison of the conventional map with RS/GIS-based map of the asbestos-bearing region of North Pakistan. Abstract, International Conference Sustainable Management of Natural Resources, Department of Geography University of Peshawar-UNESCO, organizers, 49-50.

Key words: GIS/RS, maps, asbestos.

J/153. Jehan, N., Hamidullah, S. & Ahmad, I., 1997. Economic and environmental study of asbestos from Skhakot-Qila ultramafics complex, N. Pakistan. Abstracts, National Symposium on Economic Geology of Pakistan, Islamabad, 1p.

Economic growth must be accompanied by environmental assessment to ensure sustainable development. This paper describes the economics and environmental impacts of asbestos from Skhakot Qila ultramafic complex in the agencies of Malakand and Mohmand and the district of Charsadda at the northern and north western extremities of Peshawar valley. Asbestos is mined at Narai Ohe, Newe Kili, Behram Dheri, Qila Hero Shah and Bucha, and crushed and milled at Tangi, Newe Kili and Berlin, both in primitive and relatively modern crushing plants. From 35 mines in this area, only 15 were found in operation, each producing a truck of raw asbestos and other minerals weighing 10 metric tonnes and sold for Rs. 3000/- per truck. This process daily generates a total 150 metric tonnes of raw stuff and Rs. 45000/- as income in the area. Similarly the 8 crushing plants in the area crush 4 trucks of asbestos: each one sold for Rs. 6000/- and thus generating a total income of Rs. 24000/- per day. Asbestos from the study area has been, however, analysed and proved to be the carcinogenic variety (Noor Jehan & Hamidullah. 1997). No precautionary measures are, however, taken for protection from asbestos dust. (grains and asbestos are ground in the same or closely situated (5 feet apart) crushing machines. These machines dissipate dust to the village population in the surrounding and whole mining and crushing process has therefore, created a considerable environmental chaos in the area. People around the crushing plants have begun suffering from skin and eye allergies as well as asthma. The crushed asbestos is utilised in the production of talcum powder which is another environmental dilemma recently about 100 cases of mesothelioma have been registered in the Lady Reading Hospital. Peshawar, among these 60 arc from the asbestos bearing areas. The paper recommends strict environmental laws to control the mining, crushing and industrial use of asbestos.
Key words: Asbestos, ultramafics, Skhakot qila.

J/154. Jehan, N., Hamidullah, S. & Ahmad, I., 2000. Economic and environmental study of asbestos from Skhakot-Qila ultramafics complex, N. Pakistan. In: Hussain, S.S. & Akbar, H.D. (eds.), Proceedings, National Symposium on Economic Geology of Pakistan, 1997, Islamabad, 173-182.

For details consult the preceding account.
Key words: Asbestos, ultramafics, Skhakot qila.

J/155. Jehangiri, A.W., Ahmad, I. & Afridi, I., 1999. Geology of Besai area, Khyber Agency, N.W.F.P. M.Sc. Thesis, University of Peshawar, 33p.

Key words: Geology, mapping, Khyber Agency.

J/156. Jiandong, Z., 1995. Tectonic Evolution of the Altun and Karakorum Mountains. Journal of Nepal Geological Society 11, 59-62.

The Altun and Karakorum Mountains lie on the northwestern edge of Tibet. Because of their remote setting these regions were essentially unknown. Recently the author took part in the field investigations in the Altun Mountains and surrounding areas, such as Tarim and Qaidam Basins, and West Kunlun Mountains. Based on the practical data, this paper briefly deals with geological background of the Altun and Karakorum Mountains and discusses an intracontinental subduction or A-type subduction along southwestern margin of the Tarim Bain.
Key words: Tectonics, Altun, Karakorum.

J/157. Jianming, C., 1984. Variations of the Batura glacier's surface from repeated surveys. In: Miller, K.J. (ed.), The International Karakoram Project, 1, 196-204. Cambridge University Press.

Repeated terrestrial stereophotogrammetric surveys have been used to make various maps. The glacier example quoted shows basic data requirements and presents standard techniques to study height variations of the surface, the terminus mass and ice movement. The results show that the system is a good method to determine glacial variations. However, when applying this techniques the orientation of each photo should be identical. In order to obtain reliable data, a combination of methods is necessary.
Key words: Glaciers, Batura, Karakorum.

J/158. Jianming, C., Crompton, T.D., Walton, J.L.W. & Bilham, R., 1984. The survey work of the International Karakoram Project. In: Miller, K.J. (ed.), The International Karakoram Project, Volume 2, 124-139. Cambridge University Press. Cambridge University Press.

In 1913 a triangulation network was set up to connect the survey systems of Russia and India. This chain crosses the Karakoram a region of intense tectonic deformation. The southern section of the 1913 link was remeasured by the survey party of the International Karakoram Project with a view to detecting continental movement over the intervening 67 years. The fieldwork was completed successfully despite a number of setbacks including the death of one the team. The network has been analyzed in number of ways in order to find the best method for the analysis of possible deformation. Figural distortions have been detected and geophysical interpretation of these has been essayed.
Key words: Tectonic deformation, Karakoram project survey.

J/159. Jianming, C. & Huaiyi, Z., 1980. The terrestrial stereophotographic mapping of the drainage area of the Batura Glacier. In: Shi Yafeng (ed.), Professional Papers on the Batura Glacier in the Karakoram Mountains. Science Press, Beijing.

Key words: Glaciers, Batura, Hunza, Karakoram.

J/160. Jijun, L., Derbyshire, E. & Shuying, X., 1984. Glacial and paraglacial sediments of the Hunza valley North – West Karakoram, Pakistan: A preliminary study. In: Miller, K.J., (ed.), The International Karakoram Project, Volume 2. Cambridge University Press.

The tills of the upper Hunza region include both lodgement and meltout types. Particle size analysis shows them to be relatively coarse-grained and somewhat positively skewed. There is evidence of modification of the particle size distribution by meltwater eluviation, especially in the case of the Ghulkin and Pasu glacier deposits but the role of bedrock lithology and glacier size is also discernible. Tills currently being deposited are predominantly of meltout type: these have diffuse fabrics, rather granular matrixes and contain evidence of eluviation and collapse. Re-deposition of the abundant coarse supraglacial debris by sliding under gravity is common. The thickest exposures of compact and sheared lodgement till, on the other hand, are of pleistocene age, especially those of the main valley (t 2), diffluence col (t 3) and expanded foot (t 4) stages. There is no evidence of direct deposition of till by viscous flow either during or since the Pleistocene although the abundant debris flows do contain glacial material. It appears likely that the present combination of high-activity glacial regimes and arid to semi-arid valley floor climatic conditions have prevailed since at least the beginning of the late Pleistocene. The distribution of the dense, jointed lodgement tills of Pleistocene age is consistent with their deposition in a generally free-draining environment beneath thick glaciers. The genetic classification of tills based on field relationships is generally confirmed by laboratory-derived data on particle size, particle shape, stone orientation and fabric.
Key words: Glaciers, sediments, Hunza, Karakoram.

J/161. Johnson, G.D., Johnson, N.M., Opdyke, N.D. & Tahirkheli, R.A.K., 1979. Magnetic reversal stratigraphy and sedimentary tectonic history of the Upper Siwalik Group, eastern Salt Range and southwest Kashmir. In: Farah, A. & DeJong, K.A., (Eds.), Geodynamics of Pakistan. Geological Survey of Pakistan, Quetta, 149-165.

The upper Pliocene or lower Pleistocene interval of the Siwalik (Himalaya) molasses exposed in the Jhelum area, Pakistan, has been examined for lateral variation in depositional environment and rate of fluvial sedimentation. Stratigraphic sections measured through this interval at various localities n the Jhelum area are constrained by a magnetic reversal stratigraphy. Variations in the eragte of molasses sedimentation appear to be related to large-scale sytaxial tectonics in the northwestern Himalaya. Sedimentation rates increase towards the axis and apex of the recent structure indicating that the sytaxial feature controlled the focus of mollase sedimentation during the sedimentation time. Sediments exposed in the Pabbi hills, Rohtas anticline, Chambal ridge, and the Mangla-Samwal anticline, each display variation of sedimentary/tectonic style as a function of their placement within the overall basin contour of the Himalayan foredeep.
Key words: Stratigraphy, magnetic polarity, Potwar, Siwaliks, Himalaya.

J/162. Johnson, G.D., Raynolds, R.G. & Burbank, D.W., 1986. Late Cenozoic tectonics and sedimentation in the northwestern Himalayan foredeep: thrust ramping and associated deformation in the Potwar region. In: Allen, P. & Homeweed, P., (Eds.), Foreland Basins, International Association of Sedimentologists Special Publication, 8, 273-291.

Key words: Tectonics, sedimentation, deformation, Himalayan foredeep, Potwar.

J/163. Johnson, G.D., Rey, P., Ardrey, R.H., Visser, C.F., Opdyke, N.D. & Tahirkheli, R.A.K., 1981. Paleoenvironments of the Siwalik Group, Pakistan and India. In: Rapp, G. & Vondra, C.F. (eds.), Hominid sites: their geological settings. American Association for the advancement of Science, Selected Symposia Series 63, 197-254.

This is a detailed account of the magnetostratigraphy, sedimentology and structure of the Siwaliks of central Potwar Plateau and a portion of adjacent Kashmir. Particular emphasis is placed on the alluvial character of the Chinji through upper Siwalik formations of the Siwalik Group. Descriptions are given for paleoenvironmental rationale; fluvial character of the stratigraphic succession; lateral variation in sedimentary style; fluvial cycle recurrence rate; development of the floodbasin stratigraphy; evidence of pedogenesis affecting the floodbasin stratigraphy; interpretation of the Siwalik paleosols; application to the Siwalik Miocene record; and Late Miocene Siwalik geochronology, environmental change, faunal implications and habitat. It is speculated "that sites recording favourable hominoid habitat from latest Miocene, Paleocene and Pleistocene age strat should lie to the east of in a more equitable portion of the environmental cline. As such, sites from the contemporary Nepali Siwaliks and further east may record the equitable hominoid habitat which was lost in the Potwar Plateau about six million years ago".
Key words: Paleoenvironments, Nagri, Siwaliks, Potwar, Kashmir.

J/164. Johnson, G.D., Zeitler, P.K., Naesser, C.W., Johnson, N.M., Summers, D.M., Frost, C.D., Opdyke, N.D. & Tahirkhelli, R.A.K., 1982. The occurrence and fission-track ages of Late Neogene and Quaternary volcanic sediments in Siwalik Group, Northern Pakistan. Paleogeography, Paleoclimatology, Paleoecology 37, 63-93.

Volcanic sediments, now mostly bentonites and bentonitic mudstones, occur throughout the Late Neogene and Quaternary Siwalik Group of northern Pakistan. A number of these deposits have been dated by the fission-track method, utilizing zircon phenocrysts from these deposits, and provide the chronometric constraints upon which a paleomagnetic stratigraphy is developed for the Siwalik Group. Notable in the

occurrence of these altered tuff horizons is an apparent mode in their stratigraphic development from approximately 3.0 to 1.5 m.y. B.P. which coincides with the period of activity of the Dacht-e-Nawar volcanic complex of east-central Afghanistan. Fission-track ages of certain tuffs for critical areas of northern Pakistan are reported herein.
Key words: Fission-track ages, Neogene, Quaternary volcanics, Siwaliks.

J/165. Johnson, M.R.W., 1994. Volume balance of erosional loss and sediment deposition related to Himalayan uplifts. Journal of Nepal Geological Society 10, Abstract Volume, 9th Himalaya-Karakoram-Tibet Workshop, Kathmandu, Nepal, 70.

The volume of sediment in the foreland basins, deltas and fans which are a consequence of the collision of India and Asia appears to require the removal of a vertical section ~35 km high if the sediments were entirely derived from the Himalaya. It is argued that this is implausible and that it is likely that the Himalayan hinterland (e.g. Karakoram and Tibet) was an important source of sediment prior to -20 Ma when significant Himalayan uplift commenced.
Key words: Sedimentology, erosion, deposition, Himalayan uplift.

J/166. Johnson, N.M., Opdyke, N.D., Johnson, G.D., Lindsay, E.H. & Tahirkheli, R.A.K., 1982. Magnetic polarity, stratigraphy and ages of Siwalik Group rocks of the Potwar Plateau, Pakistan. Palaeogeography, Palaeoclimatology, Palaeoecology 37, 17-42.

Six magnetic polarity sections have been established over the Potwar Plateau region of Pakistan, including the major stratotypes of the Siwalik Group. In all six sections the dominant feature of the magnetic polarity stratigraphy is a long normal polarity zone, which is contained within the Nagri Formation. This conspicuous normal polarity zone has been radiometrically dated at 9.5 + 0.6 m.y., which identifies it as magnetic Chron 9. Radiometric dates for the Upper Siwalik Formation have also been used to identify the Chron 2-3 boundary in tow of the sections. The magnetic polarity stratigraphy of three of the sections has been correlated securely with the accepted magnetic polarity time scale, so that the ages of the local stratigraphy are indexed accordingly. Based exclusively on data from stratotype sections, the Chinji Nagri and Dhok Pathan Formations have nominal age ranges of 13.1-10.1, 10.1-7.9 and 7.9-5.1 m.y. Age fluctuations on the order of 105 years may be anticipated for these formational boundaries within a radius of some 20 km of the designated stratotype. Mean sediment accumulation rates during the Chinji, Nagri and Dhok Pathan interval range from 13 to 52 cm/103 yr.
Essentially linear sediment accumulations are locally maintained over time intervals of several million years. The Chinji-Nagri lithofacies boundary marks a transition from slow to faster sediment accumulation over much of the Potwar Plateau, indicating a fundamental sedimentary-tectonic change at this time.
Key words: Paleomagnetism, Potwar, Siwaliks.

J/167. Johnson, N.M., et al., 1977. Magnetopolarity stratigraphy of the Middle Siwalik Group, Potwar Plateau, Pakistan. Geological Society of America Abstracts with Program, 9, 1039-1040.

Key words: Magnetostratigraphy, Siwaliks, Potwar

J/168. Johnson, N.M., Stix, J., Cerveny, P.F. & Tahirkheli, R.A.K., 1985. Paleomagnetic chronology, fluvial processes, and tectonic implications of the Siwalik deposits near Chingi Village, Pakistan. Journal of Geology 93, 27-40.

A 2800-m section of Siwalik strata containing the stratotypes for both the Chinji and Nagri formation has been dated by magnetic polarity stratigraphy, and the observed polarity zonation has securely been correlated with the Chron 17-7 segment of the time scale. The base of the section is the base of the Kamlial formation, which occurs near the top of Chron 17 (18.3 m.y.). The Kamlial-Chinji formation boundary occurs in the middle of Chron 15 (14.3 m.y.), the Chinji-Nagri boundary near the bottom of Chron 10 (10.8 m.y.) and the Nagri-Dhok Pathan boundary at the Chron 8-9 boundary (8.5 m.y.). The Siwalik deposits near Chinji Village consist of four distinct classes of fluvial cycles, each with a characteristics periodicity: a first order of 107 years, a second order of 106 years, a third order of 104-105 years, and a fourth order of 100 – 104 years. The river system responsible of Siwalik sedimentation flowed from west to east and had properties much like the modern Ganges River system. Sedimentation rates in the Chinji Village area increased gradually through time, going from 0.12 mm/yr in the Lower Siwaliks to 0.30 mm/yr in the Middle Siwaliks. At about 11 m.y. blue-green hornblendes suddenly appear in abundance in channel sands. The appearance of these hornblendes, accompanied with accelerated sedimentation, is the effect of uplift in the source area, specifically the Nanga Parbat region. The modern Chinji Village area is no longer a depositional site, but instead is involved in overthrusting, uplift, and erosion. As the Indian Plate has drifted north during the past 18 m.y., the Chinji Village area has been gradually transformed from a subdued karst topography into a major depositional center for Himalayan sediments and finally back into a sediment source area to complete a sedimentary cycle that has spanned some 20 m.y.

Key words: Chronology, paleomagnetism, tectonics, fluvial process, Siwaliks, Potwar.

J/169. Jones, C.L. & Israrullah, 1968. Potential for potash and other evaporite mineral resources in West Pakistan. US Geological Survey/Geological Survey of Pakistan (IR) PK-46, 17p.

Reconnaissance examination of marine evaporites in West Pakistan has revealed a highly favorable resource situation with respect to anhydrite, and a potentialy favorable position for potash and sulfur.

Further work is needed to evaluate the preliminary interpretations made during the present study. The establishment of a potash resource organisation within the Mineral Resource Directorate of the geological Survey of Pakistan is proposed. The organisation would be concerned exclusively with the investigation of potash deposits in the Salt Range and adjacent parts of the Potwar and Indus Plains.

Key words: Evaporites, potash, mineral resources.

J/170. Judd, E.K., 1957. Possibility of uranium in Pakistan. US Atomic Energy Commission Report, No. RM-E-4042, Review, 51p.

Key words: Radioactive minerals, uranium.

J/171. Jurgan, H. & Abbas, G., 1991. On the Chorgali Formation at the type locality. Pakistan Journal of Hydrocarbon Research, 3 (1), 35-45.

Key words: Stratigraphy, Chorgali Formation.