Add/1 Alizai, A.H,K., 2000. Geochemistry of Water and Soil from Dera Ismail Khan NWFP, Pakistan. M.Phil. Thesis, University of Peshawar.

The aim and motive to start 'work on the waters and soils of D.l .Khan division was to establish a brief chemical and environmental report on the quality of water, because various types of diseases have been reported form the area. For this purpose water of the area was divided in to four categories i.e. deep water (tube-wells); shallow water (dug-well, settling ponds/nalas and hand-pumps), surface water (streams and rivers). A total of thirty-four water samples were selected for study of twenty-two parameters. In order to see any contribution made by soils and rocks to the water. Twenty-two soils samples adjacent to water samples and five rock samples were also analyzed for major and trace elements.

The results obtained for the water samples from different places of D.I. Khan division are compared with that US-EPA (1989) and WHO (1981) standards for safe drinking water. On the bases of these standards the water quality of many areas are found not suitable for drinking. For example water sample from Gomal Rivers suggest that it is not safe for drinking water, however, major portion of population of the D.I. Khan division use it for drinking. The chemical redicals exceeding the permissible limit of US-EPA (1989) and WHO (1981) are: Bicarbonate (225 mg/l), sulphate (400 mg/l). Iron (43.3 mg/l), Magnesium (47 mg/l). Maganese (0.21 mg/l). Na (102 mg/l) and copper (10 mg/l). In Poroa the follow constituent are out of permissible limit i.e. Sulphate (1600 mg/l); Bicarbonate (250 mg/l); Chloride (244 mg/l): Na (175 mg/l), Magnesium (73.7 mg/l). Apart from these two areas, the water quality of other areas, which is not safe for drinking purpose are Mullazai, Tank, Umer Ada. Potah. Chadhwan. Ramak. Kulachi and Gomal university. Sulphate is high in the middle and lower part of the D.I. Khan division. High sulphate concentration in water causes diarrhea and dehydration (Zunae. 1990). Nitrate is found high at shallow water (Dug well, hand pumps, settling ponds Nala). It is reported alarmingly high at Mullazai (17mg/l) and at Chudhwan spring (90 mg/l), as compared to the maximum limit (10 mg/L) of WHO (1984) for safe drinking water. High nitrate cause infection to gastrointestinal tract and large concentration ofnitrate in water may result in the potential formation of carcinogenic nitro samines (Zunae, 1990). Chloride concentration is maximum i.e. 618 mg/l at Ramak area of D.I. Khan division, which considerably exceeds the permissible limit (200 mg/L) of WHO (1984). It crosses the permissible limit at eight other places of D.I. Khan division. Except two samples, iron is out of limit in all the water samples. Magnesium is also high at six places.

Maganese is crossing the limit at sixteen places. Potassium is high at five places. In trace elements copper is considerably out of range in the water of Gomal River. Ph is high (0.3 mgL) in the water sample taken from Gomal University tube well where by the safe limit of lead in the drinking water is 0.05 mg/l. Fluoride is also high at six places. The generalized trend for many constituents increase from north to south. The results show the concentration of many elements are high towards south.

Collection of soil and rock samples was made from the same areas where water samples were collected. The objective of this detail geo-chemical results of the rock and soil samples were to See the influence of these rock and soil samples on the water samples of the same area. The results are discussed in the concerned chapter. For the treatment or removal of these constituents can be done by the method established by US-EPA. (1988). Filtration, ion exchange and lime softening can remove copper and iron. Nitrate can be removed by biological dentrification. sulphate by ion exchange and fluoride by reverse osmosis. All these methods are effective but practically non-economical.

Key words: Geochemistry, Water, soil, D.I. Khan, NWFP.

Add/2 Anczkiewicz, R., Burg, J.P., Villa, I.M., & Meier, M. 2000. Late Cretaceous blueschist metamorphism in the Indus Suture Zone, Shangla region, Pakistan Himalaya. Tectonophysics 324, 111–134

Rb–Sr and 39Ar–40Ar phengitic muscovite dating of the transitional blueschist–greenschist facies rocks from the Shangla region of Pakistan Himalaya resulted in a concordant ca. 80 Ma age interpreted as a time of metamorphic peak. 39Ar–40Ar age spectra of sodic amphiboles were unsuitable for precise age determination. Mass-balance calculations show that the K concentration in glaucophane/crossite is ca. 25 ppm, and the K–Ar budget is dominated by inclusions of phengitic muscovite.

E–W-oriented (parallel to Kohistan arc) stretching lineation defined by preferred orientation of amphiboles was accompanied by synkinematic growth of riebeckite rims on the edges of microboudins. Evolution of the pressure conditions based on the Al2O3 content in sodic amphibole shows that this deformational stage was accompanied by a decrease in pressure from ca. 700 to ca. 400 MPa. This, together with our dating results, strongly suggests µ10 km late Cretaceous exhumation of the Shangla blueschists. The exhumation may have been associated with the increase

of arc parallel displacement rate due to changes of arc obliquity. This led to thinning caused by arc parallel extension and to exhumation of the Shangla blueschists. A lack of strong Eocene metamorphic overprint implies that after the peak metamorphism, blueschists were accreted to the Kohistan arc, which helped to prevent burial and metamorphism during continental collision. The final emplacement of the Shangla blueschists most likely occurred during the India-Kohistan arc collision and was accompanied by the weak, locally developed greenschist facies overprint.
Keywords: $^{39}Ar/^{40}Ar$ dating, Rb–Sr dating, blueschists, collision tectonics, exhumation, Himalaya, Indus Suture.

Add/3 Anczkiewicz, R., Oberli, F., Burg, J.P., Villa, I.M., Gunther, D. & Meier, M. 2001. Timing of normal faulting along the Indus Suture in Pakistan Himalaya and a case of major 231Pa/235U initial disequilibrium in zircon. Earth and Planetary Science Letters, 191, 101 – 114.

We report age data by TIMS U^Pb, LA-ICP-MS and 39Ar^40Ar techniques for main magmatic events in the Lower Swat region of Pakistan, in order to constrain the tectonic evolution of the northwestern Himalaya. The pre-Himalayan history of the Indian continent is documented by single-zircon U^Pb results from the peraluminous Choga granite gneiss, which yielded a 468þ 5 Ma lower concordia intercept interpreted to approximate the time of magmatic emplacement. The presence of a well-defined 870þ 7 Ma inherited component (upper intercept) suggests a plutonic or volcanic protolith residing at unexposed levels of the Indian crust. Zircon data for the Swat granite gneiss from the northern part of the Loe Sar dome give an emplacement age of 267+6/33 Ma, which is at variance with earlier correlations favoring an early Paleozoic origin. Subsequent to metamorphic overprint by the Himalayan orogeny, the Swat granite was intruded by late kinematic alkali-granite dykes. Single zircons from one of these dykes show reproducible 206Pb/238U data giving a precise mean age of 29.26þ0.12 Ma, whereas the 207Pb/235U ages scatter between 34 and 81 Ma, pointing to huge and variable enrichment in 207Pb. The unsupported 207Pb can be explained by incorporation of 231Pa, an intermediate long-lived daughter nuclide in the 235U decay chain, in excess of the secular equilibrium ratio. LA-ICP-MS measurements confirm the presence of unsupported 207Pb, but do not show any correlation between the latter and other selected trace element concentrations in these zircons. A concordant Ar^Ar muscovite age of 28.4 þ1.1 Ma obtained for the same dyke postdates regional mica `cooling' ages and indicates a lack of younger regional events capable of resetting the K^Ar system in muscovite. Because the dyke is pre- to synkinematic relative to normal faulting and related north-vergent folds, its emplacement age provides a maximum age for this event or reflects already ongoing local extension. A lower limit of 15 Ma has previously been established by apatite fission track analysis. The 29^15 Ma age bracket for normal faulting is coeval with extension along the South Tibetan Detachment System (STDS) on the north side of the High Himalaya. This suggests that the Indus Suture in Pakistan has acted as a western continuation of the STDS and that related faulting was roughly contemporaneous over most of the Himalaya. Keywords: Himalayas; Indus-Yarlung Zangbo suture zone; extension; geochronology; uranium disequilibrium; U^Pb; Ar-39/Ar-40; Pakistan.
Key words: Structure, dating, Himalaya, Indus Suture.

Add/4 Butler, R.W.H., Casey, M., Loyd, G.E., Bond, C.E., McDade, P., Shipton, Z. & Jones, R., 2002. Vertical stretching and crustal thickening at Nanga Parbat, Pakistan Himalaya. a model for distributed continental deformation during mountain building. Tectonics, 21(4), 9-17.

The localization of strain in the continental crust during compressional tectonics is examined using the active structures at the Nanga Parbat massif, an exhumed tract of Indian continental crust in the Pakistan Himalaya. This large-scale (~40 km wavelength) structure is considered to involve the whole crust. Thrusting at the modern surface places gneisses of the Indian continental crust onto Holocene deposits. At the Raikhot transect, the thrust zone carries a relatively narrow (2 km wide) shear zone within which minor structures are asymmetric and the deformation apparently noncoaxial. However, modeling of foliation and augen preferred orientation/ellipticity suggests that the bulk deformation is a combination of relatively small simple shear strains ($\gamma = 1$) with larger stretching strains. Heterogeneous stretching within the shear zone was accommodated by localized shearing on metabasic layers so that strain is partitioned. Outside this shear zone on the transect there is penetrative deformation throughout the Nanga Parbat massif. This broadly distributed deformation shows no asymmetry or evidence of rotation. Rather this deformation is better described as near pure-shear subvertical stretching. Augen ellipticities suggest subvertical stretches of greater than 200%. Consideration of plausible changes in crustal thickness during the amplification of the Nanga Parbat structure suggests the magnitude of vertical stretch decays with depth. Presumably these strains in the deep crust are more distributed but weaker than in the exposed middle crustal sections, assuming conservation of horizontal shortening displacement with depth. These studies suggest that penetrative vertical stretching through dominantly pure shear deformation is an effective mechanism for thickening the continental crust and that models which assume that simple shear zones penetrate the whole crust need not be of ubiquitous applicability.

Key words: Crustal thickening, deformation, Nanga Parbat.

Add/5 Clift, P.D., Hannigan, R., Blusztajn, J. & Draut, A.E. 2002. Geochemical evolution of the Dras–Kohistan Arc during collision with Eurasia: Evidence from the Ladakh Himalaya, India. The Island Arc, 11, 255–273

The Dras Volcanic Formation of the Ladakh Himalaya, India, represents the eastern, upper crustal equivalent of the lower crustal gabbros and mantle peridotites of the Kohistan Arc exposed in Pakistan. Together these form a Cretaceous intraoceanic arc now located within the Indus Suture zone between India and Eurasia. During the Late Cretaceous, the Dras–Kohistan Arc, which was located above a north-dipping subduction zone, collided with the south-facing active margin of Eurasia, resulting in a switch from oceanic to continental arc volcanism. In the present study we analyzed samples from the pre-collisional Dras 1 Volcanic Formation and the postcollisional Kardung Volcanic Formation for a suite of trace elements and Nd isotopes. The Kardung Volcanic Formation shows more pronounced light rare earth element enrichment, higher Th/La and lower end values compared with the Dras Volcanic Formation. These differences are consistent with an increase in the reworking of the continental crust by sediment subduction through the arc after collision. As little as 20% of the Nd in the Dras 1 Volcanic Formation might be provided by sources such as the Karakoram, while approximately 45% of the Nd in the Kardung Volcanic Formation is from this source. However, even before collision, the Dras– Kohistan Arc shows geochemical evidence for more continental sediment contamination than is seen in modern western Pacific arcs, implying its relative proximity to the Eurasian landmass. Comparison of the lava chemistry in the Dras–Kohistan Arc with that in the forearc turbidites suggests that these sediments are partially postcollisional, Jurutze Formation and not all pre-collisional Nindam Formation. Thus, the Dras–Eurasia collision can be dated as Turonian–Santonian (83.5–93.5 Ma), older than it was previously considered to be, but consistent with radiometric ages from Kohistan.
Key words: collision, Himalaya, isotopes, Kohistan.

Add/6 Fraser, J.E., Searle, M.P., Parrish, R.R. & Noble, S.R., 2001. Chronology of deformation, metamorphism and magmatism in southern Karakoram Mountains. Geological Society of America Bulletin, 113, 1443-1455.

U-Pb dating of metamorphic and igneous rocks from the Hunza Valley and Baltoro regions of the Karakoram Mountains in northern Pakistan addresses the thermal and magmatic evolution of the thickened Asian plate crust before, during, and after the collision of the Kohistan arc and the Indian plate. Crustal thickening and high-temperature, sillimanite-grade metamorphism in the southern Karakoram Mountains followed the collision and accretion of the Kohistan arc during the Late Cretaceous. U-Pb ages of metamorphic monazites from sillimanite gneisses in the Hunza Valley are 63.3 ± 0.4 Ma, ca. 50–52 Ma, and 44.0 ± 2.0 Ma, and monazites from a kyanite-grade schist from the Baltoro region are 28.0 ± 0.5 Ma. Metamorphic monazites from a highly graphitic garnet + staurolite schist from the Hunza Valley yield a crystallization age of 16.0 ± 1.0 Ma. Sillimanite gneisses from the Dassu dome have magmatic zircons of 1855 ± 11 Ma, reflecting a Proterozoic continental crustal source, and metamorphic monazites of 5.4 ± 0.2 Ma. Magmatism was also sporadic; early granodiorite, monzogranite, and leucogranite dikes yield zircon, monazite, and uraninite ages of 50–52 Ma and 35.0 ± 1.0 Ma. Widespread lower crustal melting during the latest Oligocene–early Miocene culminated with emplacement of the Baltoro Plutonic Unit in the Karakoram batholith that cuts deformation fabrics in the high-grade gneisses to the south. The youngest magmatic phase dated is the 9.3 ± 0.2 Ma Sumayar leucogranite pluton. On the basis of detailed structural field studies combined with U-Pb geochronology, sillimanite-grade metamorphism was either a protracted event lasting as long as 20 m.y. (64–44 Ma) or peaked at different times within the lower crust following collision of first, the Kohistan arc, and later, the Indian plate. We also present evidence for southward propagation of peak metamorphism and postmetamorphic thrusting and folding of isograds within the past 5 m.y. Detailed geochronology shows that deformation, metamorphism, and magmatism in the middle and lower crust of the south Asian margin has been occurring within the Karakoram metamorphic complex for more than 60 m.y. Similar processes may also have affected the unplumbed depths of the south Tibetan crust.
Key words: Chronology, Metamorphism, Magmatism, Karakoram.

Add/7 Heuberger, S., Burg, J.P., Dawood,H. & Hussain, S. 2001. Mapping on the North-Kohistan Suture Upper Shishi Valley, Chitral, NW Pakistan. 16th HKT in Austria. J. Asian Earth Sciences, 19 (3A).

The North-Kohistan Suture separates the Kohistan Paleo-Island Arc Complex from the Karakoram Plate. We report results from field work carried out in 1999 and 2000 in Chitral (Northwest Pakistan), more precisely in the Shishi Valley and in the region around Drosh. Several sections across the suture in the uppermost Shishi Valley show that the so-called mélange is an imbricate zone in which slices with well-defined lithologies can be recognised.
The Karakoram Plate consists of gabbros and diorites (Karakoram or Transhimalaya Batholith), of shelf type sediments like fossiliferous limestones (Aptian-Cenomanian age), shales, volcano-lithic conglomerates and metavolcanics, and of serpentinites and talcschists derived mostly from harzburgites.
The Kohistan Paleo-Island Arc Complex consists of sheared gabbros and diorites (Kohistan Pluton), of volcanosedimentary greenstones, calc-alkaline andesites succeeding to andesite lavas, tuffs and agglomerates, and of red shales and sandstones (deep water turbidites). The imbricate lithologies of the so-called mélange mostly belong to the Karakoram Plate. The present-day imbrication is due to a series of brittle sinistral faults that have faulted away the original, thrust-dominated imbrication of the suture zone.
Key words: Mapping, structure, Kohistan arc, Chitral

Add/8 Hildebrand, P.R., Noble, S.R., Searle, M.P., Waters, D.J. & Parrish, R.R. 2001. Old origin for an active mountain range: Geology and geochronology of the eastern Hindu Kush, Pakistan. GSA Bulletin, 113(5), 625–639, 10 figures; 1 table.

Prior to accretion of the Kohistan island arc during the Late Cretaceous and final suturing of India with Asia at ca. 50 Ma, the Hindu Kush mountains along the border of Afghanistan and northwest Pakistan were situated on the active southern margin of Asia. Geology and geochronology of the eastern Hindu Kush range in Pakistan demonstrate that localized crustal melting and leucogranite intrusion took place in the Gharam Chasma area at ca. 24 Ma. More regionally developed and widespread deformation, metamorphism, and magmatism took place before collision between both India and the Kohistan island arc with Asia. Ca. 195 Ma U-Pb monazite ages on a deformed leucogranite dike from the upper Lutkho valley indicate an Early Jurassic phase of crustal melting. U-Pb monazite ages of 135–126 Ma on a staurolite schist from near Gharam Chasma are interpreted as a minimum age for staurolite-grade metamorphism. Within the Tirich Mir fault zone, pegmatite dikes crosscut the staurolite schists. U-Pb dating of uraninites from one of these pegmatite dikes reveals an age of 114 - 62 Ma. Monazites from the same rock give ages of 125–121 Ma, possibly due to inheritance of older cores. These Jurassic– Early Cretaceous constraints on metamorphism and magmatism relate to subduction and accretion processes, perhaps including the suturing of the Karakoram and Hindu Kush terranes along the Tirich Mir fault. In general, high-temperature, low-pressure metamorphism and subduction- related granitoid magmatism in the eastern Hindu Kush suggest a high thermal gradient in an active-margin setting from Early Jurassic to Cretaceous time. Keywords: active margin, collision, geochronology, Hindu Kush, metamorphism, monazite.
Key words: Geology, geochronology, Hindu Kush

Add/9 Houston, C.S., 1939. The American Karakoram Expedition To K2, 1938. The alpine Journal, 51, 54-68.

The author describes his visit to the Karakoram during an American expedition to the area. This travelogue does not have an abstract. The first few pages are reproduced here for ready reference.
For a hundred miles parallel to the great Himalayan backbone along its north-western end runs a minor range, the Karakoram. This small satellite of the main watershed boasts some of the world's most beautiful and least .known peaks. Mt. Godwin Austen, called K2, 28,250 ft. high, is the highest of these and is now established as second only to Everest in altitude.
All about it cluster great peaks such as Broad Peak, Gasherbrum, Masherbrum, Bride Peak, Mustagh Tower. Truly the little travelled Karakoram is a climbers' paradise. In the 1860's Colonel Godwin Austen of the Survey of India entered the Karakoram and explored the Baltoro Glacier among others, and was probably the first to see K2 from nearby. In his honour the peak now bears his name. Sir Francis Younghusband, at the end of his great trek across Asia, crossed into India not thirty miles from K2 • Martin Conway and Dr. and Mrs. Bullock Workman also made extensive studies of the glaciers of the Karakoram and its peaks. In 1902 Wessely, Guillarmod, Eckenstein and Pfannl made an abortive attempt to climb K2 via the N .E. ridge, the first attempt ever made on the mountain, but their gallant effort was cut short by illness. In 1909 the Duke of the Abruzzi, one of the great expedition leaders of all time, led a huge party up the Baltoro Glacier to camp beneath K2. In the course of a forty-day campaign he reached 22,800 ft. on Savoia Pass where begins the steep and rocky W. ridge. He then went 20 miles eastward to Windy Gap from which he examined the E. and N.E. aspects of the mountain.

Finally he made a brief but determined attempt on the S. ridge which is now called Abruzzi Ridge. On this he reached about 21,000 ft., where he was forced to turn back owing to limited time and continuous difficulties. In his opinion the W. ridge seemed to be the route of choice. The map of the Baltoro Glacier, and the famous photographs taken by Vittorio Sella and not yet surpassed, form a great contribution to the records of exploration.

Twenty years later the Duke of Spoleto with another large expedition 6 continued the geographical and geological survey of the district, but did not touch K2. Half a dozen other parties have seen the mountain from various angles but there have been no other assaults on its summit. It has come to be recognized as an outstanding problem for the mountaineer and a challenge to the explorer. After two years of effort the American Alpine Club obtained permission from the Government of Kashmir to enter Baltistan and accept this challenge. In October 1937 plans for the first American Alpine Club expedition were begun. Owing to the formidable nature of the mountain, to the obstacles encountered by our illustrious predecessors, and to our own convictions it was definitely planned that the first expedition should be one of reconnaissance primarily. We were to make careful study of the three great routes on the mountain and decide which of these was the most favourable for an attack. Once this survey was completed we were to try to go as high as possible on the route chosen. Only in our secret thoughts did we expect to do much more than a thorough preliminary study. The nucleus of the party was soon formed and about it gathered other climbers. From many candidates a small team at last emerged: Robert H. Bates of Philadelphia, veteran of many Alaskan climbs; Richard L. Burdsall of Port Chester, New York, who was one of the conquerors of Minya Konka; William P. House of Concord, New Hampshire, one of the two who reached the summit of Mt. Waddington; Paul K. Petzoldt of Jackson Hole, Wyoming, with many fine climbs in the Tetons to his credit; and myself. To our great good fortune the Government of India gave permission for Captain N. R. Streatfeild, M.C., of the Bengal Mountain Artillery, to accompany us as liaison officer.

Even after consulting all available literature and many authorities we could find no unanimous opinion about weather in the Karakoram. Some said that the monsoon began in June, others said July, while still others said that the monsoon did not reach K2 May and June, June and July, September and October, all were advocated as the best two months for climbing in the Karakoram. In despair we decided to take the two months most convenient for us: June and July.

Key words: K-2, expedition, Karakoram.

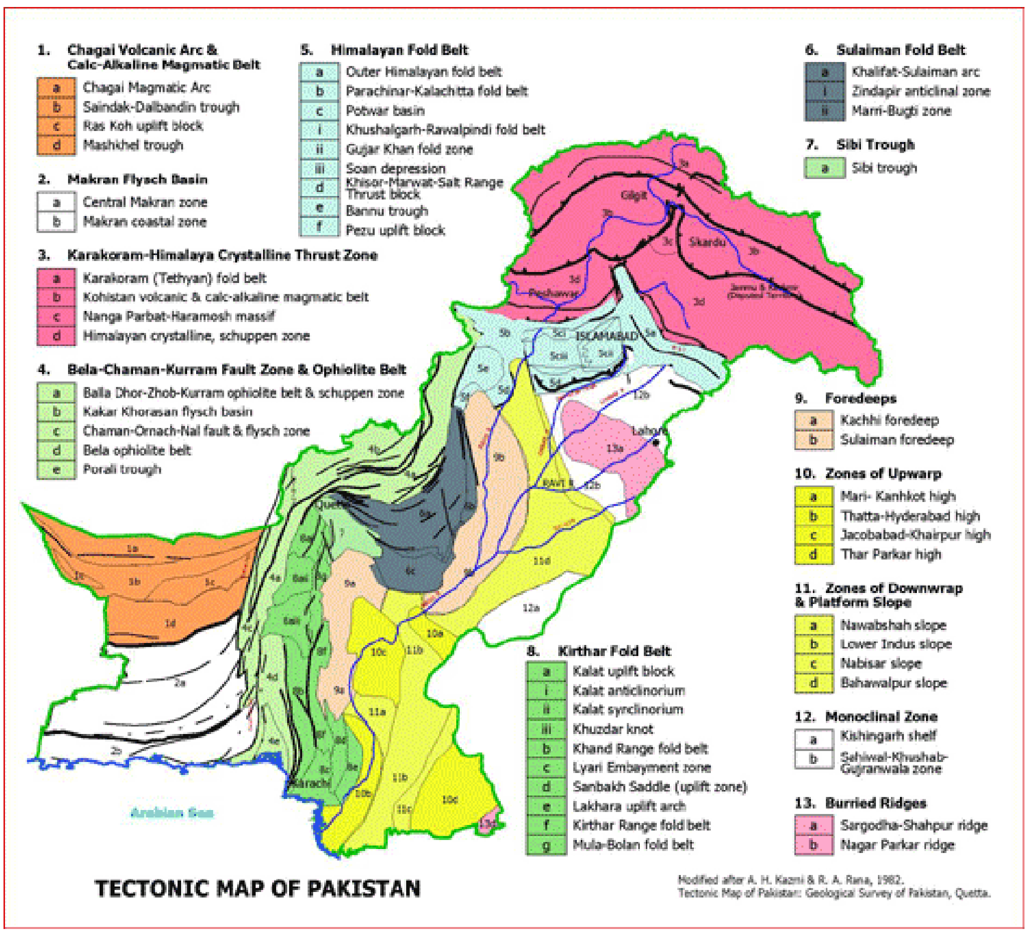
Add/10 Karim, A. & Veizer, J., 1999. Weathering processes in the Indus River Basin: implications from riverine carbon, sulfur, oxygen, and strontium isotopes. Chemical Geology, 170(1–4), 153–177.

This study deals with the major ions and isotope systematics for C, O, S, and Sr in the Indus River Basin (IRB). Major ion chemistry of the Indus, and most of its headwater tributaries, follow the order Ca^{2+}>Mg^{2+}>(Na^{+}+K^{+}) and HCO_3^{-}>(SO_4^{2-}+Cl^{-})>Si. In the lowland tributaries and in some of the Punjab rivers, however, (Na^{+}+K^{+}) and (SO_4^{2-}+Cl^{-}) predominate. Cyclic salts, important locally for Na^{+} in dilute headwater tributaries, constitute about 5% of the annual solutes transported by the Indus. Weathering of two lithologies, sedimentary carbonates and crystalline rocks, controls the dissolved inorganic carbon (DIC) concentrations and its carbon isotope systematics throughout the Indus, but turbulent flow and lower temperatures in the headwaters, and storage in reservoirs in the middle and lower Indus promote some equlibration with atmospheric carbon dioxide. Combined evidence from sulfur and oxygen isotopic composition of sulfates refutes the proposition that dissolution of these minerals plays a significant role in the IRB hydrochemistry and suggests that any dissolved sulfates were derived by oxidation of sulfide minerals.

In the upper Indus, silicate weathering contributes as much as 75% (or even higher in some tributaries) of the total Na^{+} and K^{+}, declining to less than 40% as the Indus exits the orogen. In contrast, about two-thirds of Ca^{2+} and Mg^{2+} in the upper Indus (over 70% in some tributaries) and three-fourth in the lower Indus, are derived from sedimentary carbonates. The $^{87}Sr/^{86}Sr$ ratios tend to rise with increasing proportions of silicate derived cations in the headwater tributaries and in the upper and middle Indus, but are out of phase or reversed in the lower Indus. Finally, close to the river mouth, the discharge weighted average contribution of silicate derived Ca^{2+}+Mg^{2+} and silicate derived Na^{+}+K^{+} are, respectively, about one-fourth and two-thirds of their total concentrations.

Key words: Himalayan weathering; Strontium; Stable isotopes,

Add/11 Kazmi & Rana 1982, GSP, QUETTA



Add/12 Lemmenicier, Y., Le Fort, P., Lombardo, B., Pecher, A. & Rolfo, F., 1996. Tectonometamorphic evolution of the central Karakorum (Baltistan-northrn Pakistan). Tectonophysics, 260, 119-143.
Key words: Tectonics, Karakoram.

Add/13 Roland, Y., Maheo, G., Guillot, S. & Pecher, A., 2001. Tectono-metamorphic evolution of the Karakorum Metamorphic Complex (Dassu-Askole area, NE Pakistan): Exhumation of mid-crustal HT-MP gneisses in a coinvergent context. Journal of Metamorphic Geology, 19, 717-737.
Key words: Metamorphism, tectonics, Karakoram.

Add/14 Rolland, Y., Picard, C., Pecher, A., Carrio, E., Shepard, S.M.F., Oddone, M. & Villa, I.M., 2002. Presence and geodynamic significance of Cambro-Ordovician series of SE Karakoram, (N Pakistan). Geodinamica Acta, 15, 1-21.
Key words: Geodynamics, Cambro-Ordovicain, Karakoram.

Add/15 Scarer, U., Copeland, P., Harrison, M.T. & Searle, M.P., 1990. Age, cooling history and origin of post-collisional leuco-granites in the Karakoram batholith, a multi-system isotope study. Jounal of Geology98, 233-251.
Key words: Cooling history, leucogranites, Karakoram batholoth.

Add/16 Schaltegger, U., Zellingere, G., Frank, M. & Burg, J.P., 2002. Multiple mantle sources during island arc magmatism: U-Pb and Hf isotopic evidence from the Kohistan arc complex. Terra Nova, 14, 461-468.
Key words: Magmatism, U-Pb, Kohistan island arc.

Add/17 Schneider, D., Zeitler, P., Kidd, W., Edwards, M., 2001. Geochronologic constraints on the tectonic evolution and exhumation of Nanga Parbat, western Himalaya syntaxis, revisited. The Journal of Geology 109, 563-583.
Key words: geochronology, Tectonics, Nanga Parbat.

Add/18 Searle, M., Khan, M.A., 2001. Geological Map of North Pakistan: And Adjacent Areas of Northern Ladakh and Western Tibet:(Western Himalaya, Salt Ranges, Kohistan, Karakoram, Hindu Kush). British Geological Service (BGS).
Key words: Geological map, Ladakh, Tibet, Kohistan, Karakoram.

Add/19 Zeitler, P.K., Meltzer, A.S., Koons, P.O., Craw, D., Hallet, B., Chamberlain, C.P., Kidd, W.S.F., Park, S.K., Seeber, L., Bishop, M. & Shroder, J., 2001. Erosion, Himalayan Geodynamics, and the Geomorphology of Metamorphism. GSA Today, 11(1), 4-9.
Is erosion important to the structural and petrological evolution of mountain belts? The nature of active metamorphic massifs co-located with deep gorges in the syntaxes at each end of the Himalayan range, together with the magnitude of erosional fluxes that occur in these regions, leads us to concur with suggestions that erosion plays an integral role in collisional dynamics. At multiple scales, erosion exerts an influence on a par with such fundamental phenomena as crustal thickening and extensional collapse. Erosion can mediate the development and distribution of both deformation and metamorphic facies, accommodate crustal convergence, and locally instigate high-grade metamorphism and melting.
Key words: Erosion, geodynamics, geomorphology, metamorphism, Himalaya.

Add/20 Zielinger, G, Arbaret, L., Burg, J.P., Chaudhry, N. Dawood, H. & Hussain, S., 1998. Structures in the lower units of the Kohistan arc (NW Pakistan): preliminary results. Geological Bulletin, University of Peshawar 31, Abstract Volume, 13th Himalayan-Karakoram-Tibet International Workshop, 224-227.

In NW Pakistan, the Kohistan paleo-arc, which was developed as plate an island arc above the northward subduction zone of the Tethyan Ocean during the Mesozoic, separates the Indian from the Asian plates. The southern boundary of the Kohistan arc is the so called Main Mantle Thrust (MMT), a crustal scale, northward dipping thrust on which the southern parts of the Kohistan are have been thrust over India.

Preliminary results of detailed mapping carried out in the uppermost Indian Plate (at Duber Bazar,) and the low levels of the Kohistan paleo-arc (from Jijal to Kiru) has covered the following lithologies:

Indian units: Granodiorite and strongly foliated gneisses. SW of MMT the gneisses are folded parallel to the SW trending stretching lineation. Kinematic determination shows a dominant southwestward sense of shear.

Kohistan units: The lowest levels of the Kohistan paleo-arc are dominated by dunites, pyroxenites and peridotites. Dikes of greenish chromite-clinopyroxenites cut this ultramafic sequence. Upwards, meta-gabbros (age 101±5 Ma., R. Anczkiewicz, oral com.) with high magmatic garnet content complement the so called Jijal Complex. Ca. 700 m SW of Patan, anastomosing shear zones appear in these garnet rich rocks. The density of the anastomosing shear deformation increases northward in this ca. 3 km wide zone, up to 2 km NE of Patan. This shear zone is described in more details in a companion poster. To the NE of this anastomosing shear zones, rocks are variable in composition, but mainly comprise of gabbros, hornblendite gabbros, diorites, norites, amphibolites and smaller bodies of nearly pure hornblendite (Kamila Belt). Pegmatites intruded this sequence during and after ductile deformation and correspond to a late magmatic event.

In this poster we present structural data on the anastomosed shear zone. The anastomosed shear zone, developed during finite magmatic stage, shows all deformation facies from undeformed protolith to ultra-mylonite (for details: The sense of shear on the dispersed, but in average flat to NE dipping shear zones shows dominantly SW directed relative movement of the hanging wall and minor NE directed shear. To the NE of these zone of anastomosing pattern, other shear zones form parallel W-E striking units of amphibolite facies (age 83±1 Ma.). These regular shear zones, containing porphyroclastic garnet, reach a thickness of up to 20m. Lineations strike NE-SW. The foliation of the shear zones dips more regularly to the NNE and the relation between normal and reverse shearing is balanced. The difference in the features and age (ca. 18 Ma.) between the anastomosed shear zone and the amphibolitic shear zone let us to separate the Kamila shear zone s.s., to the NE, from the Patan ductile shear zone, which is the anastomosed system described here and in the companion poster.

The region underwent late, pervasive faulting. Striations record essentially strike-slip and normal faulting. Results of principal stress calculation show three different stress fields: a poorly recorded one has a SW-NE maximum compressive principal stress ((yl), a second one has a NW-SE cl, dominantly identified by strike-slip movements. Preliminary analysis of superimposed striations indicates the SW-NE (yl as the older one. The youngest, best represented stress field shows a SW-NE minimum principal stress and steep cycle, responsible for normal faulting. The NE dipping Patan-fault is a prominent fault-structure which cuts the anastomosed shear zones. Minor offsets in lithology, recent seismic activity, rotated blocks (indicated by the change of foliation attitude from mainly W-E to NNE-SSW, south of Patan-fault) and the smooth topography in the widened Indus valley at Patan indicate a still active Patan-fault, but it seems to be a recent and regionally minor fault-contact. The Patan ductile shear zone must be separated from the Kamila shear zones. Further work on these structures will give more details about the evolution of the "Patan shear zone" and the relationship with the Kamila shear zone.

Key words: Collision, Subduction, Structure, Southern Kohistan arc.

Add/21 Zielinger, G., Arbaret, L., Burg, J.P., Chaudhry, N., Dawood, H. & Hussain, S., 1999. How is the petrography affected by shear zones in the Kohistan complex, N Pakistan? Terra Nostra 99, Abstract Volume, 14th Himalaya-Karakoram-Tibet Workshop, Kloster Ettal, Germany, 187-188.

In NW Pakistan the Kohistan complex separates the Indian and Asian plates. It was formed as an Island Arc during Mesozoic times (Bard, 1983; Coward et al., 1986). Accretion to Asia and subsequent thrusting over the northern margin of the Indian plate along the northward dipping Indus Suture (also called Main Mantle Thrust = MMT) (Tahirkheli et al., 1979) constitute the collisional history (Coward et al., 1987). Earlier history involves arc related deformation like splitting the arc in a volcanic and remnant arc (Burg et al., 1998) and SW-thrusting expressed by anastomosing shear zones in the southern, i.e. lower part of the axt probably imposed by subduction of the Tethys oceanic crust.

Our area of interest is comprised of two lithologies: The granulitic gabbro forms the upper part of the Jijal complex and is described as a calc-alkaline magma emplaced during the arc activity (Jan and Howie, 1981). The granulitic gabbro is intrusive in, and intruded by Hornblendites. P-T conditions point to granulite facies metamorphism (T>750^{0}C and P>l.8 GPa, Ringuette et al., 1998) and Sm-Nd cooling ages are 91 Ma and 96Ma (Yamamoto and Nakamura, 1996; Anczkiewicz and Vance, 1997).

The Sarangar gabbro (NE of Patan) crystallised at 800^{0}C and 0.8-1.1 GPa as deduced from preserved plagioclase-clinopyroxene assemblages (Yoshino et al., 1998). Ages are not available but structural relationship ndicates that the Sarangar gabbro is younger and intrusive into the granulitic gabbro (see companion abstract Arbaret et al., this conference). Regional amphibolite facies metamorphism affected these rocks and ended probably 83 Ma ago (Ar-Ar age of amphibole, Treloar et al., 1990). All these sites show remarkable strain localisation and provide sections from undeformed, weakly deformed with well preserved nagmatic fabric, to mylonitic high shear strain zones within tens of centimetres. Bard (1983) and Treloar et al. (1990) estimate the metamorphic conditions for the thear zones in the Sarangar gabbro at 550-650^{0}C and 0.9-l.0 GPa.

Many petrographical and geochemical studies on these rocks have been published and are partly cited above. Unfortunately they do not describe in details the relationship between petrography and deformation. Our particular aim is to obtain a better understanding of the interaction of petrography and ductile deformation. Therefore petrographic analysis across anastomosing shear zones was carried out at these distinct sites, in both the granulitic and Sarangar gabbros.

The composition in the undeformed rock of the granulitic gabbro is plagioclase, pyroxene, garnet, amphibole, quartz and rutile. The mid to fine-grained heteroblastic rock shows a granoblastic texture. The pyroxene is hypidioblastic with lobate to symplectitic contacts to plagioclase. The intensity of the symplectitic feature is getting stronger closer to the shear zone. The garnets are poikioblastic intergrown with plagioclase, quartz and amphibole. At the scale of hand-specimen a magmatic foliation is visible but there is no evidence, even under the microscope, for deformation structures. The magmatic foliation is bent close to the shear zone into the well-defined mylonitic foliation within the shear zone. Beside a strong decrease in grain size, the decrease in amount of pyroxene and the increase of amphibole and quartz are the most striking phenomenon. The garnet is porphyroclastic in the very fine-grained matrix (~0.3mm), partly rotated and fractured with new grown amphibole inside these fractures. Recrystallised quartz in the pressure shadows of garnets as well as the amphibole crystals oriented parallel to the foliation point to a higher shear strain. The change in the mineral assemblage points to a sharp increase of hydration from the undeformed to the mylonitic part of the garnet granulite.

Dominant composition in the Sarangar gabbro is amphibole (mainly hornblende), pvroxene, plagioclase, epidote and quartz. In a 13cm long section from the undeformed gabbro to the centre of one reference shear zone the main changes are as follow:

The hypidioblastic magmatic pyroxene is successively replaced by metamorphic pyroxene, amphibole and quartz. Close to the shear zone the metamorphic pyroxene is idioblastic whereas further away it rims the magmatic pyroxene. This first rim shows symplectitic intergrowth with the second rim comprised of greenish amphibole. In the shear zone, no magmatic pyroxene was observed. The plagioclase shows also symplectitic structures within the vicinity of the shear zone. The amphiboles underline the fabric in the shear zone and are cut by small quartz veins. Poikiloblastic garnet occurs infrequently. The macroscopic porphyroclasts (~2 mm) are plagioclase, quartz and pyroxene. Hydration towards the shear zone is remarkable.

Amphibolitic facies developed new minerals preferably in the shear zones and progressively (in the range of a few centimetres) into the undeformed gabbro. The hydration in the shear zone is strong and is propagating successively from the high shear strain zones to the nearly undeformed parts.

Our observation points to a high fluid flux in developing shear zones that were weak features (reduced grain size) with the hydration being concentrated in these thin zones. This process further reduced the hydrated rock strength in which in turn could be the site of increased fluid flow and subsequent amphibolitisation in the shear zone and their vicinity. The biggest amount of amphibolitised gabbro is therefore limited to the shear zones protecting the granulitic undeformed parts by channelling the fluid flux. The quantity of amphibolitised gabbro is small relatively to the undeformed gabbro.

Key words: Collision, shear zone, petrography, Kohistan arc.