progressed. This is consistent with a general 'inboard' younging of plutonism that we have previously reported for the massif (Schneider et al., 1997). Consistent with our dike crystallization ages and nearby biotite cooling ages, we infer that most of the displacement along the southeast margin of the Rupal shear ceased by 9 Ma and along the northwest margin by 2-3 Ma.

**References**

Edwards MA, Kidd W, Seeber L, Pêcher A, Le Fort L, Riaz M, Khan MA (1996), An upwardly mobile indentor? The Nanga Parbat-Haramosh Massif viewed as a crustal-scale pop-up structure. EOS Trans 236: 692.

Harrison TM, Lovera OM, Grove M, (1997) New insights into the origin of two contrasting Himalaya granite belts. Geology 25: 899-902.

Schneider D, Zeitler P, Edwards M, Kidd W (1997), Geochronological constraints on the geometry and timing of anatexis and exhumation at Nanga Parbat: A progress report. EOS Trans 237: 312.

Zeitler PK, Chamberlain CP, Smith H (1993), Synchronous anatexis, metamorphism, and rapid denudation at Nanga Parbat, Pakistan Himalaya. Geology 21: 347-350.

## Geochronologic summary and lithotectonic architecture of the Nanga Parbat-Haramosh Massif, NW Himalaya

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The Nanga Parbat-Haramosh massif (NPHM), most notable for its extremely young metamorphic and igneous ages, represents the most northerly exposure of Indian craton. Reworking of the Indian craton in the last 10 m.y. has been of a large enough scale to apparently fully overprint the Himalayan signature. Previously reported leucogranite crystallization ages for NPHM are markedly younger from those reported elsewhere in the Himalaya. Undeformed leucogranites within the massif show a southward younging of accessory mineral U-(Th)-Pb ages: a 10 Ma pluton in the north, 7 to 5 Ma dikes along the Indus and Astor Valleys, and ~2 to 1 Ma dikes, stringers and larger plutons in the south near the main summit (Zeitler and Chamberlain, 1991; Zeitler et al., 1993; Schneider et al., 1997). To the SE and SW of the summit, leucogranites again increase in age: in the SE, a dike which cross cuts the Rupal shear yields monazite ages from 17-9 Ma as well as the Early Miocene Southern Chichi pluton (Schneider et al., this vol.); to the SW, the much larger, and deformed, Jalhari granite yields monazite ages from 8-2 Ma, and in a separate sample 13 Ma. Thermochronologic results from basement micas are very young and indicate a similar southward-younging pattern, also with a marked age increase to the SE and SW, yielding typical Himalayan cooling ages in those areas.

In the central portions of the massif are found the highest grade rocks and youngest ages. Zeitler et al. (1993) obtained a ~1 Ma zircon U-Pb age for the Tato pluton. Subsequently, for the Mazeno Pass pluton, the opposite (southern) side of the Nanga Parbat summit ridge from the Tato pluton, we (Schneider et al., 1997) obtained strikingly coincident zircon and monazite U-Th-Pb ages of 1.4 Ma. That the 1.4 Ma age is obtained on both zircons and monazites for a larger body of granite illustrates the degree of very young melting.

A number of the granites cross-cut large crustal scale shear zones, hence post-dating the displacement on, and constraining the timing of, the shear zones. Along the NW margin, a small, undeformed tourmaline-bearing granitic dike which cross-cuts the high strain fabric of the MMT yields an age of 7 Ma, requiring that deformation along the MMT ceased by at least that time. This is in agreement with the conclusions of Pêcher and Le Fort (in press) which suggest that ductile deformation ended around 7-6 Ma on the Nanga Parbat-Karakorum suture to the north. Deformation in the north was due to doming and the entire northern section of the massif behaved as a single crustal block (Pêcher and Le Fort, in press).

Along the Rupal shear zone, south of the Nanga Parbat summit, the 2-1 Ma Rupal dikes also provide key timing constraints on structures and fabrics of the Rupal valley; the oldest crystallization age gives the minimum age of deformation. In this case the oldest dike dated in this study gives an age of 2.3 Ma. Thus, cessation of ductile deformation had to occur before 2.3 Ma. Furthermore, dike emplacement was coeval with cooling where the dike ages are similar to the Ar/Ar biotite cooling ages in the valley. This suggests the dikes were emplaced into shallow crustal levels, the melt having possibly migrated along the Rupal shear and into fractures accompanying the general uplift and erosional unroofing. The ages and structural orientation of the Rupal dikes compare well with those of the dikes and stringers on the north side of the summit which give ages between 3 and 1 Ma (Zeitler et al., 1993). These were emplaced, and somewhat deformed, into the Raikot-Lichar shear zone. Furthermore, monazites from two deformed granites along the WNW margin of the massif (at Jalipur and Diamir) yield ages as young as 5-3 Ma. This implies that deformation in southern Nanga Parbat (south of Indus-Astor confluence) has ceased much more recently (4-3 Ma) than the north (Haramosh; 7 Ma), and the southern NPHM, like the north, may have behaved as a single crustal block, bounded to the south by the Rupal and Diamir shear zones.

Crystallization ages on the SE margin of the Rupal valley are significantly older. Both the geochronology of a thin leucogranite dike (mentioned above) which cross-cuts the fabric of the SE Rupal shear in Chichi valley and the thermochronology of the shear zone rocks constrain the age of that portion of the Rupal shear zone to having ceased by 10 Ma, if not older (Schneider et al., in press).

The basement lithology is fairly monotonous with ages from zircon cores showing a ubiquitous Early Proterozoic inheritance, typically clustering around 1870-1850 Ma. This, as noted by Whittington et al. (1998), is similar to the Early Proterozoic inheritance of the Lesser Himalayan sequence in the central part of the orogen and therefore differs from the High Himalayan Crystallines that are common to the NW Himalaya which NPHM has long been considered a part. The Early Proterozoic zircon inheritance exists in all of the massif's units: gneisses, schists, metasedimentary rocks and larger granite bodies (Zeitler et al., 1989; Zeitler and Chamberlain, 1991; Zeitler et al., 1993; Schneider et al., 1997; Schneider, unpub data). Only a few isolated granites do not contain inheritance: the smaller leucogranite dikes and, surprisingly, the larger Jutial pluton (Schneider et al., 1997). Markedly younger than the other units in the massif, Zeitler et al. (1989) report zircons from a sample of the Shengus gneiss, in NE Nanga Parbat, yielding a 500 Ma inheritance; this sample lies near the generally agreed upon 'basement-cover' contact. Our new results from granitic rocks at Manugush (Bunar Gah, SW Nanga Parbat) indicate a yet another unit which yields a Cambro-Ordovician age. Zircons from the porphyroclastic garnet-muscovite, - kyanite gneiss with cm long feldspar laths yield concordant U-Pb ages of 480 Ma. A petrologically similar augen gneiss (termed 'lath unit') was described by Edwards (1998) on the SE side of Nanga Parbat (Astor Valley); Foster et al. (this vol.) have obtained ~500 Ma monazite ages from the cores of garnets within the lath unit. These samples also occupy the contact between the Nanga Parbat gneisses and the cover sequence. Based upon 1) the 'basement-cover' relationship across a large area, 2) the age, and 3) the similar petrologic nature between the W and E localities, we suggest that the Cambro-Ordovician lath unit was originally a largely continuous unit within the massif, intruding into the 'basement-cover' contact. Edwards (1998) has suggested that the unit was intruded during, and subsequently underwent some of, the deformation associated with the main displacement of the MMT. The unit may be faulted and eroded away on the active western margin of the massif. Other sections of the NW Himalaya (Pakistan and India) and in Nepal also contain Cambro-Ordovician intrusions which, based on geochemical data, were generated by anatexis of continental crust (Miller and Frank, 1992).

In summary, the Nanga Parbat massif is mostly Early Proterozoic basement with interleaved deformed Cambro-Ordovician granites, reworked and exposed as recent as 2-3 Ma in the summit region. The overall structure, concentric metamorphic isograds and age pattern indicate the appearance of a young gneiss dome 'popping-up' on conjugate shear zones through Indian cover metasediments which have 20-30 Ma cooling ages.

### References

Edwards MA (1998), Examples of tectonic mechanisms for local contraction and exhumation of the leading edge of India, southern Tibet and Nanga Parbat, Pakistan. PhD dissertation, State University of New York at Albany, 308 p.

Miller, F (1992), Geochemistry and isotope geology of Proterozoic and early Paleozoic granitoids in the NW Himalaya. 7th HKTW: 58.

Pecher A, Le Fort P (in press) Late Miocene tectonic evolution of the Karakorum - Nanga Parbat contact zone (northern Pakistan). Geo Soc Am Sp Paper.

Schneider D, Zeitler P, Edwards M, Kidd W (1997), Geochronological constraints on the geometry and timing of anatexis and exhumation at Nanga Parbat: A progress report. EOS Trans 237: 312.

Schneider D, Edwards M, Kidd W, Zeitler P, Coath C (1999), Early Miocene anatexis identified in the western syntaxis, Pakistan Himalaya. Earth Planet Sci Lett: in press.

Whittington A, Harris N, Ayers M, Foster G (1998), Where did Nanga Parbat come from? 13th HKTW: 211-212.

Zeitler PK, Sutter J, Williams IS, Zartman RE, Tahirkheli RAK (1989), Geochronology and temperature history of the NPHM, Pakistan. In: Malinconico LL, Lillie RJ (eds), Tectonics of the Western Himalayas, Geol Soc Am Spec Paper 232: 1-23.

Zeitler PK, Chamberlain CP (1991), Petrogenetic and tectonic significance of young leucogranites from the NW Himalaya, Pakistan. Tectonics 10: 729-741.

Zeitler PK, Chamberlain CP, Smith H (1993), Synchronous anatexis, metamorphism, and rapid denudation at Nanga Parbat, Pakistan Himalaya. Geology 21: 347-350.

## Constraining the exhumation history and tectonic evolution of the NE - and Central Pamirs

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The Pamir crust amalgamated through several orogenic cycles from the Late Paleozoic until the Mesozoic. In the study area, the northeastern Pamirs, the India-Asia collision led to intracontinental shortening, basement doming, and exhumation more than 1000 km north of the suture zone. Geochronological and structural analyses along E-W striking magmatic/metamorphic belts which are associated with the Mesozoic suture zones and the Cenozoic thermostructural reactivations show the following results:

1) In the Rushan Pschart zone (Early Cretaceous suture zone) Ar-Ar biotite ages from granitoids demonstrate regional cooling below 300°C in Late Cretaceous time. The apatite fission track (FT) ages cluster around 11 Ma. Modeled time-temperature paths for the samples which have been analyzed with FT and Ar-Ar dating methods indicate a residence time in the

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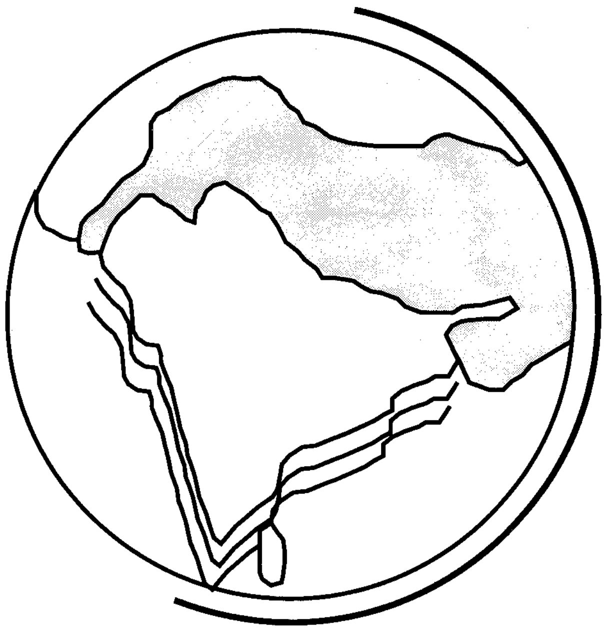

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