members of which contain sillimanite, kyanite, staurolite and garnet. The Daling Formation is mainly composed of low-grade chlorite and chloritoid schists. Lingtse Formation is predominantly gneissic, occurring as tectonic wedges in the Daling Formation. K-syenite is bluish gray in colour, massive, inequigranular, medium to coarse grained and nonfoliated except along the contact with the enclosing rocks. Optically, the extinction angle decreases from the core to the periphery (28°-19°) on the other hand 2V increases (48°-49°). All the varieties are optically negative. This indicates solid solution or zoning. Blue amphiboles contain inclusions of ilmenite, sphene, quartz and orthoclase.

The syenite is perpotassic to ultra-potassic in composition with $K_2O$>3% (8.31-8.57%) and $K_2O/Na_2O$ ratio 2.00. It is a slightly saturated syenite as it consists of minor amounts of quartz. The plots of Q-Ab-Or of syenites lie at centre of the Ab-Or join. Such syenites are formed by fractional crystallization (Hyndman, 1985). Most likely these were formed from saturated alkaline magma, at lower water pressure. Plottings of Rb vs $SiO_2$, Rb vs Nb and Nb vs Y indicate within plate tectonic setting confirmed by high and equal normalized abundance of Rb and Nb. The microprobe analysis of amphiboles, biotite and k-feldspar reveal the chemical changes, which possibly affected the K-rich syenites of Eastern Sikkim. K-feldspar, amphiboles and biotite are primary minerals with accessory quartz. Microprobe analyses of amphiboles reveal variation in composition from core to periphery in the order: magnesiokataphorite - richterite - winchite - riebeckite magnesiokataphorite - magnesioriebeckite - riebeckite - eckermannite. Compositional variation of amphiboles was plotted on $Ca_B$ vs Si binary diagrams, of isometric prisms using Si, $Ca_B$ and mg number (mg = $Mg/Fe^{2+}$+Mg) (Mitchell, 1990). Thus, the compositional trends of amphiboles were early primary to intersertal type (i.e., calcic, sodic-calcic and sodic) and therefore, reflect an early magmatic/sub-solidus trend. The decreasing $Ca_B$ and mg and increasing Fe and Na support the fact that evolution of amphiboles took place under reducing conditions (Strong, & Taylor, 1984). This variation in composition from sodic calcic to calcic sodic to sodic represents the evolution of an alkaline magma at low pressure during fractional crystallization. The presence of needles of riebeckite in other minerals depicts subsolidus amphibole of sodic variety formed at a later stage due to soda metasomatism.

Such intrusive syenites have also been found with fabric oriented parallel to foliation of Kuncha Formation phyllites and metasandstones or cross-cutting them below the Main Central Thrust in the Lesser Himalayas of Nepal (Dhittal, 1994) and Ambela Granitic Complex of Pakistan (Rafiq & Quasim, 1989) respectively. The presence of such 'within plate tectonic field' syenites suggests a zone of attenuated crust/rift depicting anorogenic activity below the MCT. The magmatism and metasomatism can be attributed to rebound relief tension or rifting during or post-thrusting of the Main Central Thrust. Anorogenic K-syenite occurrence is very rare in the vast orogenic environment of the Himalaya. Therefore, its nature and occurrence is of great significance.

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## The Karo-La Decollement, southern Tibet: A Himalayan extensional structure domed by emplacement of the Late Miocene Karo-La Granite


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Geologic mapping along the route of the INDEPTH seismic line in southern Tibet (Edwards, 1998) reveals a ~25x30 km dome exposing dark phyllites at the Karo La massif (Noijingkang - 7191m), immediately west of the ~N-S INDEPTH CMP line "TIB-5" on the western shores of Yamdrock Tso. The phyllites in the Karo La massif are >2km thick, lying structurally below the Triassic, and younger, Tethyan sedimentary rocks, all of which are affected by regionally W-E trending, north-dipping, south-vergent folds and thrusts. Kinematic fabric of foliation-parallel quartz veins/sheets, and mineral stretching lineations constrain clear top-to north displacement upon discrete horizons, especially at the top of the phyllite unit, and perhaps within it. In addition, mapping and accompanying TM interpretation show that the regional W-E fabric terminates, and soles into, the top of the phyllite unit upon the N, S, and E sides of the dome (this observation is strikingly re-emphasised on the TM by conspicuous truncation of surface traces/form lines at the margins of the phyllite body). Despite the clear top-to-north sense of shear that is presently observed, we infer that much of the strain within the phyllites was accumulated during "thin-skinned" south-directed folding and thrusting of the Tethyan sequences, during which the phyllite layer (especially the upper portions of the phyllite layer) has acted as a decollement horizon; the Karo La decollement (KLD), that has enjoyed both south-, and subsequently north- directed hanging wall displacement. We infer that the updoming of the phyllite, and the conditions for quartz veins and new mineral growth are related to the emplacement of a leucogranite (the Karo La granite) that is exposed in several places in the core of the dome. The leucogranite intrudes (cross-cuts) the phyllite, and may provide a minimum age for displacement on the KLD. The Karo La dome is cut by a major graben-bounding N-S normal fault (part of the Yadong-Gulu rift system - YGRS - Wu et al., 1998; Cogan et al., 1998). Li et al. (1998) have determined a crystallization age of 11.7 ± 0.2 Ma (xenotime) for the Karo-la granite. Apatite fission track data from the Karo La granite give an age of 4.7 ± 1Ma, and prior geochronology (Copeland, 1990) gives biotite and muscovite Ar/Ar cooling ages of 10.5 ± 0.1 and 10.9 ±0.1, respectively. These ages imply exhumation of this segment of the YGRS hanging wall between ~10 and 5 Ma, consistent with general opening of the YGRS at this time (e.g. Nyainqentanglha, Harrison et al., 1995, Wu et al., 1998). We have mapped the same phyllite unit in northern Nieru Valley-Kangmar Dome (Kidd et al., 1995), and in another nearby dome (Mangda Kangri), where the phyllite unit in each case is again present defining the core of the dome structure, and with a normal-sense decollement as its upper surface. We suggest that the phyllite marks a regional layer with an extensional decollement, originally N-dipping, that has been since domed in association with granite emplacement (during which the phyllite unit may have acted as some type of barrier to magma ascent). Ages from the main STDS in this segment of the Himalaya (Edwards and Harrison, 1997, Edwards et al., 1995) suggest that it was active at the same time, or perhaps later (the STDS is structurally lower than the KLD decollement). We remark that the existence of this regional decollement within the Tethyan Himalayan belt makes construction of simple balanced sections (e.g., Ratschbacher et al., 1994) problematic in this part of the orogen.

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## Summary of selected tectonic and geochronologic observations arising from the Nanga Parbat Continental Dynamics Project

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**Introduction**

The Nanga Parbat Continental Dynamics Project (c.f., Zeitler et al., this volume) employed various disciplines (e.g., Meltzer et al., this volume) to investigate the tectonic processes that have contributed/contribute to present situation at the Nanga Parbat Haramosh Massif (NPHM). This is a summary of some of our tectonic and geochronologic observations in Central and SE NPHM.

**Astor valley and SE NPHM**

Two antiforms (with broadly differing overall lithology) are observed in the main Astor Gorge; the Burdish Ridge and Dichil antiforms, in the west and east, respectively. The Burdish Ridge antiform is asymmetric with a thinned E-limb, while the Dichil antiform is asymmetric with a thinned W-limb. This is recognised by a very tight, pinched fold morphology of

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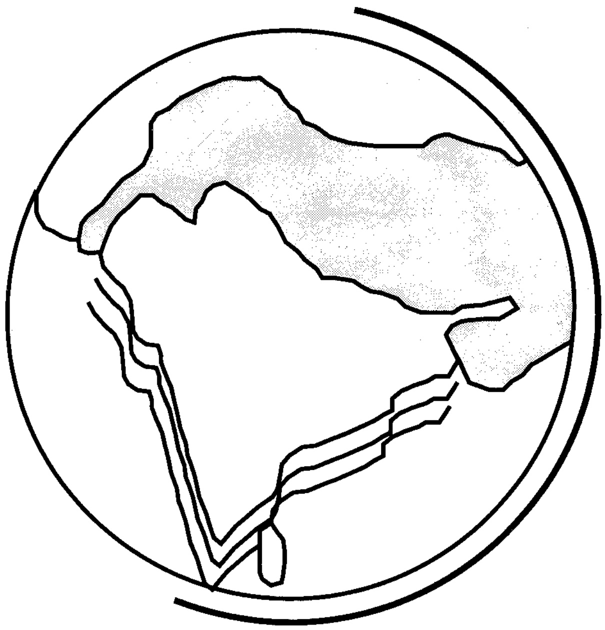

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