G/1. Gaetani, M., 1967a. Devonian of northern and eastern Iran, northern Afghanistan and northern Pakistan. In: Oswald, D.H. (ed.), International Symposium on Devonian System, Calgary 1967, Alberta. Society of Petroleum Geology 1, 519-528.

Key words: Biostratigraphy, Devonian, Iran, Afghanistan, Pakistan.

G/2. Gaetani, M., 1967b. Some Devonian brachiopods from Chitral (NW Pakistan). Rivista Italiana di Paleontologiae i Stratigrafia 73, 3-22.

Key words: Devonian, Palaeontology, Chitral.

G/3. Gaetani, M., 1967c. Northern and Eastern Iran, Northern Afghanistan and Northern Pakistan. International Symposium on the Devonian System, Calgari, vol. 1, 519-528.

Key words: Geology, mapping, Iran, Afghanistan, Pakistan.

G/4. Gaetani, M., 1990. The sedimentary sequence of the Shaksgam valley (Karakoram and Aghil Ranges). In Abstract volume, 5th Himalaya-Karakoram-Tibet Workshop, Milano, 14.

Sedimentary rocks of the Shaksgam Valley (Karakoram and Aghil Ranges) are arranged in large south-west verging folds, disrupted by several thrusts and faults aligned NW-SE. Though field data are uncompleted, three different stratigraphic sequences may be described. Everywhere, the base of the succession is thrusted.

The better documented is the northern eastern sequence. Above a clastic wedge, marine shallow water carbonates begun in the Arthinskian. Drowning, resulting in cherty carbonates occurred in the Late Permian, with huge resedimentations from active platforms during the Djulfian. Deep-water, thin-bedded carbonates persisted in the Early and possibly Middle Triassic. The re-sedimented calciruddites helped the recovering of the carbonate platform, which persisted to the Early Jurassic. Lateral Liassic equivalent are dark-gray bedded limestones, which continued up to the Middle Jurassic. Red conglomerates and sandstones spread over in Bathonian, followed by mostly terrigenous fine rocks, interpreted as distal turbidities. Yellow polymict conglomerates with mostly carbonate clasts, end the succession. In the middle, till the main fault of the Karakoram Fault Zone (KKFZ), black shales and sandstones, most probably of Permian age, represent the base of the sequence. Then, pelagic gray limestones constitute a relevant sheet, in which also Carnian conodonts were found. Finally, west of the main fault of the KKFS, black shales and several hundreds meters of the Urdok Conglomerate. Crop out. The conglomerate contains prevalent red sandstones, but also gneiss pebbles. The inferred age of the Udrok Conglomerate is Cretaceous or younger.

Key words: Sedimentology, stratigraphy, Shaksgam valley, Karakoram.

G/5. Gaetani, M., 1992. The Karakorum plate during the Permo-Triassic. Abstracts, First South Asia Geological Congress, Islamabad, p.13.

Key words: Karakoram plate, Permo-Triassic.

G/6. Gaetani, M., 1994. The Karakoram Block from Ordovician to Jurassic: A progress report. Abstract Volume, 9th Himalaya-Karakoram-Tibet Workshop, Kathmandu, Nepal, 53-54.

The Karakoram Block was a part of the Peri-Gondwanian fringe during the Paleozoic. The most ancient unmetamorphosed sediments are of Early Ordovician (Arenig) age, consisting of sandstones and shales, transgressing over a crystalline basement. Rare carbonatic intercalations point the succession up to the Middle Devonian, when a wide peritidal platform spread over, temporally stopping the terrigenous deposition. Sedimentation rates were low, 10-20 m/Ma. The mixed terrigenous/calcareous sedimentation resumed in the Late

Devonian, with brachiopod shell lags and coral patches. The Early Carboniferous is poorly documented, probably still calcareous. No data instead on the Late Carboniferous.
Starting with Permian, sedimentation rate increases and thickness of Permian rocks is between 1 and 2.5-km. They record a variety of environments. The Larger differentiation occurred from the Late Permian to the Middle Triassic, when a peritidal carbonate flat developed at southwest, facing a deeper basin at northeast. With Carnian, the carbonate platform resumed everywhere. This evaluation is interpreted as the passive margin stage of the Karakoram Block, when it followed the fate of the Mega Lhasa continent, which drifted northwards on the Tethyan Trasit Jurassic, the Eo-Cimmerian deformation, more severe in SE Pamir, is recorded also in Karakoram, mostly to northeast, with two arenaceous bodies. Below, Quartzo-lithic sandstones characterized by mafic volcanic detritus and serpentinite grains suggest the nearby presence of a collisional belt. They are sutured by red sandstones with sedimentary and metasedimentary clasts, feeded by an uplifted sedimentary succession. From the Aalenian, this orogenic episode was out and shallow water carbonates ramp aggraded onto the previously emerged area, probably developing for most of the Late Jurassic. This episode is interpreted as the first docking of the MegaLhasa spur represented by SE Pamir to the Eurasia margin, followed by an anticlockwise rotation.
The Karakoram Block is also characterized by a very wide occurrence of black slates, the “Karakoram", fringing externally to the range the previously recorded Paleozoic succession, from the Chitral, through Whakan and SE Pamir, to the W Qiang Tang in Tibet. They are considered as the alluvial and submarine fan of a large drainage system. Such a huge pile of terrigenous sediments may be fed only by a large continent and not by a small block, like the Karakoram. Consequently the “Karakoram” are considered as of Gondwanian origin. When the MegaLhasa continent was isolated by the Neo-Tethys opening, various carbonatic environments developed in Karakoram. The deeper basin starved, with cherty, nodular to platy limestones and shales, at low sedimentation rate, as are the rare occurrence of Triassic conodont bearing layers in Wakhan and SE Pamir. However, any paleogeographic reconstruction is severely hampered by Cretaceous to Cainozoic tectonics, which affected the area, causing also important lateral displacements.
Key words: Sedimentation, metamorphism, Karakoram block, Ordovician, Jurassic.

G/7. Gaetani, M., 1997. The Karakoram Block in Central Asia, from Ordovician to Cretaceous. Sedimentary Geology 109, 339-359.

For details consult the preceding account. More or less the similar, but with information of the Cretaceous period added in this one.
Key words: Karakoram block, Ordovician, Cretaceous.

G/8. Gaetani, M., Angiolini, L., Garzanti, E., Jadoul, F., Leven, E.Y., Nicora, A. & Sciunnach, D., 1995. Permian stratigraphy in the northern Karakorum, Pakistan. Rivista Italiana di Paleontologia-i- Stratigrafia, Melano, 101, 107-152.

Key words: Stratigraphy, Permian, Karakoram.

G/9. Gaetani, M., Erba, E., Jadoul, F. & Angiolini, L., 1992. Age constraints on Karakoram early deformation derived from sedimentary rocks. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, p.28.

The early deformations of Northern Karakorum have at least three age peaks. The older is Jurassic, spanning from Liassic to early Middle Jurassic, as evidenced by red and grey thin to coarse arenites, forming tens to hundreds m-thick multiple bodies. Petrographic composition indicates the orogenic character of these sandstones. The terrigenous bodies increase in thickness from west to east, and north to south, being mostly reddish with emersion evidence at west in Chapursan valley (Yashkuk Fm.) and exclusively gray with marine fauna intercalations south and eastwards (Kundil and the area between Shimshal to Shixnshal pass). More details are reported in the Jadoul et al. abstract (This Workshop). The occurrence of these arenites and shales is interpreted as connected to a nearby deformation and uplift, related to a first docking of Cimznerian microplates.
A strong deformation instead directly affected the whole sedimentary sequence in a time comprised between the Late Jurassic and the Late Cretaceous. The polymictic, mostly fluviatile, Tupop Conglomerate seals verticalized and

folded Triassic and Jurassic sedimentary rocks. Upper Paleozoic clasts were also detected. These were considered till now the youngest pre-India collision sediments of the Karakorum Range, and they were related to the final welding of the Karakorum microplate to the Asian continent, due to the Neothethys active subduction at south. The deformation was tentatively ascribed to a Mid Cretaceous time. It should be also considered the large occurrence of granitoids plutons, with 110-100 Ma age in Northern Karakorum.
During the 1991 expedition, we found a marine reddish to gray nodular limestone some hundred m thick, onlapping with angular unconformity (10 to 20o) the highly irregular surface of the Tupop Conglomerate. These scaglia-like deep-water sediments contain Inoceramidphosphatized particles and very rare Nannofossils. The identified species Ceratolithoides verbekii and Calculites obscurus till now are considered as cohexisting only in the Early and Middle Campanian. This finding represents the youngest marine sediment so far detected in Karakoram, the only Late Cretaceous marine evidence and makes possible some connection with the Late Cretaceous evolution of Western Tibetan Plateau.
Key words: Deformation, sedimentary rocks, Karakoram.

G/10. Gaetani, M. & Garzanti, E., 1991. Multicycle history of the Northern India continental margin (Northwestern Himalayas). American Association of Petroleum Geologists Bulletin 75, 1427-1446.

The geologic evolution of northern India is best recorded in the stratigraphic succession of the Zanskar Range (northwestern Himalaya), which represents the most complete transect through this ancient continental margin. Sedimentary history began in the late Proterozoic, and recorded a late Pan-African orogenic event around the Cambrian-Ordovician boundary, when the Gondwana supercontinent was eventually assembled.
The following long period of epicontinental deposition in shallow seas linked to palaeo-Tethys lasted until the Early Permian, when a neo-Tethyan rift began to open between paleo-India and the Cimmerian microcontinents. Neo-Tethyan history can be subdivided into two sedimentary megasequences, both recording a major tectonic and magmatic event in the lower part. The first one began with breakup in the Late Permian and lasted until the end of the Jurassic. The second one started in the early Cretaceous with the final detachment of India from Gondwana and the opening of the Indian Ocean, and ended with the India-Eurasia collision in the Early Eocene. The two megasequences can be in turn subdivided into six transgressive/regressive supersequences bounded by tectonically enhanced unconformities.
Basal sandstone units of Early Permian, Late Permian, Norian. Callovian, Early Cretaceous, and Paleocene age are invariably associated with oolitic ironstones or reworked glauco-phosphorites, and mark the transgressive part of each supersequence. Next, condensed nodular carbonates or shales with pelagic fauna are typically overlain by thick shallowing-upward marly units capped by regressive platformal carbonates. The six tectono-eustatic supercycles reflect successive rifting episodes which punctuated the progressive separation of India from the rest of Gondwana, and document the combination of plate/microplate reorganizations and eustatic, climatic, and oceanographic changes in the Tethyan domain.
After the onset of collision between India and Asia close to the Paleocene/Eocene boundary, obduction of the remnants of the neo-Tethys ocean floor onto the Indian margin began, and the latter underwent multi- phase deformation with fold-thrust shortening followed by heating and extension. After the main metamorphic event, ophiolitic nappes were re-thrusted and finally emplaced with their sedimentary sole on top of the passive-margin succession.
Key words: Plate tectonics, Indian plate, Himalaya.

G/11. Gaetani, M., Garzanti, E., Jadoul, F., Nicora, A., Tintori, A., & Kanwar, S.A.K., 1987. Major structural elements in upper Hunza valley (Northern Pakistan). EUG Strasbourg, 112-113.

Key words: Structure, Hunza, Karakoram.

G/12. Gaetani, M., Garzanti, E., Jadoul, F., Nicora, A., Tintori, A., Pasini, M. & Khan, K.S.A., 1990. The north Karakoram side of the Central Asia geopuzzle. Geological Society of America, Bulletin 102, 54-62.

An Italian geological team visited a remote and in part never studied area in the northern Hunza region (Pakistan), which represents the link between the Karakorum and Pamir Ranges. The north Karakorum sequence commences in the Permian with terrigenous sediments, followed by shallow- to deep-marine carbonates deposited on a newly formed passive margin. Deep-water sedimentation continued till the end of the Middle Triassic, when carbonate platform conditions resumed. An episode of deltaic red sandstones with orogenic provenance is interbedded in the Liassic, and it is transgressed by a Middle to ?Upper Jurassic shallow water marine unit. Eventually, all of the sequence was faulted and folded, with weak metamorphic imprint, before fluviatile red polygenic conglomerates sealed the succession, in a spectacular unconformity.
The north Karakorum provides an example of a microplate that rifted away from Gondwana in the Permian, reached deep-marine conditions in the Early Triassic, and marginally recorded compressive movements in the Liassic. A subsequent orogenic episode points to a reorganization of the southern Asian margin possibly around middle Cretaceous time. Finally, the north Karakorum was affected by strong fold-thrust deformation and low- to very low-grade metamorphism in the Cainozoic, related to the India-Asia collision.
Key words: Sedimentation, stratigraphy, Permian, Hunza, Karakoram.

G/13. Gaetani, M., Garzanti, E. & Tintori, A., 1990. Permo-Carboniferous stratigraphy in SE Zanskar and NW Lahul (NW Himalaya, India). Eclogae Geologicae Helvetiae 83, 143-161.

Key words: Stratigraphy, Permo-Carboniferous, Zanskar, Lahul, Himalaya.

G/14. Gaetani, M., Gosso, G. & Pognante, U., 1990a. From Kunlun to Karakoram, the EV-K2 CNR 1988 Expedition. In: Abstract volume, 5th Himalaya-Karakoram-Tibet Workshop, Milano, p.15.

During September and October 1988, a geological and geophysical expedition, sponsored by the Consiglio Nazionale delle Ricerche (CNR) and assisted on the field by the Chinese Mountaineering Association (CMA), made a reconnaissance from Mazar (Yarkand Valley) to the north side of the Karakoram (K2 and Gasherbrum).
South of the Kun Lun Crystalline, six units, all bounded by tectonic contacts, have been detected. North to south, they are:
Bazar Dara Slates and related granitoids. Gray dark slates and fine litharenites, several thousand meter thick, intruded by km-sized granitoid bodies.
Surukwat Thrust Sheets. Non-metamorphic red sandstones and anhydrites thrusted together with metadiorites, micaschists, orthogneisses, and metapelites. Aghil Dara Granodiorite. Large body of granodiorite, and subordinated porphyritic granites, quartzdiorites and gabbros. Shaksgam Sedimentary Belt. At least 3-km thick sedimentary sequence, with marine fossils from Permian to the Jurassic. Sughet Granodiorite. Granodiorites and tonalites.
Sarpo Laggo-K2 Metamorphics. Ortho- and paragneisses, marbles and pegmatoids, with less metamorphosed sedimentary thrust sheets containing fusulinids. Unit 1 and 2 are attributed to the Kun Lun and Qiantang micro plates, separated by a great fault, interpreted as the W Kun Lun Fault. Units 5 and 6 belongs to the Karakoram microplate, whilst the correlation of the sediments of Shaksgam valley is uncertain. The Karakoram Fault Zone affect the Sughet Granodiorite and the sediments of the Shaksgam Valley.
Key words: Geophysics, Kunlun, Karakoram.

G/15. Gaetani, M., Gosso, G. & Pognante, U., 1990b. A geological transect from KunLun to Karakoram (Sinkyang), China: The western termination of the Tibetan Plateau. Preliminary note. Terra Nova Research 2, 23-30.

Consult the preceding account.
Key words: Geophysics, Kun Lun, Karakoram, Tibet Plateau.

G/16. Gaetani, M., Gosso, G. & Pognante, U., 1991. Geological report. In: Geodesy, Geophysics and Geology of the Upper Shaksgam Valley (North-East Karakoram) and South

Sinkiang. Scientific Report of the Italian Expedition to Karakoram 1988 (A. Desio leader). Consiglio Nazionale delle Ricerche-Milano, 99-179.

Key words: Geodesy, geophysics, Shaksgam Valley, Sinkiang, Karakoram, Expedition.

G/17. Gaetani, M., Jadoul, F., Erba, E. & Garzanti, E., 1993. Jurassic and Cretaceous orogenic events in the N Karakoram: age constraints from sedimentary rocks. In: Treloar, P.J. & Searle, M.P. (Eds.), Himalayan Tectonics. Geological Society, London, Special Publications 74, 39-52.

At least two major episodes of tectonic deformation are recorded in the Mesozoic sedimentary succession of the North Karakoram. The older event took place between the Liassic and the early part of the Mid-Jurassic, as documented by tens to hundreds of metres thickness of dark grey litharenites (Ashtigar Fm.). The latter are sharply overlain by 35 m to 150 m thick red sandstones, interbedded with shales and siltstones (Yashkuk Fm.). Terrigenous bodies increase in thickness from west to east, and from north to south. Petrographic composition indicates the orogenic character of these quartzo-lithic sandstones, characterized by mafic volcanic and serpentinite detritus, being replaced upwards by sedimentary and subordinate metasedimentary clasts. The Ashtigar Fm. may have been deposited in a collisional basin close to a newly-formed suture belt. Contribution from allochthonous oceanic rocks was significant in the first stages of collision, whereas detritus was subsequently derived mainly from uplifted sedimentary successions. Terrigenous units were conformably transgressed by shallow-water limestones in the Aalenian, and later on marine conditions persisted until the earliest Cretaceous.
The second event of tectonic deformation occurred between the earliest and the Late Cretaceous, when the fan delta Tupop Conglomerate, mostly derived from uplifted carbonate and clastic rocks, sealed the strongly folded and faulted underlying succession. Mid-Cretaceous granitoid plutons are also widespread in the North Karakoram. This orogenic event is interpreted as related to the final welding of the Kohistan arc and Karakoram microplate to Asia.
The highly irregular topography of the Tupop Conglomerate is onlapped unconformably by reddish to grey nodular limestones, some hundred metres thick and containing phosphatized inoceramids and nannofossils of Campanian age (Darband Fm.). These are the youngest marine sediments detected in the Karakoram to date.
Key words: Deformation, tectonics, sedimentation, orogeny, Jurassic, Cretaceous, Karakoram.

G/18. Gaetani, M., Le Fort, P., Tanoli, S., Angiolini, L., Nicora, A., Sciunnach, D. & Khan, A., 1996. Reconnaissance geology in upper Chitral, Baroghil and Karambar districts (northern Karakoram, Pakistan). Geologische Rundschau 85, 683-704.

During the summer of 1992 a geological expedition crossed the northern Karakorum Range in northern Pakistan, from the Chitral to Karambar valleys, from the villages of Mastuj to Imit. Some of the areas visited were geologically unknown. A number of structural units were crossed, belonging to the Karakorum block or to other crustal blocks north of it. They are: (a) the axial batholith, in which three plutonic bodies have been identified, and (b) the northern sedimentary belt (NSB), in which three major tectonostratigraphic units form thrust stacks dipping to the north. Their internal stratigraphy and structural style are partly different. The most complete contains a crystalline basement, transgressed by a marine succession during the Early Ordovician. The youngest strata are represented by the Reshun conglomerate, of inferred Cretaceous age. The northernmost unit of the NSB is tightly folded, whereas the central one forms a monocline. Vertical faults, mainly strike-slip, dissect the thrusted slabs. Metamorphic deformation is absent or reaches only the anchizone in the studied sector of the Karakorum NSB. To the north of the Karakorum proper there are several other tectonic units, separated by vertical faults. They are, from south to north: (a) the Taš Kupruk zone, with metavolcanics of basaltic to latibasaltic composition; (b) the Atark unit, mostly consisting of massive carbonate rocks of Mesozoic age; and (c) the Wakhan slates which consist of a thick widespread succession of dark slates, metasiltites and sandstones. The fine-grained elastic rocks are supposed to be Palaeozoic to Early Triassic in age. The Wakhan slates are intruded by plutons belonging to the East Hindu Kush batholith, from which a single K/Ar age on muscovite gave a Jurassic age.
Key words: Reconnaissance, Chitral, Karakoram.

G/19. Gaetani, M. & Leven, H., 1993. Permian stratigraphy and fusulinids from Rosh Gol (Chitral, Hindu Kush). Rivista Italiana di Paleontologia i stratigrafia 99, 307-326.

Chitral (Pakistan), geologically, includes the eastern termination of the Hindu Kush and its transition to the Karakorum. The position of the boundary is not precisely defined, and may be located provisionally at the Chitral Fault, or at the Tirich Mir Fault. Four main tectonostratigraphic units are identified. From SE to NW they are: 1) Lun Shales (shales and slates with Devonian calcareous intercalations) and Devonian to Permian carbonates. 2) Metabasites, consisting of amphibolites and green tuffs, locally associated with carbonates. 3) Atark Group, mostly metacarbonates in which Permian, Triassic and Cretaceous intervals have been detected. 4) Wakhan Slates, a very thick terrigenous succession of dark colour, partly of Paleozoic age. Huge granitoid bodies have been intruded into this unit. This 4-fold subdivision is here proposed for the first time.
A terrigenous-calcareous succession of Permian age has been measured and sampled in the Atark Group at Rosh Gol. Seven lithostratigraphic units have been identified. Six of them contain fossils, mostly fusulinids, allowing identification of Yahtashian, Bolorian, Kubergandian and Late Murgabian or Midian. The most significant species of fusulinids are illustrated; these have close affinities to the Central Pamir.
Key words: Stratigraphy, Fusulinids, Permian, Chitral, Hindukush.

G/20. Gaetani, M. & Muttoni, 1991. Preliminary notes on the high Chitral geology. Abstract Volume, 6th Himalaya-Karakoram-Tibet workshop, Auris, France, 43.

The High Chitral area, from Mastug to Tirich Gol and Morich Gol valleys, i.e. from SE to NW, consists of the following units.
Lavas and volcaniclastics of the topmost Kohistan arc.
Chitral Slates (gray phyllitic slates) and marbles possibly covered with angular unconformity by 500-m thick polymict conglomerate, including abundant volcanic pebbles.
Shogram-Kuragh Unit. It includes the classical Silurian to Cretaceous succession, sealed by the Reshun Conglomerate, described by Hayden (1915), Desio (1959) and Talent et al. (1981). Disrupted in several blocks, the more complete successions lie northwestwards. It is separated of the following units by the Mt. Shogram Fault.
Lun Slate Unit. Extremely thick unit of gray dark slates, with subordinated marls and marly limestones, with metamorphic grade increasing from SE to NW. In the Morich Valley, it reaches the low-grade with phyllites and micaschists. This belt, wide 15-20 km, was formerly considered as Carboniferous, but Talent et al. discovered in several places Devonian Conodonts.
Uzhnu Gol Metacvolcanics. Bounded by regional faults, a metavolcanic body (amphibolites according to Buchroithner, 1980), some 20-km long and up to 1-km wide, has been observed. It disappears westwards.
Attak Sedimentary Unit. The term was introduced by the Austrian authors, Gamerith and Buchroithner. It forms a carbonate belt, from the upper reaches of the Rich Go to just south of the Tirich Mir. Its contact with unit 4 and 5 is due to a regional fault with significant sinistral component. The metamorphic deformation mostly hampers any detailed stratigraphy. However, in the Zundrangram area, along the Rosh Gol, a Permian sequence of about 600-m was measured. It consists of an arenite-carbonate to claystones sequence, very rich in Fusulinids in the central part that may be interpreted as passive margin succession, drawing during the Middle Permian. Moreover very thick shallow-water carbonates are testified by the presence of Megalodontids and Rudists. Previously considered only as Paleozoic, the age of this unit should be extended up to most of Mesozoic. The sedimentary sequence is crosscut by sills oriented NE-SE, subsequently penetrated by rarer NW-SE dykes.
Whakhan Slates. Separated from the previous unit by another regional fault, dark gray or black slates follow, with subordinated arenites, microconglomerates and rarer pebbly mudstones. Sure turbiditic sequences have not been observed. Along the Rosh Gol a horizon packed with Bryozoan possibly of Paleozoic age has been samples, together with poorly preserved Brachiopods. The slate may be intruded by granitoid bodies.
Key words: Stratigraphy, structural geology, metasediements, metavolcanics, Chitral.

G/21. Gaetani, M., Nicora, A., Angiolini, L. & Le Fort, P., 1993. Geological traverse from Chitral to Karambar (E Hindu Kush to W Karakoram): Preliminary geological results. Abstract, Volume, 8th Himalaya-Karakoram-Tibet Workshop, Vienna, 20-21.

In the easternmost Hindu Kush, Hindu Raj and W Karakoram, the following units may recognize from south to north:

The Axial Batholith forms two distinct branches in this region. They are separated by a band of metasediments already described east of this zone as the Darkot Group, of Permian age pro parte. Possible Mesozoic fossils have been obtained. The Yarkhun river only cuts through the northern branch where two types of granitoid have been recognized: (i) a dark amphibole-biotite granodiorite to biotite, rich in mafic enclaves, often foliated, resembling the Hunza granodiorite of mid-Cretaceous age, (ii) a porphyritic biotite ± amphibolite granite, often strongly deformed, more abundant to the north of the section, where it intrudes into the metasedimentary formations with a diffuse contact. This second type, resembling the subalkaline mid-Cretaceous Darkot pass granite, is intimately associated with the first, a situation similar in some way to that of the Karambar section (see Debon & Khan Abstract).
North of the Axial Batholith mostly sedimentary rocks crop out, usually arranged in three stacks, thrusted southwards. The crystalline basement of the middle stack has been discovered. It is made up of medium-grained biotite granite, largely eroded in a glacial basin, due to its very strong alteration and brittle deformation. To the south, the granite intrudes the dark metapelites of Chikar. The sedimentary succession is directly trangresssive on the granite with conglomerates and siltites, in which Early Ordovician acritarchs have been detected (N. Tongiorgi, Pisa). The succession continues upwards with a terrigenous unit, hundreds m-thick, with rare dolomitic intercalations in which Talent et al. (1981) found Middle-Upper Ordovician conodonts. The first significant carbonate unit consists of about 150m of yellow well-bedded dolomites, with peritidal depositional characters. Supposed age: Devonian. A mixed terrigenous carbonate unit, locally extremely rich in corals, brachiopods and bryozoans follows. Field identification: Middle Devonian and Frasnian. Upwards about 100 in of grey wackestone-crinoidal packstones follow, with solitary corals. Supposed age: Carboniferous. The lower part of the Permian is terrigenous and it is correlatable with the Gircha Formation of the Hunza region. Then a mixed carbonate-terrigenous succession, several hundreds rn-thick follows, locally crowded with brachiopods, corals, bryozoans, conodonts, gastropods, bivalves and especially fusulinids. For details refers to Angiolifli et al. (Poster Section). After an erosional surface, with local einersions and a thin terrigenous unit, a huge peritidal dolomitic formation, 700 in, thick follows. The paleontological control is poor and we suppose it represents the Upper Permian and may be the Triassic up to the Early Jurassic. We have no informations about most of the Mesozoic. The southernmost thrusted slice may have at its top the Reshun Conglomerate with Orbitolina-bearing pebbles.
A system of sinistral strike-slip faults, SW-NE oriented, the Tirich Mir Fault, brings in contact gray pale dolomites, with low metamorphic grade. Phantoms of? Devonian and Triassic fossils have been found. Most significant are mafic metatuffs and various detrital volcanogenic levels, dark red to dark green, interbedded with the sediments.
With faulted contact, the huge, several kin-thick Wakhan Slates follows. They are intruded by granitoid bodies made up in general of biotite-amphibole porhyritic granite. A single granitoid pluton (Chatteboj), with a strong contact aureole, was found also intruded in the unit 2). All these granitoid bodies could pertain either to the northern granitoid belt running from Tirich Mir to Khunjerab, in which Cretaceous ages have been obtained, or to the Batura group of Eocene age.
Key words: Stratigraphy, structural geology, Hindukush, Karakoram, Chitral.

G/22. Gaetani, M., Nicora, A., Cirilli, S., Atudorei, V. & Lucia, A., 1999. The P/T boundary in Karakorum revisited. Terra Nostra 99 (Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany), 48-49.

The stratigraphic succession including the P/T boundary in Karakorum, Pakistan, may occur in two different settings: A) Carbonate platform; B) Pelagic, poorly oxygenated basin.
In Central Western Karakorum, within the carbonate platform of the Ailak Formation, the stratigraphic control is very poor and no details can be obtained. Instead, in the Eastern Karakorum, a pelagic succession spanning the interval from the Kundil Formation (Late Murgabian-Midian=Wordian according to Yin et al., 1997) to the Borom Formation (Olenekian-Ladinian) make possible to analyse the P/T boundary to some details. Unfortunately, the strongly tectonised setting hampered in the field a correct recognition of the stratigraphic sequence and hence the interpretation published in Gaetani et al. (1995) is here reconsidered. The type section, measured by MG and LA, is here reconsidered as far as conodont are concerned (AN). Palynostratigraphy (SC) and stable isotope stratigraphy (VA) are added. Particularly, the second hithozone has been reinterpreted and is now considered a tectonic slice of the underlying Kundil Fm., within tight isochinal folding. The search fa radiolarians (P. De Wever, Paris) was unsuccessful.
The Wirokhun Fm. results now entirely made 1 dark-grey mans and slates, with only occasional limestone intercalations. Due to the lithology and the thermal deformation (CAl of conodonts = 5.5-6; TAI ci sporomorphs = 5-7, approximately corresponding to Ro of vitninite reflectance 1.35-5), most of the 60 samples collected (including

100 kg for conodonts) were barren. The Permian/Triassic boundary lies near the base of the Wirokhun Fm., being the sample KK1 12 the last Permian datum with Neogondolella ex gr. Changxingensis and N. subcarinata. In sample KK 115, (3.20 m above) the palynomorph assemblage contains Cyclogranisporites varius, Polypodiisporites mutabilis, Polypodiisporites sp., Verrucosisporites sp., Densipollenites indicus, Calamospora sp., Dictyotriletes sp., Lundbadispora brevicula, Lundbladispora sp., Eucommiidites sp., Thymospora lpsviciensis, Foveotriletes sp. The concurrent presence of a few Permian and dominating earliest Triassic palynomorphs, suggests that the very base of Triassic is here present. This interpretation is supported by sample KK127 (2 m above) in which a conodont assemblage characterised by transitional forms Hindeodus latidentatus - H. parvus, H. praeparvus and primitive Neogondolella carinata along with Neogondolellids ci the tulongensis-taylorae group, was identified.

A fully Triassic palynomorph assemblage of Induan age is recorded in the following KK124 (6.8 m above) with Cyclogranisporites varius, C. arenos us, Kraeuselisporites sp., Calamospora sp., Inaperturopollenites sp., Dyctyotriletes bireticulat us, DyctyotriLetes sp., Verrucosisporites sp., Densoisporites sp., Baltisphaeridium sp., Grandispora jansonhi, Prothoaploxypinius panaki, Thymospora ipsiviciensis, Lundbladispora brevicula, Lundbladispora sp. This age assignment is reinforced by the following KK126 (1 m above) which contains H. parvus with more evolute morphotype and Neogondolella carinata. To be noted also the presence of fungal remains in the KK 124, which become abundant 2 m above (KK 129).

No significant data are further preserved in the next 10 m of the section. We suggest that this part is the tight core of an isoclinal syncline and the cherty limestone of the sample KK 149 and KK 150 represents the top of the Kundil Fm. Sample KK 150 interestingly contains a Changxingian fauna with Hindeodus typicalis, Neogondollella cf. subcarinata and N. cf changxingensis. In sample KK 158 Hiranognathus cf. unicostatus along with several Neogondolellids is also present.

The carbon isotope profile displays a marked, gradual decrease in values from values higher than +2% recorded at the top of the Kundil Formation, to values as low as -4% which characterize the base of the Wirokhun Formation. Such low values are typically recorded in Lower Triassic carbonates and support the age assignment suggested by the palynomorph data. Moreover, the above-mentioned negative shift may correspond to the well-documented drop in values that marks the Permian-Triassic boundary worldwide. The relatively high <C values (around +2%) recorded in samples KK 150 to KK 159 support the interpretation that Upper Permian strata may be present in this part of the section (as a tectonic slice). 2 C values from carbonates belonging to the Borom Formation show little variability upsection with an average value of -2.5%. The strata examined for this study underwent severe thermal alteration and the primary carbon isotopic composition may be distorted; however, the general trends suggest correlations in agreement with the biostratigraphic data.

Key words: Stratigraphy, P/T boundary, Karakoram

G/23. Gaetani, M., Pognante, U. & Gosso, G. 1991. Geological Report. In: Desio, A. et al. - The Ev-K2 CNR Expedition to the southern Sinkiang (Kun Lun) and the Shaksgam Valley. Italian Expedition Kun Lun Karakorum, 99-190, Milano.

Key words: Expedition, Karakoram.

G/24. Gaetani, M., Zanchi, A. & Angiolini, L., 1992. Geological Reconnaissance to Shimshal Pass, Karakoram. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, 113.

A reconnaissance has been made from Pasu (Upper Hunza) to Shimshal and then up to Shimshal Pass. The rocks cropping out are mostly sedimentary, with feeble to low metamorphic inprint on the southern side of the Shimshal valley, reaching the maximum metamorphic deformation around Dut. On the right side of the valley, from Shimshal up to just NE of the Mai Dur River, the Permian to Cretaceous succession of the Sost Unit (sensu Gaetani et al., 1990) has been crossed. The Jurassic gray sandstone unit is here widely exposed. All the succession is disrupted by the strike-slip system of the Misgar Fault. Details of the structural analysis of this belt are reported in Zanchi' abstract (this Workshop).

With tectonic contact, granitoid bodies follows, intruding slightly metamorphosed slates (Misgar Slate) and carbonates. The granitoid plutons belongs to the important intrusive belt developed northwards of the Karakorum Axial Batholite, which comprises amongst others Mintaka, Kunjerab, Gyraf, and Sughet plutons. They characterize the northern edge of the Karakorum Range, being separated by a sedimentary belt from the Axial Batholite complex.

Key words: Reconnaissance, sedimentary, Shimshal pass, Karakoram,

G/25. Gamerith, H., 1976. Preliminary Geological Map of Gilgit / Hunza / Yasin, Pakistan. Scale 1/250,000. Austromineral, Vienna.

As the title indicates, this is a preliminary map of the western Karakoram Range at a scale of 1: 250, 000 (1 cm = 5 km). All the principal lithologies, comprising (meta)sedimentary rocks, volcanics, granitic intrusions, and major structures are shown.
Key words: Geology, Gilgit, Hunza, Yasin.

G/26. Gamerith, H., 1982. Geologische Karte von Gilgit/Chitral/Whakhan (Nordpakistan und Ostafghnistan) 1:250 000. Graz, privately published.

This is the geological map of the Karakoram Hindukush region of Pakistan and northeast Afghanistan (Wakhan) at a scale 1 cm = 5 km. The rocks of this transitional eastern Hindukush-western Karakoram region range from Paleozoic to Holocene. Major structures are also shown on the map.
Key words: Geology, Gilgit, Chitral, Wakhan.

G/27. Gamerith, H. & Kolmer, H., 1973. Untersuchungen an intrusive gesteinen des ostlichen Hindukusch. Geologic Rundschau, 62, 161-171.

Key words: Stratigraphy, P/T boundary, Karakoram

G/28. Gansser, A., 1964a. Geology of the Himalaya. Wiley Interscience, London, 289p.

This is the first compilation on the geology of the Himalayan mountain range. This well illustrated book also contains a geological map and covers tectonics, structure, and other aspects of the range.
Key words: Books, geology, Himalaya.

G/29. Gansser, A., 1964b. Geologic and tectonic maps of the Himalayan region. London Wiley Interscience, London, (4 maps).

Key words: Geology, tectonics, Himalaya.

G/30. Gansser, A., 1964c. The Alps and the Himalayas. 22nd International Geological Congress, Part XI.

Key words: Alps, Himalayas.

G/31. Gansser, A., 1973. Ideas and problems on Himalayan geology. In Seminar on Geodynamics of the Himalayan Region, 97-103. National Geophysical Research Institute, Hyderabad.

Key words: Geodynamics, Himalayas.

G/32. Gansser, A., 1974a. The ophiolitic melange, a world-wide problem on Tethyan examples. Eclogae Geologiae Helvetiae 67, 459-507.

The ophiolitic mélange is defined as an olistostromal and tectonic mixture of ophiolitic material and sediments of oceanic origin with exotic blocks, reflecting areas which have subsequently disappeared. Being intimately related to

ophiolitic belts they indicate important suturelines connected to plate boundaries. Ophiolitic mélanges occur mostly where continental type plates are subducted with obduction of oceanic material. These fact are discussed on examples from the Middle East and the Himalayas, where the mélanges are particularly well exposed.
Key words: Ophiolite Melange, tectonics, Middle East, Himalaya.

G/33. Gansser, A., 1974b. Himalaya. In: Spencer, A.M. (ed.), Mesozoic-Cenozoic orogenic belts. Geological Society of London, Special Publication 4, 267-278.

Key words: Orogeny, Mesozoic, Cenozoic, Himalayas.

G/34. Gansser, A., 1976. The Great Suture Zone between Himalaya and Tibet: A preliminary account, Himalaya. Colloquiam Science de la Terra, International 2nd Ed., C.N. Rech. Science, Paris. Himalaya Sciences De La Terre 268, 181–191.

Key words: Indus Suture, Himalaya, Tibet, Kailas, Ladakh.

G/35. Gansser, A., 1980a. The peri-Indian suture zone: Geology of the Alpine chains born of the Tethys. 26th International Geological Congress, Paris, 5, 140-148.

The 5.000 km long Peri-Indian Suture Zone is divided into the North Himalayan - the Arakan Yoma – and the Quetta belt. It consists of ophiolites with basic volcanics. Ultramafics and associated ophiolitic mélanges which suggest originally steep but narrow oceanic basins. The Himalayan belt is fol1owed northwards by the 2.500 km long Transhimalayan batholith which originated from a mostly oceanic crust and is different from the Himalayan and Karakorum batholiths. On its south side, the batholith is transgressed by the paleogene Kailas molasse. All these elements are interrupted by younger north south directed cross highs and fault zones. In the Arakan Yoma and Quetta belts the ophiolitic associations are similar but the geological frame has partly changed.
Key words: Suture zone, Geology, India.

G/36. Gansser, A., 1980b. The significance of the Himalayan suture zone. Tectonophysics 62, 37-52.

The 2500 km long Himalayan Suture Zone is discussed within the widest structural frame, with new results obtained from a study of the Landsat pictures. The platform sediments from the Tethys or Tibetan Himalaya, north of the Main Central Thrust, Change northwards into a belt of Flysch sediments beginning in the Triassic and reaching the Paleocene. The belt is mixed with oceanic crust material such as volcanics, mélanges and ultrabasic slabs, and is strongly tectonized: the Suture Zone. It is followed to the north by a conspicuous belt of Kailas Molasse, of Paleogene age and transgressing the late Cretaceous Transhimalayan plutons. They consist of five bodies, predominantly tonalitic, separated by structural anomalies that also cut the Suture Zone. The plutons are structurally controlled and related to the Himalayan Suture (Subduction belt?). They are followed to the north by the south Tibetan Nyenchen Tangla belt, bordered by large fault zones and characterized by frequent Paleogene acid volcanics. The Central Tibetan Chang Thang area is structurally most complex, contains some ultrabasic rocks related to large fault zones, and exposes a large subrecent basaltic volcanism with no structural control but reminiscent of a “hot spot”. The northern Kun Lun — Astin Tagh Paleozoic erogenic belt displays 200 km of rejuvenated fault zones, some older mantle fragments and subrecent volcanism.
This structural aspect of Tibet, with internal older Suture Zones, younging southwards, contrasts with the Indian plate south of the Main Himalayan Suture. This Suture Zone is the only constant structural element all along the Alpine-Himalayan belt.
Key words: Suture Zone, landsat images, sediments, Himalayas.

G/37. Gansser, A., 1980c. The division between Himalaya and Karakoram. Geological Bulletin, University of Peshawar 13, 9-22.

The 5000 km long Peri-Indian Suture Zone has doubled in the western Himalaya and the northern branch forms the division between the Himalaya and the Karakorum. The northward directed Nanga Parbat-Haramosh crystalline spur controls structure and petrology of both the Suture Zone. It divides the over 2000 km long Trans-Himalayan batholith into the eastern Ladakh and the western Swat Batholith. Geology and petrology of the Karakorum north of the Northern Suture Zone strongly contrast with the Himalaya to the south of it.
Key words: Suture zone, Himalaya, Karakoram.

G/38. Gansser, A., 1981. The geodynamic history of the Himalaya. In: Gupta, H.K. & Delany, F.M., (Eds.), Zaqro–Hindukush–Himalaya: Geodynamic Evolution. American Geophysical Union, Geodynamics Series 3, 111-121.

Key words: Geodynamics, Himalaya.

G/39. Gansser, A., 1990. Fact and theories on the Himalayas. In Abstract volume, 5th Himalaya-Karakoram-Tibet Workshop, Milano, 16-17.

Consult the following account
Key words: Orogeny, Himalayas.

G/40. Gansser, A., 1991. Facts and theories on the Himalayas. Eclogae Geologi Helvetia, 84, 33-59.

During the classical exploration in the 19th and early 20th centuries the ratio between facts and theories was 1:0.5. Plate tectonics changed it 1:3 and with geophysics, geochemistry and structural analysis the ratio became 1:5.
The backbone of the High Himalayas is a crystalline core, involving the Lesser Himalayas in the W. Exposed are Precambrian structures and metamorphism, overprinted by a Himalayan phase, its intensity still highly disputed. Cambrian non-orogenic granites cut discordantly rocks with preserved Precambrian structures. New age from 2000 to 900 may confirm this fact. Himalayan PT has not cancelled all the Precambrian elements and thrusting along the MCT has transported some relictic structures. The MCT forms a shuppen zone or can expose a sharp contact (Bhutan). Sediments of the Lesser Himalayas are now dated Late Precambrian to Cambrian, including most of the tillites. No real basement is yet known. Disputed is the fact of reversed metamorphism towards the MCT and above. The hot overthrust theory is contradicted by Jurassic palynomorphs just below the thrust. The Himalayan metamorphic overprint ends with the intrusion of leukogranites. They stress the 5000my intrusive gap from the Cambrian granites, a fact repeated in the North Himalayan crystalline, diapiric domes; a gap filled with nonorogenic Tethyan sediments. These follow above the crystallines with Late Precambrian argillaceous sediments where the high-grade metamorphism gradually decreases to anchi-phase in the Cambrian. Locally the crystalline/sediment contact can be downfaulted, negligible in the Garhwal Himalayas where basal sediments are over 5000m thick. The lesser Himalayas have a similar facies of Late Precambrian, (Dalings, Simla Slates). They suggest a more distal facies of the widespread Vindhyans, covering the northern Indian Shield.
Theories over facts increase when we approach the Indo/Yarlung suture (IYS), the obducted remnants of a large or small Tethyan ocean, outlining the collision between India and Tibet. Its timing, proven by intra-trappean Asian faunas of 67 my predates all previous assumptions, though collision was not synchronous and started earlier in the W Himalayas. The regional outline is surprisingly constant, but the details vary considerably: W Ladakh exposes 3 vertical ophiolitic melange belts. Eastwards they are capped by a large (40-km) ultramafic body, which retains a normal cover of gabbros and volcanics. Further E it is transported 50-km northwards to the tripple-junction at Tashigong, the most important but least known spot along the IYS. From here starts the Shyok suture and borders the Karakoram to the S as a deep fracture or a subduction. In a post-collision phase ophiolite nappes were thrust southwards. Remnants are seen in the Spongtang nappe (40-km thrust), the Amlang-La nappe (80-km) and Shigatse nappe (30-km). Similar nappes are even known along the suture on the West Side of the Indian shield (Quetta branch) with 30 to 50-km thrusts towards the E. In all nappes ophiolitic mélanges, frequently with exotic blocks, form the base and ultramafic bodies, often with primary textures, the top. Most of the nappes have been emplaced within the Lower Eocene.
North of the IYS follow the Andean-type Tranhimalayan plutons, subdivided into Gangdese, Kailas, Ladakh and Swat plutons, the latter already W of the western syntaxis within the Kohistan complex, where facts and theories

show an abnormal high ratio. The Transhimalayan plutons, ranging from 100-40 my, the older ones often with a more basic composition, border the complex Tibetan continental margin, from which they have been more or less contaminated. This is documented by many xenoltihs from the Tibetan “basement”. However, in the western Ladakh pluton, between the Shyok suture and the IYS, NS aligned xenoliths seem to resemble the basement of the Nanga Parbat spur.
Subsequent to the intrusions the Transhimalayas were strongly uplifted and eroded, producing an Oligocene molasse, well preserved in the central Transhimalaya with 4000-m of clastic rocks, still nearly horizontal bedded and from which the spectacular Kailas has been carved, the most sacred mountain in Asia. All the greater rivers in the wider Himalayas originate from the Kailas region cut through the highest uplifts in the Himalayas and deposit their sediments in the Indus and Bengal fans, the largest submarine deltas known.
Key words: Orogeny, Himalayas.

G/41. Gardezi, A.H., 1957. Geology of Salt Range, Potwar, Hazara and Swat. M.Sc. Thesis Punjab University, Lahore, 74p.

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

G/42. Gardezi, A.H., 1970a. Note on the Geology of the area around Nathiagali, District Hazara, West Pakistan. Geological Bulletin, Punjab University 7, 71-78.

The geological investigation around Nathiagali, District Hazara, West Pakistan, was initiated during the summer of 1963 in order to understand (a) the lithostructural features of the Hazara Slate Formation, (b) the nature and inter-relationships of calcareous bands that occur within the Hazara Slate Formation, (c) the nature of the base of post-Hazara slate rock sequence and (d) the tectonic style. During the subsequent years, as the emphasis shifted to other geological problems and to other areas as well, detailed and more extensive investigations were postponed. However, in the following paragraphs are summarised the few conclusions that were arrived at during the preliminary survey.
Key words: Geology, Nathiagali, Hazara.

G/43. Gardezi, A.H., 1970b. Stromatolite (agal reefs) in Hazara District, West Pakistan. 21st and 22nd All Pakistan Science Conference, Rajshahi, p.114.

Key words: Reefs, Hazara.

G/44. Gardezi, A.H. & Ghazanfar, M., 1965. A change of facies at the base of the Jurassic in District Hazara, West Pakistan. Geological Bulletin, Punjab University 5, 53-56.

During his mapping of Hazara District, Middle- miss (1896, p. 124, 125) observed the presence of some "yellow shales" below the so-called Trias limestone near Tarnawal, which he goes on to say might represent the upper part of his Infra-Trias formation. He, however, was not able to confirm their age.
Independent observations were made, in an- other locality, by Marks and Muhammad Ali (1961, p. 50), who noted the presence of some "brownish to greenish siltstones and shales apparently conformably overlying the cherty limestone of the Infra-Trias". These authors further observed that "higher on the western slopes of Sarbun Dhaka the same formation is developed as haematite breccias associated with red-spotted, yellow sandstones".
The junior writer had an opportunity to study the geological and structural position of the so- called yellow shales during the summer of 1964. He found them to form a distinct rock unit and in his M.Sc. Fieldwork Report referred to them as the Hazira shales, after the village Hazira. In the following year, a more detailed study was under- taken in collaboration with A. H. Gardezi. This work produced some very interesting structural and stratigraphical results, which have led to a useful clarification and elaboration of the observations already made. Their stratigraphic position and field relationships are now better understood than before. The results of this field-work are now summarised and should be considered in conjunction with the map.
The Hazira Formation consists mainly of dirty grey and yellowish brown, calcareous, shaly siltstones, containing earthy concretions and attaining a maximum thickness of some 1,000 ft. It conformably overlies the Abbottabad

formation and is itself overlain by the basal arenites of the Jurassic, which often form a thin band of whitish ironstained orthquartzite. The yellowish brown colour of the Hazira formation is replaced by a red tinge at places, as at Banda Pir Khan where it also contains a few quartzite bands. Towards its base, the Hazira Formation is generally glauconitic; this is clearly noticeable in the hand specimens.

The following details of the Hazira Formation are given:-

(a) It replaces the Haematite formation in stratigraphic sequence.

(b) Its lower boundary is gradational.

(c) Wherever its upper boundary is preserved, it is followed by a thin band of iron-stained ortho-quartzite (belonging to the Maira Formation of Davies and Gardezi, 1965. p.), which is present at the base of the Jurassic limestone throughout Hazara. Whether the Abbottabad Formation and Haematite formation intervene between the Jurassic and the Hazara slates or not, this band of ortho- quartzite is never missing and, therefore, it must form the lower boundary of the Jurassic. Its presence in no way means the presence of the Haematite formation, even in a reduced form.

The boundary relationships and stratigraphic position, as mentioned above, make a strong case for believing that the Hazira Formation is at least partly equivalent to, and represents a facies change of the Haematite formation.

(d) In spite of the great difference in lithology, the close proximity of the two facies remained puzzling. Therefore, a detailed mapping of the relevant area was undertaken. It has led to the discovery of a major thrust-fault which may be called the Lagarban Fault. This fault, starting from near the Kunhar river in the northeast continues southwards to beyond Abbottabad. The Lagarban Fault has provided translation to such an extent as to eliminate the transitional zone between the two facies, except near Kihal, Abbottabad, where at the base of the Hazira Formation a part of the Haematite formation is developed in the form of haematitic quartzite and quartzite breccias.

(e) Since its lower boundary is gradational and since it lies below the orthoquartzite of the Maira Formation the Hazira Formation should succeed or represent the uppermost part of the so-called Abbottabad Formation. Its counterpart, the Haematite formation should also represent the same with, of course, some slight breaks in sedimentation represented by the volcanic flows. This stratigraphic conclusion is also supported by the way in which the Jurassic overlaps the Hazira and Abbottabad Formations lying below it. In part of the area, there is also evidence of their overstep by the Jurassic on to the Hazara slates. Further support for this regrouping comes from the observation of the cyclic deposition of the Abbottabad Formation itself. Such a grouping would, however, be in contrast with that presented by Marks and Muhammad Ali (1961, p. 50) and should lead to the renaming of the Abbottabad Formation as the Abbottabad Group, which would include the Abbottabad Formation of Marks and Muhammad Ali and the Haematite formation or the Hazira Formation, the last two being equivalent to and interchangeable with each other.

(f) Near Jaster the lower part of the Jurassic limestone formation is very well developed and is underlain by the calcareous fossiliferous shales of the Maira Formation (Upper Liassic). These shales are lithologically quite different from the Hazira shales and have at their base the iron- stained orthoquartzite which always overlies the latter.

(g) No fossils have so far been recorded from the Hazira Formation and it can only be said that it is probably Pre-Jurassic and lies at the top of Middlemiss, "Infra-Trias", or of the Abbottabad Formation of Marks and Muhammad Ali (1962, p. 56) which has been assumed to be of Permo- Carboniferous age.

Key words: Facies change, Jurassic, Hazira, Abbottabad, Hazara.

G/45. Gardezi, A.H., Ghazanfar, M. & Shakoor, A., 1976. Geology of Darra Adam Khel area, District Kohat, Northwest Frontier Province, with observations on the facies changes and their tectonic implications. Geological Bulletin, University of Punjab 12, 97-102.

Pioneer work has been carried out in the geological unknown tribal territory of Darra Adam Khel. Stratigraphic column has been established. Facies changes of great structural significance have been discovered. Complicated local structure has been unraveled with important bearings on the tectonics of the outer Himalayas.

Key words: Stratigraphy, facies change, structure, Kohat.

G/46. Gardner, J.S., 1986. Recent fluctuation of Raikot Glacier, Nanga Parbat, Punjab Himalaya, Pakistan. Journal of Glaciology 32, 527-529.

Key words: Glaciers, Raikot, Nanga Parbat.

G/47. Gardner, J.S. & Jones, N.K., 1993. Sediment transport and yield at the Raikot Glacier, Nanga Parbat, Punjab Himalaya. In: Schroder, J.F.Jr. (Eds.), Himalaya to the Sea. Geology, Geomorphology, and the Quaternary. Routledge, 184-197.

Key words: Glaciology, sedimentology, Nanga Parbat.

G/48. Garrido, C.J., Bodnier, J.L., Hussain, S.S., Dawood, H., Burg, J.P. & Chaudhry, M.N., 1999. Geochemistry of the Jijal complex: a subarc mantle-crust transition at the base of the Mesozoic Kohistan arc. EU G. Meeting, Strasbourg, J. Conference Abstract 4, p.397.

Key words: Geochemistry, Jijal Complex, Kohistan.

G/49. Garwood, E.J., 1924. Himalayan glaciation. The Geographical Journal 63, 243-246.

Key words: Glaciology, Himalaya.

G/50. Garzanti, E., Critelli, S. & Ingersoll, R.V., 1996. Paleogeographic and paleotectonic evolution of the Himalayan Range as reflected by detrital modes of Tertiary sandstones and modern sands (Indus transect, India and Pakistan). Geological Society of America Bulletin 108, 631-642.

Detrital modes of sandstones derived from the Himalayan suture belt record the history of the mountain range since initial collision between India and Asia, which began in latest Paleocene time. Tertiary clastic wedges deposited in fore-arc, foreland, and remnant-ocean basins, and exposed along the Indus transect from northernmost India to the Arabian Sea, represent the best opportunity to study sedimentary responses to successive tectonic events during continental collision. Quartzose "continental-block" and feldspatholithic "magmatic-arc" sandstones were deposited, respectively, on the passive Indian (Tethys Himalayan succession) and active Asian (Indus Group) continental margins during Late Cretaceous–Paleocene time. Closure of the Neotethys was marked by sudden arrival of volcanic and ophiolitic detritus on the passive continental margin of the Indian plate during deposition of sediments dated at foraminiferal zones P6 (Pakistan) to P8 (India). Starting in early Eocene time (deposition of Chulung La Formation and Murree Supergroup), volcanic and ophiolitic to metasedimentary detritus was accumulated in rapidly subsiding "piggy-back" and foreland basins. Homogeneous petrographic composition within the Eocene–lower Miocene Murree Supergroup, with only slight progressive increase of detrital feldspars, suggests erosion of largely supracrustal rocks involved in thrusting in the north.
In middle Miocene time, marked enrichment in medium- to high-grade metamorphic detritus in foreland sandstones (Siwalik Group) reflects rapid uplift of a warm wedge of Indian crust, which was carried southward along the Main Central thrust. This major paleogeographic change was recorded also by quartzolithic remnant-ocean turbidites, which were fed great distances along transverse fracture zones and later accreted in the coastal Makran subduction complex (Panjgur association and Makran Group). Recycled-orogen detritus derived from the elevated Himalayan chain is still accumulating today in the Indus fan. Enrichment in feldspars with respect to ancient sandstones reflects deep erosion levels into mid-crustal rocks along the core of the growing orogen.
Key words: Fore-arc, foreland, paleotectonic, paleogeography, sandstone, sutures, Indus transect, Himalaya.

G/51. Gattinger, T.E., 1961. Geologischer querschnitt des Karakorum vom Indus zum Shaksgam. Jahrbuch der Geolgiscen Bundesanstal, 6, 3-118.

Gattenburg took part in the Austrian Himalaya-Karakoram Expedition of 1956. He carried out an intensive field work in the Baltoro basin and its southwestern adjoining area as far as Skardu on the left bank of the Indus River. In this paper, he published the geological section between the Indus and Shaksgam, and provided information on the stratigraphy, lithology and structure of the (meta)sedimentary and granitic rocks.
Key words: Structure, stratigraphy, lithology, Shaksgam, Karakoram.

G/52. Gauhar, S.H., 1965. The geology and mineral potentialities of Azad Kashmir, Gilgit and Baltistan area. Geological Survey of Pakistan, Information Release 25, 15p.

Key words: Geology, mineral resources, Northern Areas, Azad Kashmir.

G/53. Gauhar, S.H., 1969. Exportable minerals of Pakistan. Geological Survey of Pakistan, Geonews 1(3), 34-41.

This compilation lists the exportable mineral deposits of Pakistan till the year 1968.
Key words: Mineral deposits.

G/54. Gauhar, S.H., 1976. Mineral resources of Pakistan. (Summary report for 1974) Geological Survey of Pakistan, Geonews V (1), 3-14.

A summary of the mineral resources of Pakistan upto the year 1974 is compiled in this report.
Key words: Mineral resources.

G/55. Gauhar, S.H., 1984. Interim note on manganese occurrences in North Waziristan Agency, FATA., NWFP. Geological Survey of Pakistan, Information Release 247.

An earlier report on the occurrence of manganese deposit in North Waziristan is given in this report. The report is accompanied by preliminary geological map of the area.
Key words: Mineral deposits, manganese, N. Waziristan.

G/56. Gauhar, S.H., 1992. Plate tectonics, crustal evolution, and metallogeny of Pakistan. Geological Survey of Pakistan. Information Release 525, 27p.

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

G/57. Gauhar, S.H., 1999. An overview of mineral resources of Pakistan. Geological Survey of Pakistan. Records, 127, 85p.

Key Words: Mineral resources,

G/58. Gauhar, S.H., 2000. Issues in the development of gems and precious stones in Pakistan. Geological Survey of Pakistan, Information Release, 751, 32p.

Key Words: Gemology, precious stones.

G/59. Gauhar, S.H. & Afridi, A.G.K., 1980. Preliminary report of geology and mineral prospects of the Kohistan region, North West Frontier Province, Pakistan. Geological Survey of Pakistan, Information Release 127, 10p.

A summary of the economic mineral prospects of Kohistan region is given in the report.
Key words: Geology, minerals, Kohistan, NWFP

G/60. Gauhar, S.H., Asrarullah, & Farah, A., 1980. Some introductory remarks on the plate tectonic and metallogenic framework of Pakistan. Geological Survey of Pakistan, Information Release 125, 25p.

This contribution looks at the metallogenic framework of Pakistan in relation to the plate tectonic configuration of the country.
Key Words: Plate tectonics, metallogeny.

G/61. Gauhar, S.H., Khan, A.L., Abbas, S.G., Hussain, A., Tariq, M.A. & Khan, I.A., 1998. Geological Atlas of Pakistan. Geological Survey of Pakistan, Special Publication, 76p.

Key Words: Atlas, geology.

G/62. Gauhar, S.H., Mirza, M.A. & Jamiluddin, S., 1985. Map showing the status and strategy of geological mapping in Pakistan. Special Volume, Geological Survey of Pakistan, Map Series 1, scale 1:2000,000.

Key Words: Mapping, geology, Pakistan.

G/63. Gazis, C.A., Blum, J.D. & Chamberlain, C.P., 1995. The effect of hydrothermal activity on the Sr isotope systematics of gneisses from the Nanga Parbat-Haramosh Massif (Northwest Himalaya, Pakistan). EOS (Transaction, American Geophysical Union) 76, F704.

Key Words: Hydrothermal activity, Sr isotopes, NPHM gneisses, Himalaya.

G/64. Gazis, C.A., Blum, J.D., Chamberlain, C.P. & Poage, M., 1998. Isotope systematic of granites and gneiss of the Nanga Parbat massif, Pakistan Himalaya. American Journal of Science 298, 673-698.

Isotopic analyses of gneisses and anatectic granites from the Nanga Parbat-Haramosh Massif (Pakistan Himalaya), a zone of pronounced thermal activity and recent high-grade metamorphism in the Indian Plate, reveal information about the conditions of granite genesis and the nature of Sr exchange in high-grade gneisses and granites. 87Sr/86Sr ratios for both gneisses and granites are extremely high and heterogeneous (0.7721-1.0642), indicating that both granites and gneisses have an ancient metasedimentary crustal source. Whole rock Rb-Sr data for gneisses scatter around a reference isochron with an age of 1.8 Ga. Although the Nanga Parbat leucogranites have similar 87Sr/86Sr ratios to the surrounding gneisses, their Nd isotopic compositions (eNd = -23 to -25) are higher than those of the gneisses and migmatites (eNd = -26 to -29), indicating that the granites' source is not the presently exposed level of gneisses. This result is consistent with other studies that suggest these granites formed as a result of vapor-absent

melting during the recent, rapid uplift of Nanga Parbat. Biotite and feldspar mineral separate Rb-Sr data for six gneisses and one granite have near-horizontal or negative slopes (and ages) on a Rb-Sr isotopic evolution diagram. This behavior is best explained by: (1) a recent «5 Ma) local homogenization of Sr isotopes during the young metamorphism; and (2) after peak metamorphism, Sr isotope exchange occurred between biotite and carbonate minerals after feldspar became closed to Sr exchange. This exchange took place within the last 2 my and was mediated by metamorphic or magmatic fluids which augmented Sr exchange with carbonate/calcsilicate lenses and/or deposited secondary calcite veins in the granites and gneisses. This proposed Sr exchange between silicates and carbonates could have significant implications for the interpretation of the seawater Sr curve because it enables carbonate dissolution to contribute radiogenic Sr to the dissolved load in streams.
Key Words: Isotopes, granite gneiss, NPHM, Himalaya.

G/65. Gee, E.R., 1934. The saline series of Northwestern India. Current Science, Bangalore, 2, 460-463.

Key Words: Saline series, India.

G/66. Gee, E.R., 1935a. The Saline series (Lower Eocene) of northwestern India (abstract). Proceedings 22nd Indian Science Congress, Calcutta, 207p.

Key Words: Saline series, Eocene, India.

G/67. Gee, E.R., 1935b. Salt Range, Punjab and N.W.F.P. Geological Survey of India, 69(1), 64-72.

Key Words: Salt Range, NWFP, Punjab.

G/68. Gee, E.R., 1937. The occurrence of Cambrian beds in the Khasor Range, North-West Frontier Province (abs). Proceedings 24th Indian Science Congress, Hyderabad, 232-233.

Key Words: Cambrian, Khasor Range, NWFP.

G/69. Gee, E.R., 1938. The economic geology of the northern Punjab, with notes on adjoining portions of the North-West Frontier Province, India. Mining Geology and Metallic Institute Transactions, 33(3), 263-354.

Key Words: Economic geology, Punjab, NWFP, India.

G/70. Gee, E.R., 1940. Recent views on the salt-bearing formations of north-western India. Proceedings, 27th Indian Science Congress, Madras, pt.4, p.10.

Key Words: Salt bearing Formations, India.

G/71. Gee, E.R., 1945. The age of the Saline series of the Punjab and of Kohat. Proceedings, National Academy of Sciences, India, Section B, 14(6), 269-312.

Key Words: Saline series, Punjab, Kohat.

G/72. Gee, E.R., 1947. The mineral resources of Northwestern India. National Institute of Sciences, India 2(8), 20-32.

Key Words: Mineral resources.

G/73. Gee, E.R., 1949. The mineral resources of North West India. Geological Survey of Pakistan, Records, 1(1), 25p.

Key Words: Mineral resources, India.

G/74. Gee, E.R., 1950. Petroleum geology in Pakistan. 18th International Geological Congress, London, 6, 59-64.

Key Words: Petroleum geology, Pakistan.

G/75. Gee, E.R., 1957. Principal mineral resources of certain regions of West Pakistan. Geological Survey of Pakistan, Mineral Map, Sheet No. 20.

Key Words: Mineral map, West Pakistan.

G/76. Gee, E.R., 1962. Notes on Mesozoic/Tertiary stratigraphy of the (Former) Punjab, North West Frontier Province, Sulaiman Ranges. The Geologist, Geological Society, Karachi University I (1), 2-5.

Key Words: Stratigraphy, Mesozoic, Tertiary, Punjab, NWFP, Pakistan.

G/77. Gee, E.R., 1980. Pakistan Geological Map: Salt Range Series (6 sheets, scale 1:50,000). Directorate of Overseas Surveys (UK) for the Government of Pakistan and the Geological Survey of Pakistan.

This is the most detailed geological map of the Salt Range based on published data and many years of studies of E.R. Gee. It is produced on six sheets at a scale of 1:50,000. The map is essentially for the sys Indus Salt Range, however, a small portion of the Trans Indus Salt Range around Kalabagh is also shown. Salt Range is not covered in our work, however, this map shows the distribution of the Siwalik sediments which we include in our work for the sake of completion of references on the Siwaliks.
Key Words: Mapping, Salt Range.

G/78. Gee, E.R., 1983. Tectonic Problems of the sub-Himalayan Region of Pakistan. Kashmir Journal of Geology 1, 11-18.

Key Words: Tectonics, Himalaya.

G/79. Gee, E.R., 1989. Geological map of the Salt Range, Pakistan.

This geological map at a scale of 1:250,000, is based on E.R. Gee, 1980, geological map (Sheets 1-6), scale 1:50,000. For more details consult gee, 1980.
Key Words: Mapping, Salt Range.

G/80. Gee, E.R. (edited by Gee, D.G.), 1989. Overview of the geology and structure of the Salt Range, with observations on related areas of northern Pakistan. In: Malinconico, L.L. & Lillie, R.J. (eds.), Tectonics of the Western Himalayas. Geological Society of America, Special Paper 232, 95-112.

The Salt Range and its Trans-Indus extension bridges the reentrant between the outer ranges of the northwestern Himalaya and the Sulaiman Mountain arc. Upper Proterozoic to Recent successions occur in the range, which makes up the southern thrust front of the orogen. There are two regional features of particular interest. The first is the occurrence of thick saliferous deposits of Eocambrian age, overlying Precambrian basement in the Potwar Plateau and thrust southward in the Salt Range over the alluvial Cenozoic.
Thick, saliferous deposits also occur within the Eocene sequence of Kohat. These in- competent formations played a significant role in determining structure. The second feature is the presence of four major unconformities: between the marine Eocambrian to Cambrian sequence and the glacial, Lower Permian conglomerates, and below the Paleocene, the Miocene, and the late Pliocene-Pleistocene formations.
Metamorphic rocks, linking with the Precambrian crystalline basement of north- western India, crop out only in the Kirana Hills some 80 km south of the Salt Range. Within the Salt Range and related areas, unmetamorphosed sedimentary rocks compose the exposed succession, mainly shallow-water marine, until mid-Tertiary time, and lacustrine and fluvial from Miocene time onward.
Prior to Quaternary time, only epeirogenic forces affected the region, accompanied occasionally by local warping. In contrast, during Quaternary time, the effects of the Himalayan orogeny extended southward. Accentuated by movement within the Eocambrian saliferous formation, the Salt Range developed as a complex anticlinorium, emplaced southward along a major thrust, which has recently been determined by seismic reflection measurements to involve a decollement of at least 20 km. Complex fold and fault structures resulted elsewhere within the region.
Key words: Salt Range, orogeny, Potwar Plateau, Soan Basin, Himalaya.

G/81. Geological Survey of India, 1904. Quinquennial review of the mineral production of India. Geological Survey of India, Record 32(1), (For the period of 1898-1903).

Key words: GSI publication.

G/82. Geological Survey of India, 1907. Preliminary survey of certain glaciers in the northwest Himalaya. Geological Survey of India. Records, 35

Key words: GSI publication.

G/83. Geological Survey of India, 1931. Geological map of India and adjacent countries. Geological Survey of India, 5th edition.

Key words: GSI publication.

G/84. Geological Survey of India, 1943. Catalogue of publications and index of geological maps of the Geological Survey of India up to June 1941. Geological Survey of India. Memoirs, vol. 77, 114p.

All publications, up to 1940, by the geological Survey of India on the former NWFP, northern Punjab, Hindukush, Karakoram and Himalayan ranges are listed in this memoir.
Key words: GSI publication.

G/85. Geological Survey of India, 1947. Catalogue of publication of the Geological Survey of India and index of Geological maps. Up to March 1946. Memoirs of Geological Survey of India, 77.

This catalogue contains the index map on a scale of 50 miles to an inch, of the published and unpublished maps of India up to 1946, and publications of the GSI. These include the available publications on the areas of this compilation.
Key words: GSI publications, Maps.

G/86. Geological Survey of Pakistan, 1958. A preliminary geological map of Pakistan. Scale 1: 5,000,000, Geological Survey of Pakistan, Information Release 1.

This is one of the earliest efforts on preparing the geological map of Pakistan, following fragmentary information in compilations such as that of Wadia. It was revised in 1962.
Key words: Maps, geology.

G/87. George, M.T., 1993. Structural and Thermal Constraints on the Tectonic Evolution of the North-Western Margin of the Nanga Parbat-Haramosh Massif (Pakistan). Abstract, Volume, 8th Himalaya-Karakoram-Tibet Workshop, Vienna, 31-32.

In the Haramosh region of northern Pakistan, the Kohistan island arc is separated from the Indian crust of the Nanga Parbat-Haramosh massif (NPHM) by a 2.5 km-wide, steeply inclined ductile shear zone containing intercalated lithologies derived from both terranes. A combined structural, geochemical and geochronological study across this zone has helped to constrain the thermal and tectonic evolution of the region.
The youngest stage of magmatism within the eastern part of the Kohistan batholith is characterized by biotite granite sheets (Confluence granites) emplaced at 50-30 Ma and younger muscovite granite sheets (Patti granites) at ~26Ma. These are geochemically distinct, with the Confluence granites comprising a range of granitic compositions with high Sr and Ba abundances and the Parri granites terming granite sheets enriched in Rb. Undeformed granites in both suites have ($^{87}Sr/^{86}Sr$)i in the range (1.7045-0.7054 and εNd(T) of +0.1 to+2.7, suggesting that both groups may be derived from juvenile arc sources.
The Kohistan granite sheets can be traced into the shear zone at Sassi, where they are generally intensely deformed and mylonitized, although locally the sheets cross-cut shear fabrics and intrude intercalations of Indian crust material. Whilst none of the sheets appear to have intruded far into the NPHM, these relationships indicate that the Kohistan granite sheets postdate the initial collision of the northern Kohistan terrane with the Indian continent. The isotopic evidence from the undeformed granite sheets suggests that significant underthrusting of northern Kohistan by the Indian continental crust may not have occurred until after 26 Ma. Within the shear zone, deformed granite sheets show a marked increase in ($^{87}Sr/^{86}Sr$)1 (0.7075-0.7784), with decreased εNd (T)(-13 to -26). These trends are thought to be due to a combination of sub-solidus fluid infiltration and assimilation of crustal material, with fluids or material derived from the adjacent, isotopically evolved NPHM crust.
Structural data were collected from a 24-km long section along the western margin of the NPHM. The main shear fabrics within the belt are at greenschist grade and rework the earlier amphibolite-grade metamorphic assemblages. Kinematic indicators demonstrate an east-side up movement sense, with a strong component of dextral-slip. Since the foliation dips moderately to steeply west, the shear zone has a normal fault geometry, characterized by a north-westerly motion of the Kohistan arc relative to the NPHM.
The timing of movements within the shear zone have been constrained using mica geochronology on deformed lithologies within the zone. Rb-Sr muscovite-WR ages lie in the range 12-28 Ma, and reflect variable post-metamorphic cooling through the 5000C closure temperature. Rb-Sr biotite-WR and biotite-feldspar ages are 11 and 24 Ma, and have locally been reset to 6 Ma, probably during the retrograde shearing within the zone. Interestingly, leucogranites and their metamorphic country-rocks within the adjacent part 01' the NPHM have Rh-Sr ages of 2.8-7.7 Ma (muscovite) and 1.4-3.4 Ma (biotite), related to recent uplift and Leucogranite intrusion within this part of the NPHM. The absence of such young mica ages within the shear zone bordering the Kohistan arc indicates that in the Haramosh area, the major, recent uplift of the NPHM was not accommodated along the western margin of the NPHM, as occurred further south. The disparity in mica ages between the shear zone and the NPHM, and the lack of any consistent age variation within the NPHM, may indicate a relatively passive uplift of this pail of the massif.
Key words: Structure, thermal constraints, geochemistry, NPHM, Himalaya.

G/88. George, M.T., 1995a. The magmatic, thermal and exhumation history of contrasting granite magmastism between the Kohistan Island Arc and the Nanga Parbat-Haramosh massif, Western Himalaya. Ph.D. thesis, Open University, U.K.

Key words: Magmatism, Kohistan island arc, NPHM.

G/89. George, M.T., 1995b. Implication of Rb-Sr Mica Ages from the North Western Flank of the Nanga Parbat-Haramosh Massif. Abstract Volume, 10th Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

In the western Himalaya, formation of the Nanga Parbat-Haramosh Massif (NPHM) in late-Himalayan times led to the rapid exhumation of upper-amphibolite grade orthogneisses and paragneisses of the Indian continent. Monazite U-Pb ages suggest that these lithologies were locally still at metamorphic temperatures as late as 4-11 Ma(1). To the west, Indian continental rocks are separated from rocks of the upper part of the Kohistan island arc by a ductile shear zone which appears to have accommodated much of the relative uplift of the NPHM. Near Raikhot in the south (Fig. 1), fabrics within the shear zone indicate that Indian continental rocks have been thrust towards the north-west, over the Kohistan arc. Between Sassi and Darchan in the north, the shear zone dips moderately to steeply towards the west and contains lithologies derived from both the Indian continent and the Kohistan island arc. Greenschist-grade fabrics indicate dextral oblique-slip, with an extensional, west-side-down movement sense.
A detailed geochronological traverse across the shear zone in the Sassi-Darchan area has recently confirmed that exhumation-related cooling has occurred both more rapidly and more recently in the NPHM compared with the Kohistan arc. In this contribution, Rb-Sr mineral data are presented from lithologies collected from the shear zone itself, in an attempt to resolve the timing of cooling and deformation along the flanks of the NPHM in relation to present tectonic models. The well-constrained regional cooling history allows an assessment to be made of the relative importance of shear strain, mineral assemblage and grain-size in controlling cooling ages through variation in closure temperature. Mica ages obtained from several mylonitic granite sheets are similar to ages obtained from both their proximal and distal wall-rocks, and do not reflect cooling following granite intrusion. Mica ages from both igneous and metamorphic lithologies are therefore considered together. All mica ages were calculated by regression to the whole-rock.
Biotite ages mostly lie in the range 5.5-10.8 Ma. However, two amphibolites have yielded ages of 16.7 and 23.7 Ma. The majority of muscovite ages lie in the range 9.5-21 .0. However, four pelitic lithologies from Sassi yield anomalously old muscovite ages of 26, 49, 64 and 293 Ma. In addition, two samples collected from the core of the NPHM in the Astor gorge, 40 km to the south (Fig. 1), have yielded muscovite ages of 36.4 and 21.9 Ma.
The majority of biotite ages lie between those earlier obtained from proximal parts of the NPHM (2-3 Ma) and the Kohistan island arc (13-17 Ma), and they therefore probably reflect simple cooling through ~300 0C, rather than late-stage recrystallisation during shearing. The transtensional movements mentioned above occurred at >300 0C, and these movements therefore accommodated uplift of the NPHM prior to 6 Ma. Only brittle movements were occurring in the shear zone during the late-stage exhumation of the northern part of the NPHM.
Several muscovite ages are anomalously old, and indicate that resetting of muscovite during Himalayan processes was locally incomplete, whilst coexisting biotite, intergrown with the muscovite, was fully reset due to the lower closure temperature of biotite relative to muscovite. A cluster of muscovite ages lies in the range 17-21 Ma, and probably reflects cooling of many shear zone samples through ~500 0C in this period. The youngest muscovite ages obtained from metamorphic samples are 9.5 and 11.9 Ma, respectively. Such a wide range in muscovite ages (21.0-9.5 Ma) may reflect the following:
Maintenance of temperature gradients (>200 00) due to differential shearing during slow cooling, with the result that different imbricates followed different cooling histories.
Closure temperature variations (>200 CC) due to varying fluid content, grain size or mineral assemblage, with the result that different samples yield different mica ages despite cooling along the same pathway.
Isotopic resetting of the majority of biotite samples, and some of the muscovite samples, due to leucogranite intrusion, sub-solidus fluid activity, or deformation occurring at —6 Ma, at least 11 Ma after the regional 500 CC isotherm had reached the surface.
The latter hypothesis is considered to be unlikely, since it would also have to account for even younger muscovite ages (4-8 Ma) obtained from samples collected from right across the NPHM. Furthermore, the majority of biotite ages are younger than the youngest muscovite age determined, an observation which suggest that the ages are dominantly controlled by diffusion during cooling rather than resting during shearing. No correlation can be found between either lithology and grain-size and mica age, and therefore there is no evidence for significant variation in closure temperature existing between the studied samples, although it should be remembered that the grain-size is probably not equivalent to the effective diffusion distance.
In summary, this study shows that:

Closely-spaced lithologies that have been sheared along the north-western flank of the NPHM yield variable mineral cooling ages due to real variations in cooling histories followed by proximal sample, possibly combined with variations in closure temperatures. Relatively old (and variable) ages have also been obtained from the core of the NPHM further to the south, indicating that lithologies lying within the NPHM structure have also been strongly affected by differential cooling since Himalayan collision. Muscovite may not be fully isotopically homogenized during upper amphibolite-grade metamorphism. Temperatures in the Sassi-Darchan shear zone probably remained close to 500ºC for 11 Ma, whilst cooling through 300oC occurred in the period 5.5-10.8 Ma. Uplift of the northern part of the NPHM was accommodated by brittle movements occurring along the western margin.
Key words: Geochronology, Rb-Sr mica ages, NPHM.

G/90. George, M.T. & Barlett, J., 1996. Rejuvenation of Rb-Sr mica ages during shearing on the northwestern margin of the Nanga Parbat-Haramosh massif. Tectonophysics 260, 167-185.

The shear zone bordering the western margin of the Nanga Parbat-Haramosh massif (NPHM) separates terranes with distinct but well-documented cooling histories. This study was undertaken in order to examine isotopic behaviour and if possible to date deformation or cooling within the contact zone itself. Rb/Sr muscovite and biotite ages and petrographic descriptions are presented for a range of metamorphic lithologies and granite sheets which have been affected to varying degrees by greenschist-facies extensional crenulation. This deformation has been kinematically linked to the differential uplift of the NPHM. Ages for metamorphic lithologies and granite sheets are similar and are considered together. Determined muscovite ages mostly lie in the range 9–22 Ma, whilst the majority of biotite ages lie in the range 2–11 Ma. Mica ages from the shear zone are significantly more variable than ages determined for unsheared lithologies from outside the shear zone. Even closely spaced samples yield variable mica ages, and in some cases there is a significant difference between muscovite and biotite ages determined for the same sample. Muscovite ages yield a bimodal distribution, with groups of ages in the range 17–21 Ma and 8–12 Ma. The older group is thought to reflect the original, purely thermostatic cooling of lithologies through the muscovite closure temperature, prior to formation of the NPHM structure. In contrast, the younger group of muscovite ages reflects variable degrees of isotopic resetting during shearing at temperatures below the muscovite closure temperature, associated with the relative uplift of the NPHM. The majority of biotite ages also reflect partial to complete resetting during shearing. However, biotite samples from structurally competent amphibolite horizons preserve older (>16 Ma) ages, indicating that there was locally a strong lithological or fluid control on the degree of resetting. The flanks of the NPHM cooled through the muscovite closure temperature significantly earlier than the deeper structural levels presently exposed within the core of the NPHM. Greenschist-grade deformation was occurring within the shear zone at the same time that deeper levels of Indian crust were passing through the muscovite closure temperature, suggesting that the shearing reflects the relatively passive extensional movement of rocks sliding off the flank of the actively growing Nanga Parbat structure. The results highlight the isotopic complexities of long-lived shear zones present in orogenic belts, but show that useful radiometric age information may be obtained if the regional tectonic history is well understood and if the samples for dating come from well-constrained structural settings.
Key words: Geochronology, Rb-Sr mica ages, NPHM.

G/91. George, M.T., Harris, N.W.B. & Butler, R.W.H., 1993. The tectonic implications of contrasting granite magmatism between the Kohistan Island Arc and the Nanga Parbat-Haramosh massif. In: Treloar, P.J. & Searle, M.P. (Eds.), Himalayan Tectonics. Geological Society, London, Special Publications 74, 173-191.

In northern Pakistan, an integrated structural and geochemical study across the contact between the Cretaceous-Tertiary Kohistan island arc and Indian crust of the Nanga Parbat-Haramosh massif (NPHM) has identified strongly contrasting source regions contributing to post-50 Ma magmatism, which constrains the tectonic evolution of the region. Nd-model ages of Tertiary intrusives increase dramatically across the contact from c. 700 Ma in the Kohistan terrane to c. 2500 Ma in the NPHM.
Following collision between the Indian continent and the Kohistan island arc terrane at c. 50 Ma, biotite granite sheets (Confluence granites) were emplaced into the Kohistan batholith at 50–30 Ma, followed by muscovite granite sheets (Parri granites) at c. 26 Ma. These are geochemically distinct, with the Confluence granites comprising a range of granitic compositions with high Sr and Ba abundances and the Parri granites forming granite sheets enriched in Rb. Undeformed granites in both suites have $(^{87}Sr/^{86}Sr)_i$ in the range 0.7045–0.7054 and $\varepsilon Nd(T)$ of + 0.1

to +2.7, suggesting that both groups may be derived from juvenile arc sources. Detailed structural studies verify that the Kohistan granite sheets postdate the initial collision of the Kohistan terrane with the Indian continent, but are pre- or syntectonic with respect to continued underthrusting of the Indian continent below the Kohistan arc. These results, together with isotopic evidence from the undeformed granite sheets, suggest that significant underthrusting of northern Kohistan by the Indian continental crust could not have occurred until after 26 Ma.

Along the western margin of the NPHM, deformed granite sheets show a marked increase in $(^{87}Sr/^{86}Sr)i$ (0.7075–0.7784), with decreased εNd(T) (−13 to −26). These trends are thought to be due to a combination of sub-solidus fluid infiltration and assimilation of crustal material, with fluids or material derived from the adjacent, isotopically evolved NPHM crust.

The NPHM (Indian continent) has been intruded by a series of tourmaline leucogranite dykes and plutons at 2–12 Ma. These intrusives have trace-element signatures consistent with generation by vapour-absent melting of a pelitic source. Sr-Nd isotope systematics indicate derivation from metasediments such as are currently exposed in the basement rocks of the massif, although melting at the present exposure level is generally precluded by subsolidus metamorphic grades in the country rock. Extreme heterogeneities in radiogenic Sr($(^{87}Sr/^{86}Sr)i > 0.9$) are observed in leucogranite dykes from the Liachar thrust zone, probably indicating subsolidus fluid infiltration. In general the NPHM leucogranites result from rapid exhumation of metasediments characterised by unusually high heat productivity.

Key words: Geochronology, Tectonics, Magmatism, NPHM, MMT.

G/92. George, M.T., Harris, N.W.B. & Keynes, M., 1992. Granite Magmatism and Thermochronology across the Main Mantle Thrust, NW Pakistan. Abstract Volume, 7th Himalaya-Karakoram Workshop, Department of Earth Sciences, Oxford University, England, 32.

In NW Pakistan, the Kohistan Arc is separated from the west margin of the Nanga Parbat Massif (NPM) by a major ductile shear zone. Interpretation of assemblages and structures from either side of this suture suggest contrasting thermal and magmatic histories that help constrain the regional tectonic evolution.

Metamorphic assemblages from the arc record lower amphibolite facies conditions of 500-6000C and 5-7 Kb. Garnets from the arc show strong compositional zoning with XCa increasing and XMg/XMg+Fe decreasing towards the rims, suggesting garnet growth during increasing pressure but decreasing temperature. In contrast, the Precambrian ortho and paragneisses of the NPM lie in the upper amphibolite facies (kyanite grade) and show peak conditions of metamorphism of 600-7000C and 7-8 Kb. Most garnets are unzoned. Mineral growth cannot be directly correlated with thrust tectonics associated with the Main Mantle Thrust.

Lithologies from both terranes are imbricated in a steeply inclined ductile shear zone which operated at lower amphibolite fades conditions. Mineral stretching lineations on the foliation plunge steeply to the NW and shear-sense indicators suggest a dextral-normal movement, presumably related to the post-tectonic uplift of the NPM. This movement has steepened and overprinted earlier fabrics related to underthrusting of the Indian plate beneath the arc.

The youngest magmatic rocks in the arc are cross-cutting granite sheets with a poorly constrained age of 20-50 Ma(1). These sheets can be divided into early biotite granites, which are cross-cut by younger muscovite-garnet-sheets, each type characterized by a distinct trace element and isotope geochemistry. Since both suites are strongly deformed in the shear zone, these granite sheets place an important constraint on the age of shearing. The timing of deformation is being further constrained by ongoing laser Ar-Ar microstructural studies of hornblende within the zone.

The NPM basement is intruded by dykes and sheets of leucogranite. A substantial two-mica body (the Jutial leucogranite) cross-cuts the regional fabric of the NPM and is being studied in more detail. Trace element and highly radiogenic 87Sr-86Sri (0.874-0.891) indicate an origin by crustal melting of NPM basement rocks. Elsewhere in the NPM, the cross-cutting rnusc-tourm.(±bi) leucogranite sheets, dated at 2.3-7 Ma (2), show a comparable but more scattered trace element and isotopic composition (87Sr/56Sri 10.806-1.061) and probably share the same source.

NPM basement rocks have wide-ranging (87SrI86Sr) of 0.786-0.963, and variable trace element compositions. The metamorphic grade of these suggest that melting occurred at deeper levels in the NPM than those currently exposed. The heterogeneous isotopic corn positions are a common feature of Himalayan leucogranites and reflect a variable source, poor magma mixing or late fluid circulation. In addition to its unusually radiogenic Sr-isotope composition, the Jutial granite contains high concentrations of Th (22 ± 9 ppm) compared to other Himalayan leucogranites, a feature which may have contributed to the thermal budget that caused crustal melting.

The therrnochronology of the granites in both the arc and the NPM relative to their country rocks is being investigated by both Rb-Sr dating of micas and laser Ar-Ar dating of micas and amphiboles, in order to constrain the time of granite emplacement and the post-magmatic thermal and tectonic evolution of the region.
Key words: Granite, thermochronology, magmatism, MMT.

G/93. George, M.T., & Reddy, S.M., 1994. Differential unroofing and inherited radiogenic strontium in the Western Himalaya. Mineralogical Magazine, 58A, 325-326.

In the western Himalaya, the Nanga Parbat- Haramosh massif (NPHM; Indian continental crust) has been differentially exhumed relative to the adjacent Kohistan island arc terrane (Zeitler 1985). This study aims to constrain the detailed cooling history of the region by using both Rb-Sr and laser probe 4~ dating of muscovite and biotite from closely-spaced samples. Such a study should also help to evaluate the resolution of mineral ages in determining cooling rates in regions of rapid exhumation. Samples dated include granite sheets and their metamorphic country rocks, and come from the NPHM, the Kohistan arc, and from the intervening steeply dipping, high-grade shear zone.
Key words: Exhumation, NPHM, Kohistan island arc, Chronology.

G/94. George, M.T., Reddy, S.M. & Harris, N.W.B., 1995. Isotopic constraints on the cooling history of the Nanga Parbat-Haramosh massif and Kohistan Arc, Western Himalaya. Tectonic 14, 237-252.

Nineteen $^{40}Ar/^{39}Ar$ and 22 Rb-Sr mineral ages are presented for metamorphic rocks and granites collected from the northern part of the Nanga Parbat-Haramosh Massif (NPHM) and adjacent parts of the Kohistan arc, western Himalaya. The majority of these ages are interpreted as exhumation-related cooling ages, and they therefore place important constraints on the exhumation history of the region. The $^{40}Ar/^{39}Ar$ and Rb-Sr mica cooling ages for areas of the NPHM to the north of the Indus River lie in the range 2–8 Ma and are similar to previously published ages from the Indus gorge itself. Cooling histories for these areas show little systematic variation from east to west, suggesting that the basement may have been exhumed as a relatively rigid block, after the main stages of folding. Mica ages increase dramatically from the NPHM westward into the Kohistan arc, where ages lie in the range 13–30 Ma. The contrast in both cooling ages and the age differential between mineral pairs between the two terranes indicates rapid cooling of the NPHM in the last 10 m.y. compared with the Kohistan arc. The relationship between rates of cooling and exhumation is poorly constrained in regions of rapid uplift, where the characteristics of the evolving geotherm are not well understood. However, the results are consistent with an anomalously rapid exhumation history of the NPHM during the last 10 m.y. compared with the adjacent Kohistan arc. The interpretation of some of the ages documented in this study is problematical. Two biotite samples from contrasting lithologies within the NPHM have yielded higher $^{87}Sr/^{86}Sr$ ratios than the corresponding whole rocks, but the cause of this isotopic disequilibrium remains unclear. Other biotite samples from the region have consistently yielded younger Rb-Sr ages than $^{40}Ar/^{39}Ar$ ages, which may be a reflection of either preferential leaching of ^{87}Sr during fluid infiltration on a regional scale or the presence of excess argon. Alternatively, the relative ages indicate slightly lower closure temperature for strontium diffusion in biotite than for argon diffusion in biotite where samples have undergone rapid cooling.
Key words: Isotopes, cooling history, NPHM, Kohistan arc.

G/95. Gerth, H., 1938. Perm korallen aus dem östlichen Karakorum and Trias Korallen aus dem nordwestlicher Himalaya. Paleontologica Geographica, bd., 88, Abst. A, Lf, 4–6., 230–237.

Key words: Corals, Permian, Triassic, Karakoram, Himalaya.

G/96. Ghani, A. & Nasreen, S., 1990. Ultramafic decorative stones of N.W.F.P. and adjoining areas. Abstracts, First SEGMITE Conference on Industrial Minerals, Peshawar, p.7.

Decorative stones of ultramafic composition in different shades of green occur in various parts of the province and adjacent areas such as Malakand and Mohmand agencies [also Waziristan]. These include rodingite and serpentine.

Internationally, such ultramafic stones are replacing marble (the most widely used decorative stones) due to better colour, hardness, lower porosity, etc.
Key words: Decorative stones, serpentinite, Malakand, Mohmand, Alpuri.

G/97. Ghani, A., Nasreen, S. & Qureshi, K., 1994a. Geology and industrial applications of talc of Juragh area, District Swat, Pakistan. Abstracts, Second SEGMITE International Conference on the Export Oriented Development of Mineral Resources and Mineral Based Industries, p.21.

Good quality talc occurs in the Juragh area of district Swat. The deposits lie in the western part of the suture (Lesser Himalayas, exposed in Pakistan) of the Indo-Pak plate in tectonic interaction with Eurasia in the north. The deposits are developed by secondary processes undertaken by the action of hydrothermal solutions on metamorphosed calcareous sediments and impure marbles as well as retrogression during the Himalayan Orogeny. The talc is suitable for utilization in a range of industries, including sensitive ones like automobile, pharmaceuticals, elctroceramics and glazes etc.
Key words: Minerals, talc, Swat.

G/98. Ghani, A., Nasreen, S. & Qureshi, K., 1994b. Talc deposits of Juragh area, District Swat, Pakistan. Pakistan Journal of Scientific and Industrial Research 37(11), 462.

Good quality talc occur in the Juragh area of district Swat. The deposits lie in the western part of the suture (Lesser Himalayas, exposed in Pakistan) of the Indo -Pak plate in tectonic interaction with Eurasia in the north. The deposit is comprised of talc and antigorite while the country rocks are quartz-mica and dolomitic schists. The talc may have been developed by secondary processes undertaken by the action of hydrothermal solutions on metamorphosed calcareous sediments and impure marbles as well as retrogression during the Himalayan orogeny. The talc is suitable for utilization in a range of industries.
Key words: Economic geology, Talc, Swat.

G/99. Ghani, A., Nasreen, S. & Qureshi, K., 1994c. Geology and industrial applications of talc of Juragh area, Swat, NWFP. Proceedings, Second SEGMITE International Conference on Export Oriented Development of Mineral Resources and Mineral Based Industries, Karachi, 1994, 23-25.

Consult the previous account for further details.
Key words: Economic Geology, Talc, Swat.

G/100. Ghani, M.A., 1962. Cement industry in Pakistan. CENTO Symposium on Industrial Rocks and Minerals, Lahore, 235-245.

Key words: Industrial minerals, cement.

G/101. Ghauri, A.A.K., 1962. Geology of the Lowari Tunnel area. M.Sc. Thesis, Punjab University, 30p.

Key words: Geology, Lowari Pass.

G/102. Ghauri, A.A.K., 1977. The pebble petrology and the stratigraphy of Tanaki conglomerate in Hazara, North West Frontier Province, Pakistan. Journal of Science and Technology 1 (1), 48-53.

Key words: Petrology, stratigraphy, Tanaki conglomerate, Hazara.

G/103. Ghauri, A.A.K, 1984. Tectonics of western Indus suture in Pakistan. EOS., 65(45), 1094.

Key words: Tectonics, Indus suture.

G/104. Ghauri, A.A.K., Lawrence, R.D., Jadoon, I.A.K. & Saeed, T., 1987. Structure and the history of Yasin group of rocks in Hunza valley, Northern Pakistan. Kashmir Journal of Geology 5, 11-116.

Yasin Group of metasedimentary rocks lies on the northern extremity of Kohistan Island Arc. F1 (minor folds), F2 (upright fold), F3 (intrafolial and kink folds), F4 (minor folds) and F5 (crenulation observed in oriented hand specimens) are the type of folds that can be studied in addition of silickensides, veins, dykes, foliation, lineation and shear zones. Average trend of dominant axial plane foliation of F2 folds is WNW and the inclination is almost vertical. Veins of different age and origin had been of substantial help in this study. The most recent deposit travertine probably relates to a major fault.
Key Words: Structure, deformation, Yasin Group, Hunza.

G/105. Ghauri, A.A.K., Pervez, M.K., Riaz, M., Rehman, O., Ahmad, I. & Ahmad, S., 1991. The Structure and tectonic setting of Attock-Cherat and Kala-Chitta Ranges in Nizampur area, NWFP, Pakistan. Kashmir Journal of Geology 8 & 9, 99-110.

The southern belt of Paleozoic strata of Attock-Cherat Range comprising of limestone, argillite and quartzite, constitutes a major overturned south-verging fold. The southern limb of this fold is truncated by north dipping Hissartang thrust, which is the part of late, Tertiary imbricate thrust system in this area. This fault has emplaced the Paleozoic rocks of Attock-Cherat Range over the Mesozoic sequence of Kala-Chitta Range. From the town Nizampur in the east, the Hissartang fault runs at the foot of Attock-Cherat Range but near the Indus River it swings northeast and a low-angle Hissartang backthrust appears. The tectonically emplaced patches of Jurassic limestone over the Paleozoic rocks of Attock-Cherat Range are quite common east of Indus. The emplacement of Jurassic limestone over the Paleozoic rocks is the result of back thrusting of Hissartang thrust. The north dipping listric normal faults marks the late extensional phase in the area.
Key Words: Structure, tectonics, Paleozoic, Attock-Cherat Range.

G/106. Ghauri, A.A.K., Rehman, O. & Rehman, S., 1983. A new structural model of the southern slopes of Kohat pass, District Kohat, NWFP, Pakistan. Geological Bulletin, University of Peshawar 16, 97-104.

The Darra Adam Khel area has been affected by at least three phases of deformation from Cretaceous onwards. The central block was elevated by an early Cenozoic revolution and has since remained a positive area. Miocene rocks were deposited in linear depressions towards north and south of the block. A central problem in this area is north-verging folds that are anomalous to the regional structural pattern.
The chain of repetitions of Samana Suk and Chichali Formation towards the southern part of the area are neither due to tight folding nor repeated fault slicing, as is generally believed. Instead, there are relatively small, open and somewhat overturned folds developed within the southernmost limb of the main fold, during the last deformational episode, with Chichali Formation being preserved in the synclinal troughs only.
Key Words: Structure, deformation, Cretaceous, Kohat.

G/107. Ghaus, N., 1980-82. Geology of Jabri Pesar Bhajura Area, Abbottabad. M.Sc. Thesis, Institute of Geology, Punjab University, Lahore.

Key words: Geology, Abbottabad.

G/108. Ghazanfar, M., 1987-89. Geology and structure of Harno Area, District Abbottabad. M.Sc. Thesis, Institute of Geology, Punjab University, Lahore, 247p.

Key words: Structure, Geology, Abbottabad, Hazara.

G/109. Ghazanfar, M., 1994. Petrotectonic elements and plate tectonic framework of North West Himalaya. Institute of Geology, Punjab University, Lahore, Ph.D. Thesis, 380p.

Key words: Plate tectonics, stratigraphy, Neelum valley, Azad Kashmir, NW Himalaya.

G/110. Ghazanfer, M., Baig, S. & Chaudhry, M.N., 1983. Geology of Tithwal Kel area Neelum valley, Azad Jammu and Kashmir. Kashmir Journal of Geology 1, 1-10.

More than three hundred and eighty five square km area between Tithwal and Kel in the Neelum Valley on the right bank of river Neelum has been mapped for the first time. However, of the section between Doarian and Kel only a reconnaissance sketch was prepared. A detailed description and a preliminary petrography of rock unit between Tithwal and Kel is presented. The rocks between Tithwal and Loat comprise a psammatic-pelitic sequence which resemble the Tanol Formation as found further north in Neelum Valley, north of Jared in Kaghan and elsewhere in the region. The rocks found in the vicinity of Authmuqam have also been considered as part of same psammite peltie sequence and not Dogra Slates as proposed by Wadia (1928). The extensive pelitic-calcareous sequence found north of Loat has been named as Sharda Group. We suggest the term Sharda Group should be replace the term Salkhala Formation as type of rocks described in literature as Salkhala Formation are nowhere to be found around Salkhala village. Three different granite batholiths have been described. The two southern one Jura and Neelum granites are possibly Tertiary while the Kel granite in the north is Palaeozoic or older. The whole sequence of country rock has been regionally metamorphosed. Very broadly speaking the grade of metamorphism increases from south to north (biotite grade at Authmuqam and kyanite grade at Gamot). Two major structures have been detected. The major synclinal structure in the south has been called Salkhala syncline and the major anticlinal structure in the north has been called as the Kel anticline. The Neelum granite appears to be post-tectonic while the Kel granite is pre-tectonic.
Key words: Geology, structure, metamorphism, Neelum valley, Azad Kashmir.

G/111. Ghazanfar, M. & Chaudhry, M.N., 1984a. A Palaeozoic ophiolite and island arc sequence of Hazara-Kashmir Pakistan syntaxis, District Mansehra. Abstracts, First Pakistan Geological Congress, Lahore, 37-38.

For details consult the following account.
Key words: Paleozoic, ophiolites, Island arc, Panjal volcanics, Hazara-Kashmir sytaxis.

G/112. Ghazanfar, M. & Chaudhry, M.N., 1984b. A Palaeozoic ophiolite and island arc sequence of Hazara-Kashmir Syntaxis, District Mansehra. Kashmir Journal of Geology 2, 37-38.

Detailed mapping and field relationships of the rocks in Paras-Jared-Sharan area in Kaghan Valley have revealed the presence of an ophiolite-arc derived metasedimentary suit of Palaeozoic age. The ophiolite-sequence is represented by basic lavas of Panjal Trap abundant between the villages of Malakand and Shinu on the Kaghan valley roadside. North and east of the ophiolite sequence a sedimentary-volcanic sequence is represented by agglomeratic slates and arc derived metasediments. The likely age of this sequence of Hazara-Kashmir Syntaxis is between Devonian and Triassic. The sequence continues around the syntaxis, the eastern limb extending over the Kaghan ridge across Neelum Valley and beyond and the western limb turning south of Nadi Bungalow to Balakot and further south and southwest.
Key words: Ophiolites, Island arc, Paleozoic, Hazara-Kashmir sytaxis.

G/113. Ghazanfar, M. & Chaudhry, M.N., 1985a. A Third suture in Northern Himalaya. Kashmir Journal of Geology 3, 103-108.

The MKT and MMT are two sutures so far identified in NW Himalayas and Northern Area. In the region of Kaghan and Neelum Valleys the Main Boundary Thrust (MBT) constitutes an older Upper Paleozoic Panjal Suture. The Panjal Volcanics-Agglomeratic Slate-Tanol sequence in this area may together mark the opening and closure of a basin developed on a rifted continental margin possibly associated with an arc. Stratigraphy along the MBT point to the existence of an Upper Paleozoic Panjal Sea in the area of Northwest Himalaya separating the Indian Main land from its rifted tectonic slice, the Kashmir Hazara Continent Slice.
Key words: Sutures, MMT, MKT, MBT, Himalaya.

G/114. Ghazanfar, M. & Chaudhry, M.N., 1985b. Geology of Bhunja-Batakundi area, Kaghan Valley, District Mansehra, Pakistan. Geological Bulletin, Punjab University 20, 76-105.

The part of Kaghan Valley between Mahandari and Batakundi has been geologically surveyed and mapped, at 1:17,000 for the first time. Besides a detailed field description of rock units, brief description of structure and comments on metmorphism, stratigraphic correlation and geomorphology are included. The rocks range from limestones, greenstones, tillites. Pelites, calcareous pelites to psammites in the biotite to silliminite grade. Some locally produced granites and a beautifully developed migmatite unit are also present. Stratigraphically the sequence becomes older towards north. A tentative correlation of the rock units has been attempted with Panjal series, Tanol Formation, Hazara slates and Precambrian Sharda Group (Salkhalas) sucressively to the north. Major structures consist of a number of asymmetric and at places, overturned folds separated in the form of blocks by high angle north dipping thrusts. Graphite, gypsum and marble are potential economic deposits.
Key words: Geology, Bhunja-Batakundi, Kaghan Valley.

G/115. Ghazanfar, M. & Chaudhry, M.N., 1986. Reporting MCT in northwest Himalaya, Pakistan. Geological Bulletin, Punjab University 21, 10-18.

Work in Neelum valley, Azad Kashmir and Kaghan valley has now made it possible to locate the Main Central Thrust (MCT) in northwest Himalaya. Geological mapping and investigations in the two valleys indicate that the MCT extends in a NE-SW direction between Luat in Neelum valley and Batal (south of Naran) in Kaghan valley crossing the Kaghan watershed near Thod Bhaik. There is a marked difference in the tectonic style, stratigraphy and metamorphism north and south of this line. This difference compares well with that reported from India. This discovery of MCT in Pakistan now, for the first time, enables us to compare and tentatively extend the tectonic zones of Central Himalaya in India into northwest Himalaya in Pakistan.
Key words: Structure, Maps, MCT, Himalaya.

G/116. Ghazanfar, M. & Chaudhry, M.N., 1992. Four phase deformation in Murree-Abbottabad of Attock-Hazara fold and thrust belt, Northwest Himalaya, Pakistan. Abstracts, First South Asia Geological Congress, Islamabad, 55-56.

Key words: Deformation, Attock-Hazara, Himalaya.

G/117. Ghazanfar, M. & Chaudhry, M.N., 1996a. The Tethys Himalaya of Pakistan. Abstract volume, 11th Himalaya-Karakoram-Tibet Workshop, Flagstaff, Arizona (USA), 49-50.

Of the four major tectonic subdivisions of the Himalaya, the two northern ones, the Higher Himalaya Crystalline (HHC) and the Tethyan Himalaya, were neither identified nor delineated in Northwest Himalaya of Pakistan until quit recently. The demarcation of MCT in Pakistan and Azad Kashmir (Ghazanfar & Chaudhry, 1986) finally settled the character and boundary of the HHC in Pakistan. This work aims at defining and setting limits and presenting a map of the Tethyan Himalaya in Pakistan.

To the south of Indus Suture in Pakistan a belt of low grade sediments extends all along from Babusar Pass in the east to Swat in the west of these sediments have been largely ignored in the tectonic setting of the NW Himalaya. These were first mapped and described from near Babusar and later westwards to Ledi grade rocks of Banna, Allai, and Swat. In swat low grade rocks have been described from a number of locations including Sassoi, Karora and Mingora. The presence of these rocks at the head of the high grade HHC terrain below the MMT has been variously explained as a back thrusted slice of the Cambrian Abbottabad Formation which occurs far to the south (Coward et al., 1988) or as retrogressed part o f the high grade upper Kaghan metasediments which were considered Permo-Triassic (Greco et al. 1989; Spencer, 1993).
These workers thus considered the high grade gneisses of the Burawai Group of the Higher Himalaya of Upper Kaghan as the Tethys Himalaya. Such a suggestion remains highly debatable. The huge Burawai group everywhere in Kaghan and Swat is in the kyanite-sillimanite grade and is an integral part of the HHC. Field observations disprove both the back thrust as well as the retrogression hypothesis.
As opposed to this Chaudhry and Ghazanfar (1992) suggested that the only Tethyan sequence were the low grade metasediments exposed along the MMT north of the HHC. Low grade sediments below MMT were first described from Upper Kaghan by Chaudhry and Ghazanfar in 1987 where they were named as the calcareous Bachh Formation and the graphitic Richpar Formation.
Low grade metasediments are also exposed further west south of the MMT in Banna, Besham and Swat areas. The sequence is best developed in Banna, Allai area east of Besham. Preliminary mapping reveals it can be subdivided into a lower graphitic phyllite (Chiran Formation) an upper thin bedded limestone/ marble (Banna Formation) and an intervening unit comprising intercalations (Palang Formation). The whole sequence is nearly one km thick.
Further west in Swat the low sediments are represented mainly by graphitic pelites which have been called Dargai Formation (Saidu Formation). Structurally they form synclinal inliers with a faulted base.
Geological mapping has revealed that the much attenuated sequence of Upper Kaghan more or less physically continues into the Banna area. Although the units are very thin in Upper Kaghan their continuation from Babusar through Lohyalul and Ledi to Dila is remarkable.
In the Karora area of Besham the lithologies are similar to Banna area except that this is the only area where the unit instead of being faulted at the base is underlain by a boulder bed which rest on the high grade slab of HHC.
In the Kashmir Basin the Tethyan sequence discontinuously continues across the HHC to the south. A somewhat similar situation is present in Lower Swat where the Tethyan sequence occurs as synclinal inliers in the high grade terrain and possibly correlates southwards with the low grade basal rocks of the Peshawar Basin.
Although fossils are likely to be present no fossils have been reported anywhere in Pakistan from this suite far and their age is mainly a matter of correlation. Near Besham the Karora Group rocks have been cut some granite bodies which were dated Precambrian by Baig (1990).
Key words: Structure, tectonics, MMT, MCT, Himalaya.

G/118. Ghazanfar, M. & Chaudhry, M.N., 1996b. Structure and Tectonic style in Sedimentary Lesser Himalaya, south Hazara, Northern Pakistan. Abstract volume, 11th Himalaya-Karakoram-Tibet Workshop, Flagstaff, Arizona (USA), 51-52.

The Attock Hazara Fold and Thrust Belt, AHFTB, is mainly a shelf sedimentary sequence extending in east-west direction for some 250 kilometers from Garhi Habibullah in the northeast to Parachinar in the west.
A thick sedimentary sequence ranging in age from Cambrian to Neogene and overlying the slightly metamorphosed Hazara slate is present in the form of arcuate megasynclinorium which closes into the Hazara Kashmir Syntaxis in the northeast near Garhi Habibullah and complicates to the west. To the north it is separated from an extensive zone of igneous and metamorphic rocks by the Panjal Fault. This is the Main Boundary Thrust, MBT, coming from east in India. The real throw of MBT in Pakistan is distributed along a number of parallel faults passing through this belt, the chief among these being the Nathia Gali Thrust, NGT. The AFHTB is essentially a westward continuation of the parautochthonous fold belt of Pir Panjal Himalaya over the Hazara Kashmir Syntaxis. Important stratigraphic differences in the belt exist from place to place. The stratigraphic sequences of Kashmir, Hazara and Muzaffarabad constitute three different stratigraphic provinces, which juxtapose in the area of Balakot. The AHFTB constitutes the southern sedimentary fringe of the mainly metamorphosed Lesser Himalaya. West of the HKS the metasediments of Mansehra-Oghi area and the Peshawar Basin lie the north of AHFTB. This study pertains to the Abbottabad-Murree section of northeast AHFTB.
Three major phases of deformation are clearly discernible. The first phase D1 is pre-Himalayan when the Hazara slates were metamorphosed. These Precambrian slates are now overlain by a thick shelf sedimentary Phanerozoic

sequence with an angular unconformity at the base. From the metamorphosed clasts of Hazara Formation in the basal Tannaki boulder bed of the overlying Cambrian Abbottabad Formation. This orogeny has been date Precambrian (Baig et al., 1987; Chaudhry, 1964; Chaudhry et al. 1989). During the Himalayan orogeny the entire sequence underwent two major phases of brittle deformation. The main phase Himalayan deformation, D2, is now represented by the NE-SW outcrop trends of structures. These megafolds are generally overturned and isoclinal and interrupted by numerous dip slip and oblique slip faults. The vergence of these structures is enigmatic. Apart from the southeast vergence major blocks show northwest vergence of both folds and faults. The southeast vergence is clearly explainable as being in line with the Himalayan direction of transport in this area. The northwest vergence, however, has been explained as later overturning and back thrusting (Coward et al. 1988; Ghazanfar et al. 1990) pertaining to a later phase. Large scale geological mapping of this section (this study), however, indicates box folding and fan folding during D2. A number of normal faults were formed following relaxation of stress.
The final Himalayan phase of deformation D3 relates to the formation of Hazara Kashmir Syntaxis, HKS, and a major re-entrant of the Northwest Himalaya. The NE-SE trend of syntaxial phase of folds is at right angles to the NE-SW trends of D2 structures. These folds are generally intraformational and only faintly seen on the map scale where they generally appear as broad flexures and broad bends. Many of these folds are SW vergent and are not accompanied by related faults.
Key words: Structure, tectonics, sedimentation, Attock-Hazara, Himalaya.

G/119. Ghazanfar, M., Chaudhry, M.N. & Hussain, M.S., 1991. Geology and petrotectonics of southeast Kohistan, Northwest Himalaya, Pakistan. Kashmir Journal of Geology 8 & 9, 67-97.

About 2200 km^2 of southeast Kohistan has been geologically mapped and the stratigraphy of the area established. A possible sequence of events has been listed. Detailed field relations and lithologic descriptions of many units have been reported for the first time. The predominantly plutonic arc set represents a relatively older much-eroded terrane where volcanic cover stands largely removed. The relatively smaller volcano-hypabyssal suite appears to be the latest magmatic event. Most of the amphibolite mass, tholeiitic greenstones and ultramafics represent obducted masses and shreds of oceanic affinities. The hanging wall sole rocks of MMT as well as foot wall rocks along minor syntaxis do contain deeper level obducted slices and shreds of eclogites and high-pressure granulites.
The Chilas norite complex is sandwiched between northern and southern arc masses. The field and petrographic data suggest that the Chilas norite complex appear to have been formed under a spreading center. The MMT suture zone ultramafics are divided into part cumulate and part mantle tectonic. The carbonaceous-argillaceous, argillaceous and calc-pelitic phyllites and associated low-grade carbonates represent Tethyan shelf sediments, sandwiched between the Higher Himalaya and southern suture ophiolites.
Structurally the area is characterized by a number of northwest dipping high-angle imbricate thrusts, which converge into and are terminated by the Raikot fault in the east. Polyphase folding is seen in the Kamila amphibolites while the norites appear to have been folded into tight isoclinal antiform.
Key words: Structure, mapping, stratigraphy, ophiolite, Island arc, MMT, Kohistan.

G/120. Ghazanfar, M., Chaudhry, M.N. & Hussain, M.S., 1992. Geology, tectonics and structure of northeast Kohistan and Kaghan. Abstracts, First South Asia Geological Congress, Islamabad, p.14.

Key words: Structure, Tectonics, Kaghan, Kohistan.

G/121. Ghazanfar, M., Chaudhry, M.N. & Latif, M.A., 1987. Three stratigraphic provinces at Hazara-Kashmir boundary, Pakistan. Kashmir Journal of Geology 5, 65-74.

A stratigraphic study of Hazara-Kashmir boundary in the region of Kaghan, Garhi Habibullah and Muzaffarabad indicates presence of three different stratigraphic sequences now tectonically juxtaposed. Two different stratigraphic levels are indicated for Tanols/Tanawal of Hazara and Kashmir.
Key words: Stratigraphy, tectonics, Hazara-Kashmir.

G/122. Ghazanfar, M., Chaudhry, M.N. & Mirza, S.B., 1984. Geology of Tithwal-Kel area, Neelum valley, State of Azad Jammu and Kashmir. Abstracts, First Pakistan Geological Congress, Lahore, 29-30.

For further details consult Ghazanfar et al., 1983.
Key words: Geology, Neelum valley, Azad Kashmir.

G/123. Ghazanfar, M., Chaudhry, M.N., Pervaiz, K. & Qayyum, M., 1990. Geology and structure of a section of Attock-Hazara fold and thrust belt around Ayubia, District Abbottabad, Pakistan. Abstracts, 2nd Pakistan Geological Congress, University of Peshawar, p.4.

Detailed geologic mapping of Kuza Gali - Dunga Gali - Ayubia area has been carried out at a scale 1:9560. Lithostratigraphy, structure and regional geology of the area has been discussed and described in relation to the larger tectonic framework. Stratigraphically the area shows exposures of rock units from Middle Jurassic to Eocene and belongs to the so-called Kohat-Potwar Basin. The overall structure is an anticlinorium bounded by the two synclinoria to its north and south. The whole being a small section of the Attock Hazara fold and Thrust belt of Pakistan.
Key words: Structure, Maps, Attock-Hazara.

G/124. Ghazanfar, M., Chaudhry, M.N., Pervaiz, K., Qayyum, M. & Ahmed, R., 1990. Geology and structure of Kuza Gali-Dunga Gali-Ayubia area, Hazara-Potwar basin with a reference to hydrocarbon prospects of Attock-Hazara fold and thrust belt, Pakistan. Journal of Hydrocarbon Research 2, 43-56.

Key words: Structure, maps, hydrocarbons, Hazara Potwar basin, Attock-Hazara.

G/125. Ghazanfar, M., Chaudhry, M.N. & Qayyum, M., 1990. The stratigraphic framework of Northwest Himalayas along the Kaghan valley section, Pakistan. Abstracts, 2nd Pakistan Geological Congress, University of Peshawar, p.34.

This paper is a first time attempt at systematizing the stratigraphy between the Main Boundary Thrust (MBT) and the southern Suture zone (SSZ) as exposed in Kaghan valley. The sequence in the Kaghan valley between Para and Naran is mainly inverted and becomes successively older towards the north. From south to north the rocks may be subdivided into three main groups: 1) the Kashmir sequence, Mid-Paleozoic to Miocene, which represents, by and large, tectono-stratigraphy of the Pir Panjal (Kashmir) to the east; (2) the Kaghan Group, possibly Late Proterozoic, which occurs between Mahandri and Naran; and 3) the Sharda Group, possibly Archean to Mid-Proterozoic, which occurs north of Naran and represents a continuation of the Higher Himalaya to the east. The Kaghan valley section also traverses important tectonic scars, including from south to north the Murree Fault, the Panjal Fault, the Main Central Thrust (MCT) and the Main Mantle Thrust (MMT).
Key words: Stratigraphy, MCT, MMT, Kaghan valley, Himalaya.

G/126. Ghazanfar, M., Chaudhry, M.N. & Qayyum, M., 1992. The stratigraphic framework of Northwest Himalayas along the Kaghan valley section, Pakistan. In: Sinha, A.K. (ed.). Himalayan Orogeny and Global Tectonics. Wadia Institute of Himalayan Geology, Dehra Dun, India, 307-327.

Consult the preceding account for further information.
Key words: Stratigraphy, MCT, MMT, Kaghan valley, Himalaya.

G/127. Ghazanfar, M., Chaudhry, M.N. & Spencer, D.A., 1995. The geological character and problems of Lesser Himalaya in Pakistan. Abstract Volume, 10^{th} Himalaya-Karakoram-Tibet Workshop, (ETH Zurich) Switzerland.

With the delineation of the Main Central Thrust (MCT) in the Northwest Himalaya of Azad Kashmir and Pakistan, the Lesser Himalaya slab can now be defined. The Lesser Himalaya of Pakistan and Kashmir is divided into a northern metamorphic zone and a southern sedimentary zone. The northern metamorphic zone is represented by the mutually analogous Kashmir Basin in the east and the Peshawar Basin in the west separated by Kaghan and Northern Hazara in between. Whilst the Lesser Himalaya of Kashmir and Peshawar basins are characterized by simple fold structures, the intervening Kaghan and Northern Hazara are marked by schuppen structures. The Kashmir and Peshawar basins are limited to the south by the sedimentary zones of Pir Panjal in the east and the Attock Hazara Fold and Thrust Belt in the west. Both these sedimentary belts are again marked by numerous closely spaced ramp faults. In the area of Balakot these two zones along with the sedimentary sequences of Muzaffarabad comprise three stratigraphic provinces on the boundary of Hazara and Kashmir. Southeast Hazara is characterised by a four phase sequence of deformation. The first phase is Pan-African while the other three phases are Himalayan in age. The earliest Himalayan phase of deformation is marked by south verging folds and thrusts, the second by north verging structures and finally the third by open north-south cross folds related to the formation of HKS. Evidence of pre-Himalayan metamorphism is now well documented in the Lesser Himalaya of Pakistan. The pre-Himalayan phases start in the Proterozoic and end in the Hercynian. The Tanol-Tanawal controversy, regarding the age and correlation of these formations in Kashmir and Hazara, can now be finally settled. The Tanawals of Kashmir are Devonian to Carboniferous while the Tanols of Hazara are Precambrian in age and are older than the Hazara slate to which they have always been considered younger.
Key words: Geology, metamorphism, MCT, Himalaya.

G/128. Ghazanfar, M., Chaudhry, M.N. & Spencer, D.A., 1999. The geological character and problems of the Lesser Himalaya in NE Pakistan. Geological Bulletin, Punjab University 33 & 34, 9-42.

With the delineation of the Main Central Thrust in the Northwest Himalaya of Azad Kashmir and Pakistan, the Lesser Himalayan slab stands defined The Lesser Himalaya of Pakistan and Kashmir are divided into a Northern Metamorphic Zone and a Southern Sedimentary Zone. The Northern Metamorphic Zone is overlain by the Peshawar Basin in the west of Pakistan and also includes' Northern Hazara and the middle parts of Kaghan and Neelum valleys to the east.
Whilst the Kashmir and Peshawar Basins are characterized by a Tethyan stratigraphic sequence deformed by simple folding, the intervening middle Kaghan and Northern Hazara areas are highly deformed schuppen structures on the limbs of the Hazara-Kashmir Syntaxis. The Kashmir and Peshawar Basins are limited to the south by the sedimentary zones of the Pir Panjal in the east and the Attock-Hazara Fold-and-Thrust Belt in the west. Both these sedimentary belts are marked by numerous closely spaced ramp faults. The Attock-Hazara Fold-and-Thrust Belt is marked by a polyphase sequence of deformation. At least one phase is Precambrian. The occurrence of Pre-Himalayan/Pre-Cambrian metamorphism in the Lesser Himalaya is now well established. The Himalayan overprint is missing or at best limited. The Tanol-Tanawal controversy regarding age and correlation of these formations in Kashmir and Hazara is discussed and it is here suggested that among the Pre-cambrian formations the Tanawals of Hazara are in fact older than the Hazara slates.
Key words: Geology, tectonics, metamorphism, MCT, Himalaya.

G/129. Ghazanfar, M., Chaudhry, M.N., Spencer, D.A., Hussain, S.S. & Dawood, H., 1999. The nature and problems of the Tethyan Himalaya in Pakistan and western Kashmir. Geological Bulletin, Punjab University 33 & 34, 43-69.

This paper aims to define, describe and discuss the occurrence of the tectonic subdivision of the Tethyan Himalaya in northern Pakistan and western Kashmir. With the demarcation of the Main Central Thrust in the Neelum and Kaghan valleys (western Kashmir and Pakistan), the Higher Himalaya and the Lesser Himalaya have now been differentiated in these areas. In the NW Himalaya, two domains of the Tethyan sedimentary rocks have been

recognised, both north and south of the Main Central Thrust. To the south, the Lesser Himalaya in Pakistan and Kashmir is overlain by a sedimentary sequence of Tethyan affinity. The relationship of this Southern Tethyan Sequence, incorporated as part of the Lesser Himalaya, is interpreted to be analogous to that of the cover sediments in Kashmir and the autochthonous fold belt of Pir Panjal. To the north of the Higher Himalaya and directly underneath of the Indus Suture, the 'Northern Tethyan Sequence' possibly consists of low grade sediments which are found in Upper Kaghan, Banna, Karapa and Lower Swat. These sediments can be interpreted to be analogous to the Tethyan Himalaya. Other interpretations of these sediments (i.e., their suture zone affiliation) are also discussed. Finally, the high grade metasedimentary cover of Higher Himalaya is also regarded as being the equivalent of the Tethyan Himalaya in the 'Northern Tethyan Sequence'. The role and significance of these Tethyan sequences, in the subdivision terminology of the Himalaya, is assessed with the other known subdivisions of the Pakistani Himalaya and western Kashmir.
Key words: Tectonics, MCT, Kaghan valley, Neelum valley, Tethyan Himalaya.

G/130. Ghazanfar, M., Chaudhry, M.N., Zaka, K.J. & Baig, M.S., 1986. The geology and structure of Balakot area, District Mansehra, Pakistan. Geological Bulletin, University of Punjab 21, 30-49.

Nearly 65-km2 area in the vicinity of Balakot has been mapped at 1:10,000. The stratigraphy and major structures are described and discussed. The stratigraphy of Balakot brings out three separate stratigraphic sequences of rocks east and west of the river Kunhar. A new stratigraphic interpretation of the metamorphics is presented. The small but interesting Bamphora structure is explained. The Muzaffarabad fault is correlated with the Riasi fault and with the Great boundary fault, passing through Potwar. Jhelum fault is the youngest major structure, which has displaced the western limb of the Hazara-Kashmir Syntaxis.
Key words: Geology, structure, Balakot, Mansehra.

G/131. Ghaznavi, M.I., 1981. Graphite deposit of Mohriwali, upper Azad Kashmir. Geological Survey of Pakistan, Information Release 167.

Key words: Mineral Deposits, Graphite, Kashmir.

G/132. Ghaznavi, M.I., 1988. The petrographic properties of the coals of Pakistan. M.S. Thesis, southern Illinois University, Carbondale, 175p.

Key words: Petrography, coal.

G/133. Ghaznavi, M.I., & Karim, T., 1978a. A note on phosphorite deposits of Lagharban and Kalu–di–Bandi areas, Hazara District, NWFP, Pakistan. Geological Survey of Pakistan, Information Release 103, 31p.

Phosphorite deposits have been discovered in Kalu-di-Bandi and Lagarban areas (toposheet. 43 F/7) of Hazara district. The phosphorite is found in the upper cherty dolomitic part of Abbottabad Formation. The phosphate beds are present along both the western and eastern limbs of an overturned syncline.
The phosphorite zone found in the western limb is more promising because of its quantity. It is lenticular in shape with average thickness of 18 feet and lateral extension 8500 feet. The P205 percentage varies from 24 to 31%. The reserves of this zone upto 500 feet dip depth are about 5.00 million tons.
The eastern limb deposit is not as extensive as that of western limb. The phosphate zone has 14 feet average thickness and the lateral extension is about 3500 feet. The P205 percentage of this zone is very good and varies from 30 to 38%. The reserves of this zone are about 2.00 million tons.
The total probable estimated reserves of Kalu -di-Bandi area are about 7.00 million tons upto dip depth of 500 feet.
Key words: Mineral deposits, phosphorites, Hazara.

G/134. Ghaznavi, M.I., & Karim, T., 1978b. Phosphorite deposits of Dalola–Daulatmar area, Hazara District, NWFP. Pakistan. Geological Survey of Pakistan, Information Release 104, 31p.

The phosphorite deposits have been discovered in Dalola-Daulatmar areas (toposheet No.43F/7) of Hazara district. The phosphorite is found only in the middle silty beds of Galdanian Formation. Three different phosphorite zones in the same stratigraphic horizon have been discovered in this area. The zone No 1 is 5580 feet long and has 28 feet average thickness. The zone No 2 is 2700 feet long with 48 feet average thickness. While the third zone No 3 is further divided into A and B with 3630 feet and 2300 feet respective lengths. The average thickness of former is 29 feet and of later 18 feet. The P205 percentage varies from zone to zone and within the same zone. The best and richest zone is No 2 and the poorest is zone No 3. The P205 percentage of phosphorite deposits of this area varies from 8 to 39%. On the whole the phosphate is low grade and needs beneficiation to upgrade. The total probable estimated phosphorite reserves of this area are about 9 million tons upto a dip depth of 300 feet.
Key words: Phosphorites, Hazara.

G/135. Ghaznavi, M.I., Karim, T. & Maynard, J.B., 1983. A bauxitic paleosol in phosporite-bearing strata of Northern Pakistan. Economic Geology 78, 344-347.

The area around Abbottabad contains commercial grade phosphate in several localities. The stratigraphy of the phosphate-bearing units is of great interest. This report documents the position of a major unconformity which can be used to improve stratigraphic correlation and which may shed some light on the genesis of the phosphate beds. The phosphate deposits are contained in stratigraphic sequence comprising the Abbottabad formation, a cherty dolomite; the Hazira formation, a complex unit, mostly silt stone; and the Samana Suk limestone, which is of Jurassic age.
Key words: Stratigraphy, phosphate deposits, mineralization, Indian plate, Abbottabad.

G/136. Ghazi, B., 1987-89. Geotechnical study of proposed Ghazi-Gariala Hydropower Project and material testing of District Hazara and Attock. M.Sc. Thesis, Punjab University, Lahore, 140p.

Key words: Hydropower, geotechnical, Ghazi, Hazara.

G/137. Ghazi, S., 1992. Environmental hazards along the Mansehra-Duber segment of the Karakorum Highway. Mountnews 5, 65-72.

Key words: Environmental hazards, KKH.

G/138. Ghiglione, P., 1946. Himalaya: Karakorum. 1st Geogr. De Agostini, Novara.

Key words: Geography, Karakoram.

G/139. Ghumman, M.A., 1976-78. Detailed Geology, Petrology and Economic Geology of Toposheet No. 43 B/9. M.Sc. Thesis, Punjab University, Lahore.

The Shangla Par-Alpurai Area is composed mainly of schist and phyllites containing volcanics at some horizons. These rocks were originally deposited in eugeosynclinal conditions or argillaceous sediments and have subsequently been metamorphosed to schists and Phyllis. These rocks are probably Cambrian in age. They have been intruded by the ophiolites, which have now been metamorphosed to amphibolites. These art the southern amphiboles which are ortho in character. Subsequently the area has been strongly folded and intruded by Basi granite and then by the ultramafic body. This body was originally a complex peridotite-pyroxenite-amphibole-pyroxene etc. rock which has been altered first to serpentinite and then further metasomatised at places to talc-carbonate rock. The area lies on the Northwestern Limb of the syntexis and therefore, the prominent strike is NW+SW. Almost all major contacts are faulted. The folding pattern is isoclinal.

Key words: Mapping, petrology, economic geology, ophiolites, Swat.

G/140. Giaradino, J.R., Shroder, J.F. & Vitek, J.D. (Eds.), 1987. Rock Glaciers. Allen and Unwin, London, 355p.

Key words: Glaciology, glaciers.

G/141. Gilani, T.M., 1984-85. Geology of Nauseri-Reshian area with special emphasis on the structure of the area. M.Sc. Thesis, University of Azad Jammu & Kashmir, Muzaffarabad, 119p.

The project area covers about 307 square kilometers, located between Reshian and Jura to the ESE and NE of Muzaffarabad, Azad Kashmir. The work has involved geological mapping of the area on a scale of 1:25,000. in this thesis an attempt has been made to introduce the detai1ed geology of the area. Bulk geological sequence of the area consists of sedimentary, volcanic, metamorphic and granitic rocks. The area is tectonically, highly disturbed being involved in Himalayan orogeny. Major and minor structures of the area are described with the help of figures and maps. For Petrographic analysis sixty thin sections were studied microscopically. Tectonic setting and stratigraphy of the area are described briefly. Economic rocks and minerals found in the have been described in detail to some extent.
Key words: Structure, geology, Azad Kashmir.

G/142. Gilani, T.M., Baig, M.S., Ashraf, M., Khan, M.S., Raja, M.K.K., Rashid, A., Aziz, M. & Lucky, M.H., 1991. Geology of Reshian-Nauseri Area, Azad Jammu and Kashmir, Pakistan. Kashmir Journal of Geology 8 & 9, 191-192.

The area lies in the Pir Panjal Range of the lesser Himalaya, a pre Cambrian to late Paleozoic sequence of the Northern margin of Gondwana is imbricated by NE dipping thrust faults. The major thrust faults from south to north are the Murree thrust and the Panjal thrust. The former emplaces the late Paleozoic Panjal formation on to the Oligocene to Miocene molasses of the Murree formation. The Panjal thrust emplaces the Precambrian tanol formation and early Paleozoic granitoids on to the Panjal formation. Petrography of the rocks is given and comments are made on regional metamorphism,
Key words: Structure geology, stratigraphy, Pir Panjal Range, Azad Kashmir.

G/143. Gill, W.D., 1951. The tectonics of the Sub-Himalayan fault zone in the northern Potwar region and in the Kangra district of Punjab. Quarterly Journal Geological Society of London 107, 112-121.

The paper defines three major zones of deformation across the Nimadric (Tertiary freshwater) geosyncline between the foreland and the autochthonous folded belt in the North-West Himalaya:-
(1) A zone of open folding, affected to a varying degree by fold-faulting.
(2) A fault zone, displaying a number of reversed faults of steep northerly hade and great lateral extent with open folds between them in the west and, in places, gently dipping monoclines in the east.
(3) A zone with closely spaced strike-faults and severely compressed folds, referred to in the Potwar area as the isoclinal zone, terminating at the main boundary fault which forms the general northern limit of Nimadric rocks.
This succession of structural zones has a superficial resemblance to progressive deformation of the Jura type towards the nappe zone, and previous workers have regarded the tectonic pattern as reflecting tangential pressures from the north.
The author seeks to demonstrate that such an interpretation is denied by the evidence of the structures themselves. Two areas are chosen to illustrate in adequate detail the tectonics of all three zones, and in particular the crucial fault zone. In the west, the Jhamat-Khushalgar area of western Potwar typifies the fault zone of the area between the Indus and the Jhelum rivers. In this area there is clear evidence of the steep hade of the great strike-faults at the surface, and also important evidence of their continued steep hade in depth from the results of boreholes drilled by the Attock Oil Company. Analysis of the relationship of the faults to the fold structures leads to the conclusion that

the faults have no genetic relationship to the fold axes. They are considered to be fractures due to shearing stresses principally with a vertical orientation, whilst the folding reflects the subsidiary compressive force. The Nadaun Dun area of Kangra district is some 200 miles to the southeast of the Potwar area, but lies across similar structural zones and typifies the relationships of the anticlinal zone and the fault zone in the region east of the Jhelum River. In this area the Gumber fault is seen to present all the features of the great strike-faults of the fault zone in the Potwar and is an upthrust structure produced by quasi-vertical movement. A feature not present in the Potwar is the marked contrast between the gently dipping monocline to the north of the fault and the strongly folded country to the south, providing a clearer distinction between the influence of tangential and vertical forces. It appears that the fault movement provided a block-line against which tangential forces from the south were directed. Important evidence of tangential pressure from the south is provided by the Barsa fault, which typifies the most common form of fold-fault in the anticlinal zone throughout the region. Gravity collapse structures are recorded in the form of severely overturned "flaps" of sandstone on the south side of the Sola Singhi ridge.
Key words: Tectonics, structure, deformation, Kangra, Potwar,

G/144. Gill, W.D., 1952. The stratigraphy of the Siwalik series northern Potwar, Punjab, Pakistan. Quarterly Journal of the Geological Society of London 107, 375-394.

Detailed mapping of the Jhamat area in the west and of the Soan syncline in the east forms the basis of revision of the stratigraphy of the Siwalik Series in the northern Potwar region. The succession is here affected by facies changes of regional significance: -

1. Near the Indus River the uppermost 3000 feet of the Middle Siwalik sequence (Upper Nagri and Dhok Pathan stages) contain thick beds of conglomerate which die out eastwards and south-eastwards into sandstones and clays. Farther eastwards, across the Soan syncline, a clay facies develops at progressively lower horizons in the Nagri Stage, replacing a considerable portion of the massive sandstones of the type area. The facies change is accompanied by a reduction in thickness. The facies variation in the Middle Siwalik rocks is indicative of a channel environment in the west at Jhamat, clearly coinciding with the line of the present Indus River and grading eastwards into deposits of "flood plain" type.
2. The Lower Siwalik rocks show a development of coarser facies in the opposite direction to that noted in the Middle Siwalik. At the eastern end of the Soan syncline the lowest 1500 feet of the Chinji Stage, which in the west is almost entirely of clay-shale facies, contain thick beds of hard sandstone and the sequence is very similar to that of the underlying Kamlial Stage.

In the Soan area, the complete Siwalik succession from the Kamlial Stage to the Pinjor Stage (Villafranchian) is free from any marked unconformities but is overlain with strong unconformity by post-Siwalik Pleistocene beds—the Lei Conglomerates. This interpretation differs greatly from that of de Terra (1936, 1939), who placed the first great unconformity of the area at the base of the Tatrot Stage. The revision explains Pilgrim's reluctance to include the Villafranchian in the Pleistocene, since in the Indian Siwalik belt this stage forms the highest member of a conformable succession which was intensely folded and subjected to peneplanation before the next deposition took place. The decision at the International Congress in 1948 to adopt the Villafranchian as the base of the Pleistocene places the Siwalik phase of Himalayan orogenesis within the Pleistocene System.
Key words: Stratigraphy, Siwaliks, Foreland basin, Potwar.

G/145. Gill, W.D., 1953. The genus Assilina in the Laki series (Lower Eocene) of the Kohat Potwar Basin, North West Pakistan. Cushman Foundation Foraminiferal Research Centre 4(2), 76-84.

Key words: Palaeontology, Laki beds, Kohat-Potwar basin.

G/146. Gingerich, P.D., 1977. A small collection of fossil vertebrates from the middle Eocene Kuldana and Kohat Formations of Punjab (Pakistan). Contributions from the Museum of Paleontology, University of Michigan 24(18), 190-203.

1975 the author made a new collection of fossil vertebrates from the Middle Eocene Kuldana and Kohat Formations in the Kala Chitta mountains of the Punjab Province in Pakistan. Vertebrates were found at twelve localities in the

vicinity of Lammidhan and Chharat. All of the identifiable mammals came from Lammidhan. Two additional mammal specimens from Lammidhan in the British Museum (Natural History) are also described and illustrated for the first time. It is suggested that Gandakasia may be a primitive cetacean rather than a mesonychid condylarth. The new artiodactyl genus Lammidhania is proposed for the anthracothere species 'Anthracobune ' wardi Pilgrim, 1940. Discovery of a small concentration of mammal specimens at one locality suggests that there is very good potential for the discovery of additional middle Eocene mammals in the Kuldana Formation and its lateral equivalents.
Key words: Vertebrates, Eocene, Kuldana Formation, Kohat Formation.

G/147. Gingerich, P.D. & Gunnell, G.F., 1995. Rates of evolution in Paleocene mammals of the Clarks Fork Basin of Wyoming, and a comparison with the Neogene Siwalik lineages of Pakistan. Palaeogeography, Palaeoclimatology, Palaeoecology 115, 227-247.

Rates of size change are quantified in 19 species-level evolutionary lineages of Clarks Fork Basin Paleocene and early Eocene mammals. Intrinsic rates of change in Clarks Fork Basin lineages range from about $10^{-0.1}$ to $10^{-3.4}$ haldanes (standard deviations per generation), with a median rate of about $10^{-1.1}$ haldanes. These values are in the usual range of intrinsic rates commonly seen in other settings. Temporal scaling slopes indicate that seven of the 19 Clarks Fork Basin lineages were stable over time (37%), five were stable with a random component (26%), four were indistinguishable from random (21%), two were directional with a random component (11%), and one lineage cannot be classified. Clarks Fork Basin mammalian species have mean durations of about 0.95 m.y. and median durations of about 0.76 m.y. Intrinsic rates of size change are similar to those for Miocene Siwalik mammals, but the average species duration is less than one-half the average for Siwalik mammals.
Key words: Paleontology, mammals, vertebrates, Paleocene, Siwaliks, Wyoming.

G/148. Gingerich, P.D., Raza, S.M., Arif, M., Anwar, M. & Zhou, X., 1994. New whale from the Eocene of Pakistan and the origin of cetacean swimming. Nature, 368, 844-847.

Modern whales (order Cetacea) are marine mammals that evolved from a land-mammal ancestor, probably a cursorial Palaeocene–Eocene mesonychid. Living whales are streamlined, lack external hind limbs, and all swim by dorsoventral oscillation of a heavily muscled tail. A streamlined rigid body minimizes resistance, while thrust is provided by a lunate horizontal fluke attached to the tail at a narrow base or pedicle6. We describe here a new 46–47-million-year-old archaeocete intermediate between land mammals and later whales. It has short cervical vertebrae, a reduced femur, and the flexible sacrum, robust tail and high neural spines on lumbars and caudals required for dorsoventral oscillation of a heavily muscled tail. This is the oldest fossil whale described from deep-neritic shelf deposits, and it shows that tail swimming evolved early in the history of cetaceans.
Key words: Palaeontology, marine mammals, Eocene.

G/149. Gingerich, P.D. & Russell, D.E., 1981. Pakiscetus inachus, a new archaeocete (Mammalia, Cetacea) from the early-middle Eocene Kuldana Formation of Kohat (Pakistan). Contributions from the Museum of Paleontology, University of Michigan, 25, 235-246.

A new genus and species of primitive protocetid whale, Pakicetus inachus, is described from the early-middle Eocene Kuldana Formation at Chorlakki, Kohat District, North-West Frontier Province, Pakistan. The holotype is a nearly perfectly preserved posterior portion of a cranium. Pakicetus is distinctive among whales in retaining an extremely primitive auditory region. The auditory bulla articulates with the squamosal, basioccipital, and paroccipital in addition to a normal cetacean articulation with the posterior process of the periotic. The cochlear part of the periotic articulates with both the squamosal and the basioccipital. Three genera of early-middle Eocene whales are now known from Pakistan. Pakicetus is intermediate in size between Ichthyolestes and Gandakasia, and it resembles both to some degree in dental morphology. "Protocetus" attocki from Ganda Kas is here referred to Pakicetus.
Key words: Paleontology, mammals, Eocene, Kuldana Formation, Kohat.

G/150. Gingerich, P.D. & Russell, D.E., 1990. Dentition of Early Eocene Pakicetus (Mammalia, Cetacean). Contrib. Museum of Paleontology, University of Michigan, 28(1), 1-20.

Thirty deciduous and permanent teeth of Pakicetus inachus are described from Chorlakki in Pakistan. Geological sequence stratigraphy indicates that Pakicetus is latest early Eocene (latest Ypresian) in age. Incisors of Pakicetus are simple high-crowned sharply-pointed teeth. The upper canine may have been double-rooted. Lower canines vary in size and may have been dimorphic. Premolars have simple narrow crowns with coarse serrations on some anterior and posterior crests. Upper molars retain three roots and distinct protocones. ~owermolars have simple pyramidal trigonids and narrow trenchant talonids. These teeth are combined in a model based on the type braincase-basicranium showing that all represent a single species. Pakicerus inachus may prove to be a junior synonym of P. attocki when the latter is better known, but restudy of contemporary Ichthyolestes and Gandakasia confirms that these genera are distinct. The three early Eocene genera are placed in a new subfamily Pakicetinae of the rchaeocete family Protocetidae. Teeth of Pakicetus have several distinctively archaeocete characteristics. Upper and lower cheek teeth have wear facets on apices of pointed cusps indicating that the lower jaw was retracted when food was punctured. Buccal phase shearing and lingual phase grinding wear facets are also mesent. Deciduous teeth at Chorlakki indicate that iuveniles and adults were present in approximately equal proportions, suggesting that juveniles, like adults, spent a significant amount of time on land.
Key words: Paleontology, Eocene, mammals, Kohat.

G/151. Gingerich, P.D., Russell, D.E., Hurtenberger, J.L., Shah, S.M.I., Hassan, M., Rose, K.D. & Ardrey, R.H., 1979. Reconnaissance survey and vertebrate paleontology of some Paleocene and Eocene formations in Pakistan: Contribution Museum of Paleontology, The University of Michigan, 25(5), 105-116.

In 1977 we spent approximately two months in the field in Pakistan studying three geological formations to assess their potential to yield identifiable fossil mammals. The middle Eocene Domanda Formation was examined at six localities spanning a 100 km distance along the east side of the Sulairnan Range in southwestern Punjab. This formation yielded abundant fish remains, including skulls and skeletons, and some reptilian bone. Mammalian remains included a poorly preserved skull fragment and postcranial elements of cetaceans. Land mammals may also be represented, but they are too poorly preserved to be useful for study. The Domanda Formation appears to be entirely a shallow water marine formation, with little potential to yield land mammals unless localized deltaic facies can be found.
The Paleocene Bara Formation was examined at five localities in the Lakhi Range in Sind. This formation yielded only fragmentary remains of crocodilians and turtles, but the middle part of the formation appears to be fluvial in origin, and with further work it could eventually yield mammals. The early-middle Eocene Kuldana Formation was examined at six localities in Kohat District, North-West Frontier Province. All of these localities yielded reptilian and mammalian bone and tooth fragments, and one locality near Chorlakki village yielded a diverse assemblage of mammals. The vertebrate fauna of the Kuldana Formation is becoming increasingly well known in Punjab and Jammu- Kashmir on the east side of the river Indus, and our work indicates that good collections can also be made west of the Indus as much as 100 km west of previously known localities.
Key words: Reconnaissance, Palaeontology, Vertebrate, Paleocene, Eocene, Kohat.

G/152. Gingerich, P.D., Russell, D.E., Singogneau-Russell, D. & Hartenbeger, J.L., 1979. Chorlakkia Hassani, A new middle Eocene Dichobunid (Mamalia Artiodactyla) from the Kuladana Formation of Kohat (Pakistan). Contributions to the Museum of Paletontlolgy, The University of Michigan 25 (6), 117-124.

A new genus and species of artiodactyl, Chorlakkia Hassani, is described from the middle Eocene Kuldana Formation in the Kohat District of Pakistan. This is the smallest artiodactyl described from the Paleogene of Asia, and it is one of the smallest artiodactyls yet known. The familial position of Chorlakkia is somewhat uncertain, but it appears to belong to the family Dichobunidae (s.1.).
Key words: Vertebrates, Eocene, Kuldana Formation, Kohat.

G/153. Gingerich, P.D. & Sahni, A., 1979. Indraloris and Sivaladapis: Miocene adapid primates from the Siwaliks of India and Pakistan. Nature 279, 415-416.

The primate family Adapidae underwent a major radiation during the Eocene in Europe and North America. Asian and African Eocene mammalian faunas are still poorly known, but there is sufficient evidence to indicate at least a modest radiation of Eocene adapids in Asia and probably also in Africa. Apart from possible lemuriform and anthropoid primate derivatives, the family Adapidae was thought to have become extinct at the end of the Eocene (middle Tongrian, approximately 37 Myr). We present here new evidence which indicates that at least two genera of adapid primates, Indraloris and Sivaladapis (gen. nov.), survived into the late Miocene of India and Pakistan. These genera are little advanced over Eocene Adapidae in terms of dental adaptations and are apparently south Asian relicts of a much earlier radiation.
Key words: Vertebrates, Indraloris and Sivaladapis, Eocene, Miocene, Siwaliks.

G/154. Glennie, E.A. (ed.), 1932. Gravity, the depth of the Indus alluvium. In: Geodetic Reports of the Geological Survey of India 7, 79.

Key words: Gravity, Indus alluvium, Geodesy.

G/155. Glennie, E.A., 1956. Gravity data and crustal warping in Northwest Pakistan and adjacent parts of India. Royal Astronomical Society, Monthly Notices, Geophysics Supplement 7(4), 162-175.

Gravity data are used to investigate the geological structure of an area of about 160000 square miles in the light of the crustal warping hypothesis. The region is in N.W. Pakistan and India, and includes the whole of the alluvial plains of Sind and Punjab, the Salt Range and the Potwar Plateau.
A new gravity anomaly is introduced and used by an original method, which leads automatically to the detailed contouring of the basement rock below the region, the basement being assumed to be the upper surface of the Earth's crust. The standard crustal section employed is a two-layer crust with a total thickness of thirty kilometres but a table permits direct comparison with other sections of a six-layer crust, two of which have increased thickness.
The basement contours show a ridge about 300 miles long separating the Indus Basin from the Lahore Basin. It is hidden by alluvium except for a few outcrops near its northern end. This ridge has apparently suffered sub-aerial erosion under typical S.W. monsoon conditions, extending in places to a depth of over 3000 feet below sea level. This modification of the basement requires a revision of the contours over the ridge, and two contoured charts show firstly the simple crustal upwarp underlying the ridge and secondly the eroded surface of the basement. A deep valley with its bottom far below sea level cuts through the ridge connecting the Indus and Lahore Basins. In Sind a similar valley leads from the direction of the sea to the Indus Basin, but here interpretation is uncertain.
It is concluded that the hypothesis yields results giving depths to the basement of the right order in deeply downwarped areas, but in upwarped areas the possibility of erosion, or other concealing factors, leads to uncertainty of interpretation unless the area is wide enough to include a complete section of the upwarp.
Key words: Gravity, structure, Potwar, Salt Range, northern Pakistan, NW India.

G/156. Godwin-Austen, H.H., 1863-1864. On the glaciers of the Mustagh Range. Proceedings, Royal Geographical Society 34, 19-56.

Godwin-Austin, after whome is named the 2^{nd} highest peak in the world, K2, describes the large glaciers of upper Baltistan, and provides evidence showing that they were formerly much more extensive.
Key words: Glaciation, Mustagh Range, Baltistan.

G/157. Godwin-Austen, H.H., 1864. Geological notes on part of the North-Western Himalayas: with notes on the fossils by Davidson, T., Etheridge, R. and Woodward, S.P. Quarter Journal Geological Society 20, 383-387.

The paper describes (1st) the fluvio-lacustrine series of the Kashmir valley and Baltistan; (2nd) the Siwalik series of the Outer Hills; (3rd) the [so-called] Nummulitic [really secondary] series of the outer Pir-Panjal; (4th) the Jurassic

series of Zanskar; (5th) the carboniferous of the Kashmir valley; and (6th) the older rocks of these districts. The Carboniferous fossils described are all of from the Kashmir valley, and not, as stated, from Shigar, in Baltistan. A list of terrestrial shells is given from the lacustrine deposits.
Key words: Lithology, paleontology, fossils, NW Himalayas.

G/158. Godwin-Austen, H. H., 1966. Corrigenda to the Abstract. Capt. Godwin Austen's paper; Geological Notes on the Northwestern Himalayas. Quaternary Journal of Geological Society London, 22, p.35.

Key words: Fossils, Himalayas.

G/159. Godwin-Austen, H.H., 1894. Peak K2 (Godwin-Austen). The Geographical Journal 5, 431-432.

Godwin-Austen was the first to produce a geographic map with location of the K2 and the neioghbouring peaks.
Key words: K2, geography.

G/160. Gohar, A., 1999. Concrete feasibility for the limestone of the Kohat formation, District Kohat. M.Phil. Thesis, University of Peshawar, 99p.

Limestone is a valuable raw material, which is widely used in the chemical and construction industries throughout the world. With huge deposits of limestone in Pakistan, it is immensely used as concrete aggregates. The Eocene limestone of the Kohat Formation is generally exposed in the Kohat, Hangu and Bannu districts. It is cream to gray in color, hard, compact, well-bedded and fossiliferous. The limestone of Kohat Formation has been evaluated mineralogically, chemically and physically, for its use as concrete aggregates during present study.
Mineralogically, the studied limestone is dominantly calcite with abundant fossil shells. Fine-grained quartz, chalcedony, clay, dolomite and opaque phases are present in minor amount. The limestone generally has fine to medium-grained granular mosaic with bioturbated microfossils. Deleterious minerals to concrete are generally foliated in the argillaceous variety of the studied limestone.
Chemically, the studied limestone (by weight) is classified as high-calcium limestone, with CaCO3 between 81.23 and 98.93%. The SiO2 varies from 0.50 to 13.90 wt %, Al203 from 0.47 to 0.74 wt %, Fe203 from 0.05 to 0.30 wt %, CaO from 46.07 to 57.03 wt %, Na2O from 0.35 to 0.45 wt % and K20 from 0.01 to 0.05 wt %. MnO and MgO are up to 0.25 and 2.69 wt %, respectively. The average chemical compositions of various cements manufactured in N.W.F.P. are within the ASTM limits. The alkali-silica reactivity graph for the limestone aggregates based upon ASTM C 289-90 also verify the petrographic observations. Physical properties (i.e., soundness, water absorption, Los Angeles abrasion and specific gravity) are generally in accordance with the ASTM standards for aggregates to be used in concrete. The studied limestone of the Kohat Formation except its argillaceous variety found in the eastern part of the study area, is generally free of dolomitization and has no other- deleteriotes substances as far as the durability of concrete is cancerned. This Eocene limestone of the Kohat Formation is therefore, recommended for its use as concrete aggregates.
Key words: Limestone, concrete, Kohat.

G/161. Gohar, S., 1962. Geology of Bagnotar, Nathiagali and Kohala, Hazara. M.Sc. Thesis, Punjab Univeristy, 25p.

Key words: Geology, structure, Hazara.

G/162. Gohar, S.H.U., 1985-87. Lithostructural mapping and geology of Bara Gali-Kunola Area, District Abbottabad, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 95p.

This report gives an account of geological studies and lithostructural mapping carried out in Kuldana-Bara Gali area. The prescribed area lies on both side of the road leading from Murree to Abbottabad. It is a mountaneous region with fairly high relief.
Lithostructural mapping of approximately 20 sq.Km was carried out. The stratigraphic succession ranges from Hazara Formation (pre-Cambrian) 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 the 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 two cross section (AA' and BB') were also drawn in order to interpret the regional structure and tectonic history of the area. This 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 (Hydrocarbons) and the economic importance of the rock units present in the project area.
Key words: Lithostructure, mapping, Abbottabad.

G/163. Gondal, M.M.I., 1982-84. Economic geology and petrology of graphite and other minerals in Naran-Paludaran Area, middle northern Kaghan valley, District Mansehra. M.Sc. Thesis, Punjab University, Lahore, 138p.

Key words: Petrology, economic geology, Kaghan valley, Mansehra.

G/164. Goraya, M.A., 1976. Report on Lithostructural mapping of Paras area, Kaghan valley with special emphasis on petrography and petrogenesis. M.Sc. Thesis, Punjab University, Lahore, 53p.

Key words: Lithostructure, mapping, petrography, Kaghan valley.

G/165. Gormov, A.V. & Zeb, Z., 1992. On the mineralogy of pink topazes from Katlang deposit (Pakistan). (Russian with English abstract). Zapiski Vsesoyuznogo Mineralogicheskogo Obshchestva 121, 72-79.

In addition to the relatively recent discovery of significant amount of emerald, aquamarine, and ruby, Pakistan has also begun to produce fine gem quality pink topaz. In a small hillock of recrystallized limestone north of Katlang, narrow calcite veins encase pink topaz crystals up to 3 cm long accompanied by larger amounts of reddish brown, tan and colourless topaz crystals. More than 70000 ct of gem quality pink topaz has been reported to date. The refractive indices, optic axial angle, unit-cell dimensions, and density of the topaz are influenced by a partial replacement of fluorine by hydroxyl ions. The color is due to trace elements – principally chromium (Cr^{3+}). Treatment experiments reveal that the color of the brown, tan, and colorless topaz from this source may be improved by irradiation and heat.
Key words: Mineral deposits, topaz, gemstone, Mardan.

G/166. Gornitz, V. & Seeber, L., 1981. Morphotectonic analysis of the Hazara arc region of the Himalayas, North Pakistan and North West India. Tectonophysics 74, 263-282.

In the Hazara arc region of northern Pakistan, some of the active basements structures buried below a thick, detached sedimentary layer are inferred from the distribution of lineaments and the drainage patterns, as viewed in Landsat satellite imagery and from river profiles.
A prominent set of NW-trending lineaments seen on satellite imagery, coincides approximately with the southwest or updip side of the Indus—Kohistan seismic zone (IKSZ) —the most active basement structure of the region, even though this structure is buried beneath and decoupled from a 12 km thick sedimentary layer. The IKSZ has been interpreted as an extension of the Himalayan Basement Thrust, and is also associated with a prominent topographic "step".
Knickpoints on major rivers in the region lie on or north of the IKSZ. All Indus River tributaries, examined north of the IKSZ, show prominent knickpoints, while two tributaries draining south of the IKSZ have no knickpoints. These

results suggest ongoing uplift above and north of the IKSZ, and are consistent with the tectonic model obtained from the seismic data. Another prominent lineament set is detected along the north—south section of the Indus River. This set is probably related to the Indus River horst—anticline and associated reentrant. One of the two highest lineament concentrations occurs at the intersection between the NW-trending IKSZ lineament and the N-trending Indus River lineament. The other is along the west bank of the Indus Valley, 25 km north of Tarbela Dam. A topographic ridge (Swabi—Nowshera ridge) appears to be forming along the west side of the Indus River, in the Peshawar Basin. The rising ridge is ponding the Kabul River upstream of Nowshera, where the drainage is braided.
Key words: Tectonics, Hazara arc, Himalaya.

G/167. Gortani, M., 1920. Permocarbonifero e Permiano nella catena del Caracorum. Rendicanti Accad. Lincei, Ser. II (29), 53-55.

Key words: Paleontology, Permocarboniferous, Karakoram.

G/168. Gortani, M., 1921. L'Ordoviciano nell Caracorum orientale. Rendiconti della Reale Accademia dei Lincei, Series 5(30), 183-185.

Key words: Ordovician, fossils, Karakoram.

G/169. Gortani, M., 1928. Fossili Ordoviciani dell Caracorum. In: Realizioni Scientifiche della Spedizione Italiana de Filippi nel'Himalaia, Caracorum e Turchestan Cinese (1913-1914), Series 2(5), 3-97. Zanichelli Bologna.

Key words: Paleontology, Ordovician, Karakoram.

G/170. Gortani, M. & Merla, G., 1934. I fossili del Paleozoico. In: Relazioni Scientifiche della Spedizione Italiana de Filippi nel'Himalaia, Caracorum e Turchestan Cinese (1913-1914), Series 2(5), Zanichelli Bologna.

Key words: Paleontology, Paleozoic, fossils, Karakoram.

G/171. Goudie, A.S., 1981. Fearful landscape of the Karakoram. The Geographical Magazine 53, 306-312.

Key words: Paleontology, Paleozoic, Fossils, Karakoram.

G/172. Goudie, A.S., 1984. Salt efflorescences and salt weathering in the Hunza Valley, Karakoram Mountains, Pakistan. In: Miller, K.J. (Eds.), The International Karakoram Project 2, Cambridge University Press.

In the Karakoram Mountains, Pakistan, rainfall levels are low in the village, and under conditions of high evaporation salt effloresecences form, composed largely of magnesium sulphate (hexahydrite) and gypsum. Moraines and rock fall debris of the twentieth century have been severely weathered by salt attack.
Key words: Salt efflorescence, weathering, Hunza, Karakoram.

G/173. Goudie, A.S., Brunsden, D., Collins, D.N., Derbyshire, E., Ferguson, R.I., Hashmet, Z., Jones, D.K.C., Perrott, F.A., Said, M., Waters, R.S. & Whalley, W.B., 1984. The geomorphology of the Hunza valley, Karakoram Mountains, Pakistan. In: Miller, K.J. (Eds.), The International Karakoram Project 2, 359-410. Cambridge University Press.

The Hunza Valley in northern Pakistan shows greater relative relief than any other place on Earth. It cuts through the diverse structural and lithological elements of the Karakoram Mountains. At low altitudes it flows through an area of aridity and of desert vegetation. The slopes in the area are highly unstable, weathering by salt and frost is active, glaciers are active and large, discharge is highly seasonal, channels are subject to marked changes, and sediment and solute loads are high. The overall denudation rate is approximately 5000 t km-2 yr-1.
Key words: Geomorphology, glaciers, denudation, Hunza, Karakoram.

G/174. Goudie, A.S., Jones, D.K.C. & Brunsden, D., 1984. Recent fluctuations in some glaciers of the Western Karakoram Mountains, Hunza, Pakistan. In: Miller, K. J. (Ed.), The International Karakoram Project 2, 411-455. Cambridge University Press.

During the International Karakoram Project, 1980, the snout positions of the Minapin, Ghulmet, Hasanabad, Ghulkin, Pasu and Batura glaciers were surveyed, and their positions related to previous investigations over the last century. They have shown considerable fluctuations, including major advances at the turn of the century, and general retreat from the 1930s to the 1979s.
Key words: Glaciers, fluctuation, Hunza, Karakoram.

G/175. Gough, S.J., Searle, M.P., Waters, D.J. & Khan, M.A., 2001. Igneous crystallisation, high pressure metamorphism and subsequent tectonic exhumation of the Jijal and Kamila complexes, Kohistan. Journal of Asian Earth Sciences 19, p.23.

Key words: Metamorphism, tectonic exhumation, ultramafics, Jijal, Kamila, Kohistan.

G/176. Gourirane, A., 1993. Étude petrologique et géothermobarométrie des eclogites de la haute-vallée du Neelum (Himalaya, Pakistan). Faculte des Science, Laboratoire de Geologie et mineralogie, UCL, Louvan-La-Neuve (Belgium).

This account describes the Petrological study of eclogites and geothermobarometry in the high-valley of Neelum (Himalaya, Pakistan).
Key words: Geothermobarometry, eclogites, HP metamorphism, Neelum, Azad Kashmir.

G/177. Government of NWFP, 1975. Outline development plan for reconstruction and rehabilitation of earthquake affected area in Swat and Hazara districts. Planning and Development Department Govt. NWFP, Pakistan.

This document concerns the government plan for rehabilitation of the population of Swat and Hazara areas affected by the Pattan Earthquake. There is also a strategy outlined for reconstruction and development of the area.
Key words: Pattan earthquake, rehabilitation, reconstruction, Swat, Hazara

G/178. Government of NWFP, 1983. Mineral directory of North West Frontier Province. Directorate of Industries, Commerce and Mineral Development, Peshawar, Publication, 211p.

This exhaustive work gives information on the geological framework and available mineral resources, along with production data, of the Province. It also gives information on the concerned directorate, Mineral Coordination Committee/Board, licenses and leases. The document contains tables and a map showing location of the minerals.
Key words: Mineral resources, NWFP.

G/179. Grazoali, Lante Della Rovere, G., 1881. Brevi recordi di un viaggio nelle montagne dell Kashmir. Bollitin del Club Alkpino Italiano, 15, 227-250.

This is a travelogue of a journey to the mountains of Kashmir.

Key words: Geography, travelogue, Kashmir

G/180. Greco, A., 1986. Geological Investigation in the Reshian Area (Jhelum valley, State of Azad Jammu and Kashmir). Kashmir Journal of Geology 4, 51-66.

Petrographical and structural geology investigations have been carried out in the Panjal Volcanics, Triassic Limestone, and Salkhala Series exposed in the Reshian area. The study of the microstructures shows a complex relationship between deformation and metamorphism. The highest metamorphic grade-greenschist in the volcanics and amphibolitic in the Slakhala- has been reached before the main deformation phase. Retrograde mineral paragenesis is pre- to synkinematic. Only in the upper part of the investigated area the highest metamorphic conditions seem to persist during the deformation. Shear was the most important. Due to the thrusting of the Salkhala over the Panjal and over the Murree Formation a penetrative, continuous schistosity has been developed. Its trend is sub-parallel to the bedding and the thrust planes, and it is accompanied by an intense stretching lineation, showing the NE-SW direction of tectonic transport. In a later phase the crenulation cleavage, which cuts the previous structures, has been developed in the less competent rocks. All these events agree with the tectonic model elaborated by Bossari et al. (1984).
Key words: Petrography, structure, Panjal volcanics, Salkhalas, Kashmir.

G/181. Greco, A., 1988. Tectonic and metamorphism in the Himalayas of NE Pakistan (Kaghan Valley and Azad Kashmir). Abstracts, 4th Himalayan-Karakoram-Tibet Workshop, Lausanne, Switzerland, 24-15.

Key words: Tectonics, metamorphism, Kaghan valley, Azad Kashmir.

G/182. Greco, A., 1989. Tectonics and metamorphism in the western Himalayan syntaxis area (Azad Kashmir, NE Pakistan). Ph.D. Thesis. ETH Zurich, Switzerland, 194p.

Key words: Tectonics, Metamorphism, Kaghan valley.

G/183. Greco, A., 1991. Stratigraphy, metamorphism and tectonics of the Hazara-Kashmir syntaxis area. Kashmir Journal of Geology, 8 & 9, 39-65.

Key words: Stratigraphy, metamorphism, tectonics, Hazara Kashmir.

G/184. Greco, A., Martinotti, G., Papritz, K., Ramsay, J.G. & Rey, R., 1989. The Himalayan crystalline nappes of the Kaghan valley (NE Pakistan). Eclogae Geologicae Helvetiae 82, 629-653.

Key words: Structure, Kaghan valley, Himalaya.

G/185. Greco, A. & Spencer, D.A., 1993. A section through the Indian Plate, Kaghan valley, Northwestern Himalaya, Pakistan. In: Treloar, P.J. & Searle, M.P. (eds.), Himalayan Tectonics. Geological Society of London, Special Publication 74, 221-236.

A map is presented which summarizes the work of the ETH Himalayan Group in the Kaghan Valley and adjacent areas of the NW Himalaya in Pakistan. The stratigraphical, structural and metamorphic features of the lithologies belonging to a virtually complete section through the Indian plate are described. Evidence is presented which shows a stratigraphic range in ages from the Precambrian Salkhala Formation to the Eocene Murree Formation which have been metamorphosed at various metamorphic grades ranging from very low grades/unmetamorphosed to eclogite facies. An inverse metamorphism, associated with the Main Central Thrust is also described. A large-scale tectonic

subdivision of the area into the classical Sub-, Lesser and Higher Himalayan elements can be correlated with the Kashmir Himalaya to the east. A tectonic model is presented which suggests that an anticlockwise rotation of the transport direction caused the refolding and stacking of the nappe piles in the Paleogene.
Key words: Structure, tectonics, plate tectonics, Kaghan valley, Himalaya.

G/186. Gregory, C.E., 1932. The Shyok Ice-barrier in 1931. The Himalayan Journal 4, 64-74.

My original intention was to spend some time shooting in the Hanle district of Ladakh and then go on to Phobrang and cross into Chinese Turkistan by way of the Aksai Chin. With this object I left Srinagar on the 12th April, and when passing through Leh arranged with Bishop Peter of the Moravian Mission to send my porters and supplies for the Changchenmo-Aksai-Chin crossing, to Phobrang. On arrival at the latter place I received word that my passport for Central Asia had not arrived, and it looked possible that I might not get one at all. I therefore went off to shoot round Dakpo Karpo and the Changchenmo; on my return again to Phobrang I learnt by wire that the passport had been despatched from Nanking on the 29th May and I judged that it should reach Leh by the 5th July at the latest. I now decided to return to Leh and travel by the shorter and quicker route by the Karakoram pass. I left Leh on the 23rd June, having given instructions for the passport to be forwarded to me by special runner, and spent some time mapping the Chong Kumdan glacier and the Shyok lake. Having completed this work I pushed on to Daulat-Beg-oldi, close to the Karakoram pass, but after waiting some time for the passport, my supplies began to run short, and, though I tried to persuade my caravanbashi to go on to Suget for more, he refused to do so and I was forced to return. This short paper therefore is merely a brief summary of my observations of the Chong Kumdan glacier-dam.
It was on the 28th June that I left Takshai, the last village in the Nubra valley. Up till that date no one had crossed the Saser pass that year and the inhabitants of Nubra stated that it was still deep in snow and unfit for pony-transport. I had three permanent porters with me and collected six more at Takshai (pay Re. l/-a day). In the Thulan-buti defile I met the first of the Yarkandi caravans. Their news was not very hopeful; they had stayed at Saser Brangsa, north of the pass, till their food was almost exhausted, and had then tried to force it, with the result that they had had to abandon their baggage on the pass after losing two ponies and three asses. I therefore left my own animals at Skyangpo-che and moved up towards the pass with my coolies only, halting that evening at the first of the lakes. I intended to start at 5 a.m. the next morning, cross the pass and reach Saser Brangsa that day, but at midnight, when I looked out, the snow was frozen hard and the moon full, so that I felt it was an ideal opportunity to cross. I went over to the porters, but they were not for it, saying that it was too cold and that in their local boots they would get frostbitten, but that they would start at five. At five the next morning it was snowing hard and we were forced to remain there all day. It was again snowing at 5 a.m. on the 3rd July, but an hour later the sky looked better, the snow had stopped and the porters agreed to make a move. Fortunately for us the sun hardly came out all day and the eight miles to Saser Brangsa were covered in eight hours. On the 4th July I moved the camp up the Shyok valley to the Kichik Kumdan glacier, from the terminal moraine of which I could see the snout of the Chong Kumdan glacier lying across the valley like a bar of silver. There was very little water in the Shyok, and at the Saser Brangsa ford it was only about a foot deep. On the 5th I went up to the Chong Kumdan. The point from which the best view can be obtained is about a thousand feet above the main valley bottom on the right bank of the Shyok. From here the Shyok lake can be seen stretching away to the north, beyond the three miles of glittering ice-pinnacles of the Chong Kumdan glacier almost immediately below. The panorama published with this paper gives some idea of the magnificence of the spectacle. The lake at that time was ten miles long and varied from a mile to a mile and a half wide. Later when I went round and camped at the north end of it, I found that its level was rising at a rate of from six to seven inches a day. Above the surface-level on the hillsides at the edge of the lake were to be seen previous marks caused by water-erosion. In July the lake was from thirty-five to forty feet below the highest erosion-mark from which fact I concluded that by the beginning of the winter of 1931 the surface would be at its high-water level. As regards percolation through the ice-barrier, three hundred yards downstream of the snout of the glacier the Shyok river-bed was dry. On the 5th July there was very little water coming off the Chong Kumdan, and though on the 6th there was more, there was still less here than was issuing from the Kichik Kumdan glacier.
The Chong Kumdan glacier descends from a broad trough in the mountains. Standing at the snout it is up the Chong Kumdan valley and not up the main Shyok valley that one looks. The Chong Kumdan glacier and lake, in fact, form the upper branches of a ” Y “, the tail of which is the Shyok valley below the snout. Unless this is realized, the map, which shows a ” T ” lying on its side, is misleading. At the time of my visit the width of glacier against which the waters of the lake were resting was about 1500 yards, the same as that of the valley bottom immediately below the snout. The ice of Chong Kumdan, or left branch of the ” Y “, extended for a distance of 1100 yards below the point where the eastern edge of the lake met the ice.

The height of the ice at the snout was about ninety feet; where it was holding up the lake it might be as much as two hundred. Here it was a mass of pinnacles and it was difficult to judge the height. These pinnacles extend for a distance of three miles up the glacier and are due, I think, to the effect of the warm dry wind blowing up the main valley. They and their attendant ice-walls make climbing on the glacier difficult and crampons, ice-axe and rope are essential. I did not come across any bad crevasses, but the surface was badly cracked, and there would have been danger of an accident with laden or inexperienced men. The height of the pinnacles was from sixty to eighty feet. Once the sun reached the glacier surface, stones and ice started to fall; for this reason it was unsafe to be on the glacier after eight o'clock. A curious feature of the Chong Kumdan glacier was the complete absence of dead lateral moraine. The valley out of which the glacier emerges has steep cliffs on either side or the glacier ice reached right up to these cliffs. The terminal moraine consisted of a small pile of stones, out of all proportion to the size of the glacier. The channel cut in the ice by the escaping waters in 1929 could be clearly seen and acted as a central drain for the surface ablation of the glacier. Should the lake overtop the glacier, its waters would use this channel and probably open it up so rapidly that a flood would follow. If the barrier actually breaks, it seems to me probable that it will do so in August 1932, this being the month that it has usually burst before. With the water up to the high-water level and the old scar in the glacier, with the almost complete absence of percolation, I consider that the lake is almost certain to overtop the barrier or burst it in 1932. Should anyone think of going up to the ice-barrier in 1932, I would suggest that, after halting at Saser Brangsa, they move up the right bank of the Shyok to just short of Kichik Kumdan, using porters only from Saser Brangsa onwards. The next camp should be pitched near the snout and the party should start the next morning very early, pass the two side glaciers on the right bank of the Chong Kumdan, and cross the main glacier just above where it is joined by the lake. Should there be a break, in all probability this route will be above it and will remain. On the north side of the glacier a camp could be pitched on the spur on the west edge of the lake, just above the point where the lake meets the ice. This would save the long detour by the Depsang plains. Also, the two metal boats left by Gunn in 1929 at the mouth of the Chip-chap have now been removed. I ought perhaps to warn people against attempting to climb the cliffs on the left bank of the Shyok just below the glacier. Though it is possible to do so and to reach the lake by this route, the chimneys that have to be traversed form dangerous stone-shoots. I would also recommend that any party moving on the glacier itself should be clear of it by 8 a.m., when the sun may get on to it and render it dangerous from falling ice and stones.

Note by the Editor. Thanks to the courtesy of Captain Gregory and Messrs. Ludlow and Gunn, we have now some forty photographs of this glacier, taken from various points during the last four years. Much as I should like to do so, it is not possible to publish all these, though a careful examination makes clear some very interesting conclusions. In addition to the photographs and accounts of these observers, we also have a report by Mr. P. C. Yisser of his observations in July 1930. The photographs taken in 1928 and 1929 from below the snout are very similar. The larger series of 1929 show some definite features that led me then, in spite of Gunn's report, to doubt whether the glacier had begun to retreat, and I then foretold that the channel cut by the lake would heal during the winter of 1929-30, and that another lake would be impounded. These features are very marked when the 1929 photographs are compared with Captain Gregory's beautiful series taken in 1931.

In 1929 the upstream photographs show a vertical, and in places an overhanging, dam face holding the lake. The ice at the edges of the lake showed cracks and the ice-pinnacles emerged almost directly from the water's edge. The ice itself showed intensely white in the photographs, and even from a distance little englacial or medial moraine could be observed. These features may be seen to some extent in the two photographs in the Himalayan Journal, vol. ii, opposite pages 38 and 46. A complete series of fourteen photographs by Ludlow emphasizes them.

In 1931 there was a marked change. The lateral pinnacles were much reduced in size and became more degenerate; masses of medial moraine were being carried to the edge of the ice and were falling into the lake. In 1929 the lake edge of the dam had a marked convex bulge into the lake, probably owing to pressure against the rock wall opposite. The 1931 dam showed a straight, almost a concave, edge to the lake. Downstream of the glacier, the 1928 photographs show a protuberant tongue, possibly due to snout-spread, in the centre of the Shyok valley. There is little difference in 1929, both before and after the burst. The edges in both 1928 and 1929 were vertical (slightly more so in 1928 than after the burst in 1929, probably due to seasonal ablation in August). In 1931, as shown in the illustrations in this volume, not only the snout-tongue, but the whole snout-face was breaking up into detached ice-pinnacles very much interspersed with englacial and surface moraine. In pinnacled glaciers such as this, moraine-banks are only left as isolated terminal moraines when the ice-pinnacles are dead. 'Retreat' is most irregular, and, as could be seen in the neighbourhood of the Kichik Kumdan glacier in 1928, much dead ice is left below the living snout. If further proof were required that 'retreat' and degeneration has now set in, it is to be found in the pictures of 1929 and 1931 which give a longitudinal profile of the glacier surface. Ludlow's and Gunn's photographs of 1928 and 1929 show that of the portion of the glacier lying across the Shyok valley, the highest point lay then towards the left bank of the Shyok, which indicates that the ice had been forced up by pressure against the wall. The panorama looking up the Shyok across the glacier, published in the present volume, shows that the highest point in 1931 was where the glacier enters the Shyok valley. From here the height tailed off towards the left bank, indicating a relief from pressure. This panorama also shows very distinct signs of pinnacle degeneration, particularly towards both edges and the opposing wall.

In 1929 the waters of the lake cut a channel approximately five hundred feet wide. The channel apparently commenced from near the right or western shore of the lake, took a course towards the centre of the glacier and emerged near the left or eastern side of the Shyok valley. In July 1930 the Vissers reported that the channel had completely healed and that there was no sign of it, though traces of the burst were still to be seen below the snout. In the same month, in 1931, though there was still no percolation through the glacier and no water issuing from beneath the ice, the channel had again opened out and acted as a central drain for surface water from the glacier. These facts again point conclusively to a release from pressure.

Estimates of the height of the ice at the snout and of the depth of the water at the dam are difficult to compare. In the snout observations we do not know whether the observations were made at the same spot. Ludlow's estimate in 1928, from some distance away was," at its snout it could hardly have been less than 200 feet high ". Gunn gives the height in August 1929 as" about 500 feet". Visser does not mention it, but in July 1931, Gregory gives it at about 90 feet. A few days before the burst in 1929 Gunn gives the depth of the lake at the dam as about four hundred feet; in July 1930, when the reformed lake had reached a length of three miles, Visser calculated the depth at the dam to be 133 feet; in July 1931, Gregory thought that it might be as much as 200 feet. Too much reliance must not be placed on these figures; it is notoriously difficult to make such estimates. But even assuming that Ludlow was liberal, that Gunn was radical, and that Gregory was conservative, these figures do bear out the conclusions given above from examination of the ice-formation in the photographs.

The two points of human interest are: Will the dam burst catastrophically? And if so, when? The second question may be answered first. There can only be a catastrophe if the dam bursts when the river is at or near normal high summer-level. This is between mid- July and October, inclusive. Damage from scour and isolated accidents from drowning may occur at other periods, but villages and grazing should be above the flood level. The point is: Will the dam hold till then? In my opinion, though there was no percolation in July last year, degeneration had set in to such an extent that in all probability there was a good deal of leakage before the winter. By October I believe the glacier may have been too degenerate for any substantial recuperation during the winter, and that spring and summer ablation in 1932 with normal periodic decline will relieve the lake of much of its water. It is an opinion that I hesitate to put forward, for observations of the little glaciers of other parts of the world are of no value for comparison. Of one thing I feel certain. I still maintain that after 1932, there will be no further danger of a block for over thirty years.

The above Note was sent to Captain Gregory, who comments as follows:

Now that I have had time to examine carefully the state of the glacier snout as shown in Gunn's photographs, I too think that degeneration has set in ; but at the same time, though I do not know very much about the subject, I shall be very astonished if so great a volume of water can be carried away by percolation. It may be of interest to mention the following facts which may affect the percolation question. In 1931 on the 7th and 8th July there was no percolation at the snout when I was there. On the 12th July I crossed the Shyok at Saser Brangsa; the water was then knee-high as against about eight inches on the 4th July, say ten inches higher. On the 17th and 18th July I was at Yapchan when the lake was rising at the rate of six or seven inches a day. On the 22nd I again crossed the Shyok at Saser Brangsa; the water was now -up to the men's hips, say 2 feet 10 inches at midday. The crossings on the 12th and 22nd were made at the same time of day, and the difference of level may have been merely seasonal. When I crossed the Shyok at Khalsar, about 135 miles downstream of the barrier, there was a good deal of water and a Yarkandi had been drowned the day before, but the men at the ferry did not say anything about the water being particularly high. I wonder whether percolation set in just after I left the Chip-chap.

In my opinion the normal seasonal advance and regeneration in the coming winter will almost certainly close the narrow transverse channel that has been cut, and by next spring this should have completely healed. 1 believe that another lake will almost certainly form next spring, but since the seasonal retreat next summer will now be assisted by periodic retreat, the dam will definitely degenerate in height and strength. It may be that the lake so formed will drain away by percolation, or it may gradually wear away a channel, taking several days to drain (as happened in the last of a similar series with the Khurdopin glacier). If the healing is so complete as to prevent either of these two courses, I believe the dam will break again in August 1931, the month of maximum inflow to the lake, and the month of maximum degeneration of the ice. Under no circumstances can the dam impound a lake in the next few year* of the same magnitude as that liberated in 1929. In my opinion there ii no danger of a serious flood for many years to come, while the present danger of a complete block and a minor flood will be over at latest in 1932, alter which there will be nothing to worry about till 1969. There will then be Ml eight-year scare-period".—Himalayan

Journal, vol. ii, p. 46. With the exception that I did not foresee a healing so complete that the dam would hold throughout 1931, this forecast has been accurate and I see no reason to modify the prediction for the future. The terminal moraines left by the Chong Kumdan when the pinnacles have melted cover a very wide area, as may be seen in the photographs opposite pp. 200, 202, Chap, xx, vol. ii, of Professor Giotto Dainelli's Pxri e Qenti del Caracorum (Firenze : 1924). These photographs were taken in 1914, about thirty years after the previous year of maximum advance. It appears to have been impossible then to determine how much of this moraine was on ice. It is well worth while comparing Dainelli's photographs of this glacier in its degeneracy with those of the last few years taken since its rejuvenation.
Key words: Glacier surge, Shyoke dam, Himalaya.

G/187. Gregory, J.W., 1930. The fossil fauna of the Samana Range and some neighbouring areas; Part 7, The Lower Eocene corals. Geological Survey of India, Memoir Palaeontologica Indica, New Series 15(7), 81-128.

Key words: Paleontology, corals, Eocene, Samana Range, Hangu.

G/188. Griesbach, C.L, 1880. Geological notes. Geological Survey of India, Records, 13(2), 83-93.

This might be one of the earliest accounts on the geology of Indian subcontinent, including the present day Pakistan.
Key words: Geology, India.

G/189. Griesbach, C.L., 1880. Paleontological notes on the lower Trias of the Himalayas. Geological Survey of India, Records 13(2), 1-94.

This paper, although treating of rocks beyond the area under consideration, yet has some observations regarding the age of rock-groups within that area.
Key words: Palaeontology, Lower Trias, Himalaya.

G/190. Griesbach, C.L. 1886. Field-Notes from Afghanistan (no. 3) Turkistan. Records of the Geological Survey of India, 19(4), 235-267.

Key words: Field geology, Afghanistan, Turkistan, India.

G/191. Griesbach, C.L., 1887. Field notes from Afghanistan; (no.4) from Turkistan to India. Geological Survey of India, Records, 20 (1), 17-26.

Key words: Field geology, Afghanistan, Turkistan, India.

G/192. Griesbach, C.L., 1892. The Geology of the Safed Koh. Geological Survey of India, Records 25, 59-109.

Key words: Geology, Safed Koh, India.

G/193. Grinlinton, J.L., 1928. The former glaciation of the east Liddar Valley, Kashmir. Geological Survey of India, Memoir 49(2), 289-388.

Key words: Glaciation, Kashmir.

G/194. Griffiths, J.B., 1987. Pakistan's Mineral Potential: Prince or Pauper. Industrial Minerals, July, 1987, No.238.

The paper describes the economic geology of Pakistan. It gives detail information about the production of different mineral from Baluchistan, Punjab Province, Sind, and North-West Frontier Province and their economic importance for Pakistan.
Key words: Industrial minerals.

G/195. Grote, A., 1958. Notes on the fossils from Kohat. Journal, Asiatic Society of Bengal 27, 77-78.

Key words: Paleontology, Fossils, Kohat.

G/196. Gruber, G., 1970. The Buni Zom Group in Chitral. The Himalayan Journal 30, 305-311.

Key words: Geology, stratigraphy, Chitral.

G/197. Gruber, G., 1977. Glaciers and snow-line in Chitral. Franfurter Wirtschafts und sozialageographische schriften 26.

Key words: Glaciers, Snow line, Chitral.

G/198. Grujic, D. & Wosnitza, E., 1999. Thermomechanical analogue modelling of Himalayan collision processes. Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 63-64.

To simulate crustal rheological stratification in physical models, it is necessary to take into account the variations in mechanical properties induced by temperature. So far this has been done by using different materials, such as sand and silicone putty, for brittle and ductile behaviour respectively (e.g. Davy and Cobbold, 1991). Major advances have been made in understanding the Himalayan collision processes in this way (e.g. Chemenda et al., 1995). However, the major drawback with such models is that the material points within the model crust retain their physical properties throughout the experiment regardless of their changing position within the crust. The second approach to model the crustal layering is to use a single material with temperature-sensitive viscosity. This design has the advantage to reproduce the mechanical consequences cf thermal readjustment during the model run. In our opinion this is the most important direction in improvement of modelling technique for plate tectonic processes. For example, it has been shown that the changing rheology of subducted sediments is an important phenomenon governing the material balance in the subduction zones (e.g. Mancktelow, 1995). This concept has been also applied to the exhumation of the Greater Himalayan Sequence (GHS) in the Bhutan Himalaya by ductile extrusion (Grujic et al., 1996).
Channel flow model
The process of extrusive flow can be approximated quantitatively by channel flow models that have been used to describe subduction zone processes. Such model characterises a thrust system as a viscous material-filled channel lying between two rigid sheets that deform the viscous material between them through induced shear and pressure gradients within the channel. The exact result depends on the geometry of the channel, but the simplest qualitative characteristic of these models is that the velocity field is a hybrid between two end-members (e.g. Turcotte and Schubert, 1982): (1) induced shear applied at the boundaries which produces a uniform vorticity across the channel; and (2) induced pressure gradients which produce a “pipe-flow” effect with highest velocities in the centre of the channel and opposite vorticity at the top and bottom of the channel. In these channel flow models the transition from uniform simple shear to “extrusive flow” is highly sensitive to viscosity and to lateral pressure gradients.
In a parallel-sided channel, the driving force for reverse flow at the top of the channel—the buoyancy ci subducted material—is compensated by lithostatic pressure. In situations where the channel walls are non-parallel the (nonlithostatic) pressure gradient might cause high rates of buoyant return flow of the channel fill provided that the

viscosity is low enough (Mancktelow, 1995). In a thrust system such as the Himalayan Main Central Thrust (MCT), a lateral pressure gradient would develop due to building of topography during collisional tectonics. Similarly, major changes in viscosity also accompanied motion on the MeT. Swapp and Hollister (1991) and Davidson et al. (1997) presented evidence ci early heating of the GHS followed by rapid high-T decompression. This early heating history may have been aided by heat advection due to the leucogranite intrusions into the GHS (e.g. Hollister et al., 1999). The related temperature increase would result in a drop in viscosity within the “channel” at the same time as the creation of orogenic topography produced a lateral pressure gradient within the channel.
In the GHS the main history of the system apparently records a hybrid process with a major influence of the pipe-flow effect. In particular, the reverse shear sense at the top of the channel is exactly the flow-pattern inferred across the top of the GHS along the South Tibetan Detachment system whereas south-direct ductile thrusting dominates at the base of the GHS belt.
Thermomechanical analogue models
In order to investigate the extrusion processes, in particular the role of rheology in distribution and propagation of deformation, we have constructed a deformation rig specially designed for thermomechanical modelling. We use analogue materials with temperature-sensitive viscosity to properly simulate the change ci mechanical properties with depth. By inducing a vertical thermal gradient in the model, by precisely heating the bottom and cooling the top, one can produce a viscosity gradient. As the material points in the model change their depth by deformation they consequently change their material properties. The thermal perturbation is monitored by a series of resistance temperature detectors and by infrared camera. Correlating the thermal with physical field in the model one can deduce its rheological structure. As the differential stress. strain and temperature can be accurately measured during the experiment the onset of the instability can be easily defined, It also means that the rheology of the materials and the bulk rheology of the model can be characterised under exactly the same conditions as hold in the experiments themselves. Using all the informations together the dynamics of the structures formed can be investigated.
Key words: Collision, thermomechanical, Himalaya.

G/199. Gubelin, E.J., 1968. Gemmlogische beobachtungen an neuen smaragden ous Pakistan. Der Aufschluss Sonderheft 28, 110-116.

Key words: Gems, Emerald, Pakistan.

G/200. Gubelin, E.J., 1981. Geological observations on new Emeralds from Pakistan. Gemology, 7.

Only during the last few years have the gem riches of Pakistan become known to the rest of the world. This article reports on three gem materials currently being mined: emerald, corundum (most importantly, ruby], and spinel. Intensely colored emerald crystals occur in dolomitic talc schists in the Swat Valley. Unusually high optical properties and density serve to distinguish these emeralds from those found elsewhere. Numerous gas-liquid inclusions are also typical. In the Hunza Valley, specimen and gem-quality crystals of corundum and spinel occur in beds of marble enclosed in gneisses and mica schists. The gemological properties of the Pakistan rubies and sapphires vary only slightly within normal limits.
Key words: Gemstones, ruby, emerald.

G/201. Gubelin, E.J., 1982. Die edelsteinvorkommen Pakistan-I. Teil: Die rubine aus dem Hunza tal. Lapis 7(5), 19-31.

Consult the following account for further info.
Key words: Gems, ruby, Hunza.

G/202. Gubelin, E.J., 1982. Die edelsteinvorkommen Pakistan. II. Teil: Die smaragdvorkommen im Swat-tal. Lapis 7(6), 19-26, 1 fig. 18 photos, 1 map.

Emerald is found with quartz and dolomite in the Swat Valley of Pakistan, near Mingora in the area of Hindu-Kush. Stones of a fine colour have a Ë 1.588 and ω 1.596 with a birefringence of 0.007. Strong bands occur in the

absorption spectrummat 683 and 680 nm with weaker bands at 662, 646, 637, 477.4 and 472.5 nm. The stones appear an orange red through the Chelsea colour filter. Specific gravity is 2.77. Inclusions of calcite and dolomite crystals have been noted, with various patterns of liquid droplets. A table of constants of emerald from various localities is given.
Key words: Gems, emerald, Swat

G/203. Gubelin, E.J., 1982. Gemstones of Pakistan: Emerald, ruby and spinel. Gems and Gemology 18, 123-139.

Three gem materials are currently mines – emerald from dolomitic talc schists in the Swat Valley, and corundum (especially ruby) and spinel from marble enclosed in gneisses and schists in the Hunza Valley. The geology, mining, recovery and properties of each gem are given. Optical data and chemical analyses (by M. Weibel) are also given in a table.
Key words: Gems, emerald, ruby, spinels, Swat.

G/204. Gubelin, E.J., 1984. Rosa topas aus Pakistan. Lapis 1(9), 23-28.

Consult Gubelin et al., 1986 for further information.
Key words: Topaz, gems, Pakistan.

G/205. Gubelin, E.J., 1990. Gemological characteristics of Pakistani emeralds. In: Kazmi, A.H. & Snee, L.W. (ed.), Emeralds of Pakistan: Geology, Gemology and Genesis, 75-91. Van Nostrand Reinhold, New York.

The gemmologically ascertainable diagnostic properties of emeralds from Khaltaro, Gujar killi, Makhad, Charbagh and Swat mines 1, 2 (5-8 specimens from each) together with 70 specimens from the Mingora area are given. All of the emeralds have mean constants of E 1.583 and W 1.590, rather high for gem-quality emerald but in agreement with emeralds containing appreciable Fe: D ranges 2.66 – 2.78 with a median of 2.71 g/cm^2. There is a bro absorption band in the blue from 420 for E to 430 for nm for W, with an absorption maximum at 427 nm. This absorption band is consistently present in the Pakistani emeralds tested and is an additional means of identification. Primary fluid inclusions are of two types; narrow rectilinear filaments in parallel alignment along and pronged three-phase inclusions reminiscent of those in Columbian emeralds. The second fluid inclusions are also of two kinds, finger print inclusions and flat film- like, two-phase inclusions. Mineral inclusions found are actinolite, chromite, dolomite, enstatite, feldspar, gerdorffite, magnesite, mica and pyrrhoitites: 321 colour photographs of the inclusions are presented.
Key Words: Gemology, emerald, Gujar Killi, Swat.

G/206. Gubelin, E.J., Graziani, G. & Kazmi, A.H., 1986. Pink topaz of Pakistan. Gems and Gemology, vol. 18, pp. 123–139.

The occurrence of pink topaz in Pakistan was discovered less than 20 years ago. This attractive material has been reported on several occasions in the gemological literature [Afridi et al., 1973; Bank, 1976a and b; Petrov et al.; 1977a, b, and c; Jan, 1979), but details of the deposit itself have only recently become available. In this article, the authors report on their investigation of the geology and mineralogy of the pink topaz deposit near Katlang, and on the chemistry and the gemmologically ascertainable properties of this material. As part of this study, the authors also investigated the other color varieties of topaz found at the deposit and their reaction to treatment.
The topaz is found in one of two hills that rise abruptly from the fertile agricultural plain of the Mardan District in the neighborhood of a small village. This settlement of farmers and the topaz hillock both bear the same name-Ghundao-and are located about 4 Km (2.5 mi.) north of the small town of Katlang (figure 2). The geographic coordinates of the topaz-bearing hill of Ghundao are latitude 34Â¡24'N longitude 72Â¡06'E which places it about 63 km (40 mi.) northeast of Peshawar and about 20 km north of the district capital Mardan "as the crow flies" (approximately 50 km southeast of the Swat Valley emerald deposits; see Gubelin, 1982). The hill is easily reached by automobile. The other hill, which contains no topaz deposits, lies about 1 Km northwest of the Ghundao hill.

The summit of Ghundao, the topaz hill, is approximately 80 m higher than the village, and the two hills are conspicuous features of an otherwise unbroken plain
Key Words: Gemology, topaz, Mardan.

G/207. Guerra, I., Luongo, G., Maistrello, M. & Scarascia, S., 1983. Deep seismic sounding along the profile Lawrencpur-Sango Sar (Nanga Parbat). Bollettino di Geofisica Teorica ed Applicata (Pamir-Himalaya Volume) 25, 211-219.

Key words: Seismic profile, Lawrencepur, Nanga Parbat.

G/208. Guex, P.J., 1978. Le Trias en fer vient des Salt Ranges (Pakistan); Problems biochronologiques. Ecologae Geologae Helvetiae 71, 105-141.

Key Words: Triassic, Salt range.

G/209. Guillot, S., Cosca, M., Allemando, P. & Le Fort, P., 1999. Contrasting metamorphic and geochronologic evolution along the Himalayan belt. In: Macfarlane, A., Sorkhabi, R. & Quade, J., (Eds.), Himalaya and Tibet: Mountain roots to mountain tops. Geological Society of America Special Papers 328, 117-128.

Systematic different pressure-temperature-time paths are recorded along the internal zone of the Himalayan orogen. High-pressure rocks rapidly exhumed during the Eocene and Oligocene are restricted to the western part of the Himalayan belt. Farther to the east, both in the North Himalayan Crystalline massif sand in the High Himalayan Crystalline slab, there are upper amphibolite facies rocks, which were unroofed during the Miocene. In the High Himalayan Crystalline slab, a systematic decrease in mica 40Ar/49Ar cooling ages can be correlated with the degree of low-pressure anatexis to the east. The observed contrasts in both the metamorphic and geochronologic evolution along the Himalayan belt can be related to the counterclockwise rotation of the Indian plate during the India-Asia collision. Such rotation, together with a shallower dip of the intracontinental subduction plane to the east, would explain the delay in nappe stacking, a warmer thickened upper crust, and the observed decrease in ages from west to east.
Key Words: P-T-t paths, metamorphism, geochronology, Himalaya.

G/210. Guiraud, M., 1982. Geothermobarometrie du facies schiste vert a glaucophane. Modellisation et applications (Afghanistan, Pakistan, Corse, Boheme). Ph.D. Thesis, University of Montepellier, France, 86p + annexures.

Key Words: Geothermobarometry, glaucophane, Shangla, Khost, Afghanistan, Pakistan.

G/211. Gul, A., 1983-85. Geology and petrology of Burawai Area, upper Kaghan valley, District Mansehra, Pakistan. M.Sc. Thesis, Punjab University, Lahore, 125p.

The project area lies in the upper Kaghan valley on both sides of the river Kunhar and along its adjoining tributaries. The Kaghan valley administratively is a part of the district Mansehra, province of Sarhad, Pakistan. Within the Kaghan valley the area starts at Battakundi in the south and goes upto Babun near Jalkhad in the north and covers about 114 square kilometers (nearly 70 square miles) and is covered by the Survey of Pakistan, toposheet No. 43 F/13, at the scale 1:50,000. The area lies between;
Latitude; 34°-53'-38" to 35-00'-00"
Longitudes73°-45'-00" to 73°-58'-30"
Battakundi, Dabukan, Dunga, Bans Bandi, Rakhan, Burawai, Wetar and Seri are the main villages on the roadside, in the project area. This report represents partial fulfilment of the requirements for the M.Sc. Applied Geology Examination at the Institute of Geology, University of the Punjab. The field work for this field

Key Words: Petrology, petrography, Kaghan valley, Mansehra.

G/212. Gul, A., Rehman, S.S. & Hamidullah, S., 2001. Hydrological studies of Panjkora River system and its tributaries Dir District, NWFP, Pakistan. Abstracts, 4th Pakistan Geological Congress, Islamabad, 64-65.

The North West Frontier Province (NWFP) is primarily drained by the Indus River along with a tributary network of perennial streams including the Kabul, Swat, Chitral, Kunhar, Bara, Kurram, Gambila, Gomal and Haro. Among these, River Panjkora, a snow fed tributary of Swat River which originates from the mountains of Dir Kohistan near Thal and drains Dir District and part of the Malakand Agency. The confluence of Panjkora and Swat rivers lies northwest of Kolangai village near the border of Malakand and Bajaur agencies. The catchments area of this river is mostly forested. This river is important for its high head and great discharge even in winters. Sarhad Hydel Development Organization (SHYDO) has selected a number of sites on this river and its tributaries for high head power production. This study is planned to carry out hydrological investigations of the water samples of Panjkora River for better management. Water samples were collected from eleven sits, Rashai dub/Thal down to Bussaq/Sharbati village and were analyzed for pH, alkalinity, hardness, TDS and suspended sediments concentration. Chemical analysis are under process and there data together with other parameters will be compared with generally accepted water quality standards for the maintenance of human and aquatic life and also for agricultural growth of the region. Various recommendations are suggest for better use of this natural gift, on the basis of data obtained during the current investigations.
Key Words: Hydrology, Panjkora River, hydropower.

G/213. Gul, A., Shoaib, M., 1995. Geochemistry of oil field water of Sadkal Oil Field (OGDC), Fatehjhang, Attock District, Punjab, Pakistan. M.Sc. Thesis, University of Peshawar, 41p.

Key Words: Geochemistry, oilfields, Fatehjhang, Attock.

G/214. Gul, J. & Rehman, N., 1999. Structure and stratigraphy of a part of N. Waziristan, south of Mir Ali and Miran Shah Road, N.W.F.P., Pakistan. M.Sc. Thesis, University of Peshawar, 78p.

Key Words: Structure, stratigraphy, North Waziristan.

G/215. Gupta, H. & Delany, F. (eds.), 1981. Zagros-HinduKush-Himalaya, Geodynamic Evolution. Am. Geophys. Union, Geodyn. Ser. 3, 323p.

This is a compilation of many papers by Gupta and Delany dealing with the three mountain systems. Papers of interest to the present work are individually annotated.
Key Words: Geodynamics, tectonics, Himalaya, Hindukush, Zagross.

G/216. Guraya, M.A. & Khizr, K., 1981. Geology of Swani–Sheringal region, Kohistan, District Dir, North West Frontier Province with special emphasis on Mineralogy and Petrology. M.Sc. Thesis. Institute of Geology, Punjab University, Lahore.

Swani-Sheringal Area is part of Hindu Kush range and is included in Northwest Himalayas. The area is mainly composed of metamorphic rocks of sedimentary origin, with igneous intrusions. The main rock units in the area are calcareous quartzites, chlorite schists, biotite schists and amphibolites. Calcareous quartzites are believed to be the oldest rock unit of the area. Chlorite schists, biotite schistose and amphibolites have formed as a result of progressive regional metamorphism of calcareous quartzites. The contacts of calcareous quartzites with the schistose and the contacts between chlorite and biotite schistose are gradational. Amphibolites are developed as formless patches in the schistose. The area is tectonically highly disturbed being involved in Himalayan Orogeny. The report

presents a detailed geological and petrological investigation of about 40-km2 area. A detailed map of the investigated area on a scale of f1: 10,000 are presented, along with its cross-section along X-Y line. Succession of Rocks of the area has been worked out. Detailed petrography of all the major units of the area is described.
Key Words: Mineralogy, petrology, Dir, Kohistan.