Stress field evolution in the northwest Himalayan syntaxis, northern Pakistan

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[1] We have conducted a systematic inversion of striated fault planes throughout northern Pakistan in order to better depict the temporal and spatial variations in stress patterns. Two domains are evidenced at a regional scale, separated by the active Raikhot fault, the western boundary of the Nanga Parbat spur. West of this fault, a wrench-type stress field with $\sigma 1$ axis oriented around N–S predominates in the Karakorum and in Kohistan. It predates Pliocene-Quaternary exhumation of Nanga Parbat and corresponds to the Miocene or earlier regional stress field related to Indian-Asian convergence. East of the Raikhot fault, compression parallel to the belt accounts for initiation of the Nanga Parbat anticlinorium after 5 Ma. It is followed by predominant post-2 Ma extension, both parallel to the belt and NNE–SSW oriented. Thus, in the N–W Himalayan syntaxis, multidirectional extension is juxtaposed on short timescales to shortening either parallel or perpendicular to the belt. Such juxtaposition could be characteristic of strain and stress partitioning during oblique convergence. **Citation:** Pêcher, A., et al. (2008), Stress field evolution in the northwest Himalayan syntaxis, northern Pakistan, *Tectonics*, *27*, XXXXXX, doi:10.1029/2007TC002252.

1. Introduction

[2] The Himalayan syntaxes have attracted significant attention in recent years because they provide strong indications for coupling between tectonic and surface processes responsible for extremely rapid exhumation documented in the Nanga Parbat (in the NW syntaxis) and Namche Barwa (SE syntaxis) massifs, respectively [e.g., *Zeitler et al.*, 2001a, 2001b; *Burg et al.*, 1998]. Less attention has been paid, however, to the tectonic evolution of these regions, and in particular how stress and strain fields evolved to produce the highly complex, noncylindrical structural patterns observed today. In particular, if tectonics and surface processes strongly interact in these regions, we may ask the question whether (and if so, how) this interaction is recorded by the evolving regional stress fields.

[3] Neotectonic activity in the NW Himalaya has been dramatically emphasized by the recent M = 7.6 Balakot earthquake in Kashmir (8 October 2005). The Balakot earthquake followed the Pattan 1974 earthquake, the epicenter of which was located 100 km farther NW. The focal mechanisms of both earthquakes reveal active thrusting in a NE–SW shortening regime, perpendicular to the average orientation of northwestern Himalaya. A few tens of km farther north, in contrast, a recent microseismicity survey has revealed an active E–W extensional regime in the Nanga Parbat area, while the adjacent Kohistan block appears to be nearly aseismic [*Meltzer et al.*, 2001]. Such a juxtaposition of different tectonic regimes underlines the complex stress and strain pattern in this part of Himalaya: the northwestern Himalaya-Karakorum belt is a typical case of a mountain chain formed by transpressional tectonics, in which strain partitioning has probably controlled the Pliocene-Quaternary tectonics [*Seeber and Pêcher*, 1998], and where exhumation patterns and its driving forces have varied temporally and spatially [*Zeitler*, 1985].

[4] In order to better depict the temporal and spatial variations in stress patterns, we have conducted a systematic inversion of striated faults planes observed in outcrops throughout the northern Pakistan Himalaya. We collected data in a broad area of northern Pakistan, from the Hunza, Gilgit and Indus valleys in the west, to Deosai and Skardu area in the east, and Jhelum valley in the south (Figure 1). Our results complete a preliminary study in the same area [*Pêcher and Seeber*, 2003] and broaden the local investigations of *Zeilinger et al.* [2000] in the southern part of the Kohistan arc along the Indus valley and *Burg et al.* [2005b] in the Kashmir syntaxis.

[5] As compared to similar but older mountain belts, the NW Himalaya seems particularly propitious to such an analysis: to a large extent, inferred paleostress tensors should reflect the recent stress field, as in several areas (i.e., Karakorum, Nanga Parbat, Kashmir) brittle deformation is superimposed on a ductile deformation pattern acquired during early Pliocene times, or possibly even later. In these areas, the paleostress pattern should be similar to the current stress field, which allows some direct control of

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