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Summary of selected tectonic and geochronologic observations in SW NPHM arising from the Nanga Parbat Continental Dynamics Project

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Introduction

This abstract is a summary of some of our tectonic and geochronologic observations in SW NPHM arising from the Nanga Parbat Continental Dynamics Project (Zeitler et al., this issue).

Truncation of cover sequence

In the area that is encompassed by the N-S trending Bunar valley, and NW trending Diamir valley, the main fabrics trend mostly N to NNE. In this area, the Indian "cover" passive margin rocks that form the original MMT footwall include sequences of carbonates and amphibolites (probably the Permian "Panjal Traps") interlayered with metapelites. In Diamir Valley, these are not more than a few 100's metres thick. Here, the regionally NW-dipping cover sequences and MMT hanging wall (Kamila amphibolite) are overturned to become SE-dipping. These overturned layers are traceable to a recumbent open fold (the Gashit fold) in Airl Gah near the village of Gashit, where they form the upper (overturned) limb. The hinge line and axial plane of the fold plunge gently N. South of this fold, the lower limb is exposed, thus sequences are not overturned and are observed to dip moderately to steeply west. The thickness of the cover sequence increases markedly to the south; carbonates, amphibolites and metapelites of several km of structural thickness are present in the W-E Airl-Nashkin section, 10 km to the south of Diamir valley.

The abrupt northward thinning of cover sequences in SW NPHM is orders of magnitude too large to be original depositional variation and there must be some type of tectonic excision. Large amounts of STDS-type normal motion have not been reported from the MMT. Similarly, we have found no compelling evidence around NPHM for large-scale normal motion on the MMT (the MMT-normal motion seen in SE NPHM cannot account for several km of exhumation). Consequently, we suggest that a large-scale frontal ramp in the original MMT gave rise to a local duplex structure that imbricated thin slices of cover, and possibly basement. This model is consistent with our mapping in Niat Gah, the next main valley to the west of NPHM, where a basement slice occurring close to the MMT implies large-scale imbrication of the cover sequences.

Jalhari Granite synkinematic in Diamir Shear Zone

Structurally lower in the MMT footwall, and to the east, the cover sequence passes into a dominantly plutonic, ~5 km thick crystalline sequence that forms a continuous-along-strike (>30 km), ~N-S belt with vertical to steeply E-dipping fabrics. The Diamir and Airl Gah (both ~W-E) valleys offer almost continuous outcrop sections through the belt. From these valleys, it is clear that a coarse-, to medium-grained biotite granite (the Jalhari granite) grades into granitic and porphyroclastic gneiss due to syn- to post-plutonism deformation. Jalhari leucogranite lenses (10s - 100s m thick) showing little to no sub-solidus deformation are separated by 10's – 100's m thick layers of gneiss where deformation of the granite has been localised. These higher strain layers anastamose around the granite lenses, and mark reverse faults that climb to the west. The granitic gneiss shows significant sub-solidus strain, including S-C porphyroclastic fabric whose sense of shear consistently indicates east side (NPHM) up and over west. Well-developed ductile/brittle shear bands and local fault gouge horizons, both of the same range of orientations as the ductile fabric, are also common. Late strain is often indicated by narrow (metres) zones where hydrothermal flux has developed thick biotite accumulations. Spectacular asymmetric folding (cm-wavelength) of the biotite layers indicates east side up and over west. Th-Pb ion microprobe [UCLA's Cameca IMS1270] analyses of monazites separated from deformed and undeformed portions of the granite give ages ranging from 2-8 and 12 Ma, respectively (Schneider et al., this issue).

Overall, the granite gneiss belt defines a N-S trending, W-vergent, reverse sense shear zone ~5 km in width. We term this the Diamir Shear Zone. The E over W displacement sense of the Diamir Shear Zone is consistent with the development of the Gashit fold, and with the upper limb that includes the overturned cover/MMT layers (again note that here on the NPHM SW flank the massif is again "bulging out" in cross-sectional view). The Diamir shear zone forms the mechanical continuation of the main Raikhot Fault: at Raikhot Bridge, where last seen, the structure is marked by a NW-vergent reverse fault with NPHM in the hanging wall (Madin, 1986; Madin et al., 1989). The Raikhot Fault is much narrower (<<5 km) however, and represents more focused strain.

We interpret the emplacement of the Jalhari granite to be at least partly syn-kinematic with exhumation of NPHM, intruded in discrete episodes between 2 and 12 Ma.

Eastern margin of Diamir Shear Zone and Mazeno Pass section

The geology between the Diamir Shear Zone and the central portions of massif is well exposed in the Diamir and Airl Gah valleys. The zone boundary is marked by brittle deformation within layers/lenses of retrograde (highly chloritised) metapelite. These then pass to more typical basement gneisses (e.g. showing metre-scale layering due to differing Fe-weathering & biotite content). From here to Rupal Valley, structures are more complex. Across Mazeno Pass, the 1.4 Ma pluton (Schneider et al., this volume) shows evidence of some normal motion associated with its emplacement. (top to NW on steep, NW-dipping fabric). Principal gneissic fabric here is N-NE trending. In places this is cut by quartz-pegmatites, and by leucogranite dykes that stem from the Mazeno Pass pluton. Some of the leucogranite dykes cross-cut the quartz-pegmatites, and in both cases, wall rock margins show normal sense of opening, but this may not be significant if (e.g.) the granite remained super-solidus during much of the strain.

Conclusion

In conjunction with our observations of Central and SE NPHM (Edwards et al., this issue), we conclude that the uplift of the NPHM massif is accommodated upon two conjugate shear zones that define a pop-up structure. The RCSZ (on the eastern flank) is the "retro" structure while the Raikhot Diamir system (on the western flank) is the "pro" or "dominant" structure. The overturning (bulging out) of the massif is occurring on both flanks, however this occurs outwith the main shear zone on the eastern flank (away from the centre of the massif); this is consistent with an overall more-diffuse focus of strain in the retro shear zone. We have recognised original "high Himalayan" features in the areas outwith of central NPHM, including (1) the original MMT, and (2) evidence for Early Miocene plutonism that is ubiquitous to the main Himalaya and hitherto unrecognised in the NW Himalaya.

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New map of southern Nanga Parbat

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A new structural and lithologic map (as part of the Nanga Parbat Continental Dynamics Project) has been made for the southern Nanga Parbat area in the Pakistan Himalaya. About 90% of the mapped area was hitherto unreported in recent geological literature, the remaining 10% being covered by preliminary or work.

The portions of the massif where mapping was conducted include: (Clockwise from Mazeno Pass) Diamir, Bunar, Biji and Jalhari Gah area (in the SW), the Astor Gorge and Dichil Gah - including the the two tributaries that intersect the Eastern margin, Rama, Bulan and Ghurikot Gah areas (including the two northern tributaries of Ghurikot Gah), The Lower Rupal Valley (Tarshing Area) and northern Rattu valley, Chichi valley (to the foot of the pass to the Kishanganga) and central and Upper Rupal areas (to the foot of Toshe Gali and up to and over Mazeno Gali).

Three major findings include (1) a major new shear zone, the Rupal-Chichi Shear Zone , (2) the Diamir-Rupal Shear Zone - a significant continuation of the Raikot system for >60 km to the SW, and (3) that the original MMT on the east side has not been

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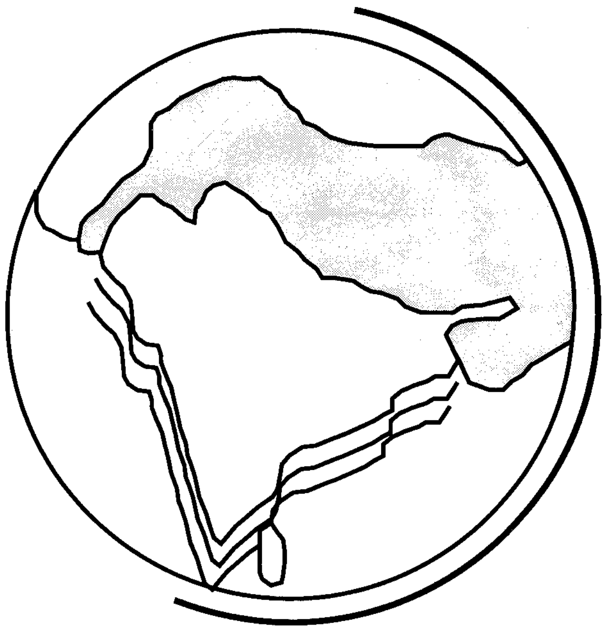

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