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Geochronology of the Indus Gorge and Astor Valley Sections through the Nanga Parbat Syntaxis: Constraints on Uplift History

POSTER

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The Indus Gorge provides a constant altitude east-west section across the north-trending Nanga Parbat syntaxis. The Astor Valley, to the south, provides a second section, this one NW-SE trending, through the syntaxis, although not a constant altitude one. The syntaxis is a structural half window, within the core of which Indian Plate gneisses are updomed from beneath a cover of overthrust volcanics of the Kohistan-Ladakh island arc complex. These sections provide an opportunity for detailed, structurally constrained, sampling for both P-T-t path analysis and geochronology. Here we present data from these traverses that enable us to constrain the uplift history of the syntaxis. 120 samples were collected for analysis by hornblende and mica Ar-Ar and K-Ar techniques, and by zircon and apatite fission track techniques. When those data of Zeitler (1985), Zeitler and Chamberlain (1989), Smith et al (1992) and George et al (1993) are included we have a copious, closely spaced data set.

1) A marked break in cooling ages occurs across the western margin of the syntaxis. This margin is marked by the Raikot-Sassi Fault Zone, a complex fault system with an overall oblique sense of displacement that includes both right lateral and thrust type displacements. The data imply that significant displacements have occurred along this zone within the last 1 to 2 Ma.

2) The eastern margin is marked by neither a significant fault zone nor a marked step in cooling ages. Instead cooling ages gradually decrease westward across the margin into the syntaxis, a decrease explained by exhumation during the growth of a large scale antiformal fold located within the syntaxis.

3) Within the Indus Gorge section, hornblende and mica Ar-Ar ages are both younger within the western half of the syntaxis than in the eastern half. This is consistent with the recognition of a series of domal structures within the syntaxis not all of which grew synchronously. Within the Indus Gorge section, the data are consistent with the growth of an antiform within the eastern part of the section before 5 Ma ago, and the subsequent

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growth of a similar structure, at ca. 3 Ma ago, in the western part of the section. Neither zircon nor apatite ages show this age difference from east to west, indicating that folding may have become of secondary importance to uplift controlled by faulting along the eastern margin after about 2 Ma ago. Locally hornblende and monazite ages indicate T>500°C as recently as 9-10 Ma and in the case of muscovite Rb-Sr ages as recently as 5 Ma. Some of these very young ages may be due to localised thermal perturbations due to melt emplacement.

4) Within the Astor Valley section, a different cooling profile is recorded with mica ages increasing towards the west, a pattern shown less well by the fission track ages. The tectonic siginifance of this variation is, as yet, uncertain.

Although a combination of early folding followed by later oblique slip thrusting along the western margin may explain the uplift and cooling history of the Indus Gorge section, it may be unwise to extrapolate this model without qualification to the rest of the syntaxis, as shown by the data from the Astor Valley. The internal structure of the syntaxis is best modelled as a series of nested domes. Folds within the Indus Gorge plunge south, whereas those within the Astor Valley plunge north. More detailed geochronology is required to demonstrate the extent to which these developed diachronously as well as their temporal relationships to thrusting along the western margin.

Total exhumation and overall uplift rates are difficult to quantify given the vertical telescoping of isotherms due to rapid uplift and unroofing, and the emplacement, as recently as 2 Ma ago, of leucogranite dykes and bodies to high structural levels. However, due to the constant altitude of the Indus Gorge section, the antecedent nature of the river and the magnitude of the unroofing indicated by the cooling history data, we feel confident that exhumation amounts approximately equal bulk uplift amounts. As such, it is hard to escape the conclusion that fold amplification was exponential, or that recent uplift rates have been as high as $6 mm yr^{-1}$, as suggested by Zeitler (1985).

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Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: Berichte der Geologischen Bundesanstalt

Jahr/Year: 1993

Band/Volume: 43

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Artikel/Article: Geochronology of the Indus Gorge and Astor Valley Sections through the Nanga Parbat Syntaxis: Constraints on Uplift History 79-80