Comparison between the Tectonic Movements of Mt. Everest and the Nanga Parbat-Haramosh Massif

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**Introduction**

If the Himalayas are a land of extremes from the topographical, geophysical and geological point of view (Windley B.F., 1986), the Karakorum is a land of superlatives, having the highest concentration of mountains beyond 8000 metres, having the longest glaciers beyond the poles, being the source of one of the longest rivers. From the geophysical point of view it contains the largest gravity anomalies (G. Poretti, 1998) and thickness of the earth crust (75 km) (Finetti & al. 1979, 1983) and the highest values of deflection of the vertical.

It contains also the highest relief (4000 metres from the Indus plains to the summit of Nanga Parbat). It seems also that this area is subject to the highest uplift. This has been mentioned by many authors deriving it through indirect methods, but not yet confirmed by accurate direct observations. Lewis Owen reports 0.7 mm/y using fission-track methods (L. A. Owen, 1989). Higher values (2 mm/y) are inferred by several researchers (Zeitler P., 1985; Gorniz & Seeber L. 1981; Lyon-Caen & Molnar P., 1983). Finally an average value of 6-10 mm/y was in the hypothesis of Zeitler & al. 1985 including uplift and erosion.
The present study presents the preliminary results of a first survey consequent to the recent installation (2009) of GNSS network including three permanent GNSS stations between Islamabad and the Northern Areas of Pakistan and four points located on the Nanga Parbat – Haramosh massif.

Since a permanent GPS station was located near the Pyramid Laboratory at Lobuche in the Khumbu region in 1994 providing long records of data during the last 15 years, the goal of the project is to compare data obtained from Everest with the ones from Nanga Parbat in order to evaluate, not only the total uplift (if quantifiable) of the two massifs, but also the direction of the crustal movements.

Regional Geology and Plate Tectonic Setting

Northern Pakistan comprises three former distinct and previously apart plates named Karakoram, Kohistan and Indian. These Plates collided with each other during Cretaceous-Tertiary ages and formed the present day configuration of this region (Tahirkheli et al., 1982; Coward et al., 1987). This collisional tectonics and mountain-building activity is termed Himalayan orogeny being the result of continent-arc-continent collision. The Kohistan Island Arc is sutured to the Karakoram Block (Shyok Suture) in the north along MKT (Main Karakoram Thrust) and to the Indian Plate (Indus-Tsangpo Suture) in the south. The tectonics of Kohistan is related to collisional tectonics of Hindu Kush, Karakoram and Himalayan Ranges which involve Indian Plate with Nanga Parbat-Haramosh Massif, Karakoram Block and in between sandwiched Kohistan Arc.

Geology of the Nanga Parbat area

Nanga Parbat–Haramosh massif is delimited by two thrust-displacement shear zones that have a spatial and temporal link with granite plutonism from ca. 10 to 1 Ma. The shear zones define a crustal-scale antiformal pop-up structure, with dominant west-northwest–vergent and subordinate east-southeast–vergent thrusting. This is substantially different than the surrounding area where the main exposed Himalayan structures are oriented parallel to the orogenic trend and are early to middle Miocene or older (Schneider et al., 1997). The western Himalaya syntaxis includes the Nanga Parbat–Haramosh massif, a now exposed section of largely Proterozoic Indian plate crust, initially overthrust by Cretaceous island arc rocks along the Main Mantle thrust. Nanga Parbat is an area of extreme relief that has undergone rapid exhumation since 10 Ma (e.g., Zeitler P., 1985), exposing migmatites and granulitegrade rocks at the core of the massif (Smith H.A. et al., 1992). Nanga Parbat syntaxis comprises three major rock units: a) Iskhere-Mushkin-Rupal Gneiss; b) Shengus-Harchu Gneiss; and Haramosh-Tarshing Schists. A wide range of rocks intruding these major lithological units has been noticed in nearly all of Nanga Parbat synaxial region, which included basic dykes and a wide variety of granites. The younger phases of granite up to 0.75 Ma are intruding the Nanga Parbat Gneisses.

The survey of the Mt. Everest mountain range

Fifteen years (unfortunately not continuous) of observations with a permanent GPS station at the Ev-K2-CNR Pyramid Laboratory allow to determine the precise direction of the tectonic movement of the Mt. Everest area. Taking into account several time intervals
linking to the permanent GNSS station in Lhasa, the shift of the point was computed to be of 4.2-4.5 cm/year (Poretti G., 1998) to the North-East with an azimuth of approximately 45°.

A research project carried out between June 2009 and November 2010 is trying to find out the uplift and the direction of the movement of the Nanga Parbat area with the installation of three permanent GPS stations (Islamabad, Gilgit and Skardu) that will be re-measured every year for the next five years.

Conclusions

The aim of the project is to evaluate the variation in elevation and direction of the Nanga Parbat massif and to compare these results with those obtained from Everest in order to understand if their movements can be correlated in amount and direction. After only one year it is seems that the movement of the Nanga Parbat area is more bended to the East, but it is still too early to draw conclusions that are not within the margin of error of the instruments employed. More reliable results will be obtained from the repeated observations during the next 2-3 years.


**Key words:** Nanga Parbat, GNSS net