PRELIMINARY FISSIONTRACK DATA ON THE EFFECTS OF THE SUBDUCTING NAZCA RIDGE ON THE GEOMORPHOLOGY IN SOUTH-CENTRAL PERU

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INTRODUCTION :

The subduction of oceanic lithosphere with strong relief such as a ridge may produce superimposed tectonic effects on continental margins (von Heune et al., 1991). Because these ridges are generally believed to have been sourced at hotspots on or near a midocean ridge, they tend to be aseismic and more buoyant than the surrounding ocean floor. This buoyancy leads to low-angle subduction (Pilger, 1981). Where the ridge bearing flat slab enters the subduction zone it has an initial and profound effect on the geomorphology of the associated trench. Furthermore the subduction of a buoyant aseismic ridge is likely to result in enhanced rates of exhumation of the upper crustal sections of the overlying slab compared to neighbouring areas, and in a rerouting of rivers as the buoyant ridge possibly causes an anomaly in the crustal uplift pattern. It is these effects that we intend to quantify. The Peruvian coast provides an ideal location for such a study as it combines “normal“ subduction of the Pacific Plate with an intervening ridge subduction. The Coastal Batholith in Peru (12-18°S) offers the unique possibility to study the effects on one lithological unit in one climate zone (desert) therefore decreasing the parameters that might influence the results.

Preliminary fission track data from the Lima and the San Juan region suggest a slight variation in ages. Tracklength modeling however show a almost identical uplift history for the two areas. Initial data do not support an effect on the geomorphology caused by the subducting Nazca Ridge. Fast uplift in Late Eocene is followed by reburial and renewed uplift during Miocene time. That fact that the age of the sample from Lima is very similar to the one in San Juan despite the big difference in stratgraphic age suggests that fissiontrack ages were reset along the whole southern Peruvian coast prior to the Eocene. The data further suggests that significant erosion of Eocene and Miocene sediments have taken place in the coastal areas.

CONCLUSIONS :

The Pacific oceanic crust, specifically the Nazca Plate, is being actively subducted eastwards underneath the Andes at a rate of approximately 8 cm per year. Extending along the west coast of South America is a major oceanic trench, the Peru-Chile trench, which is the geomorphological expression of this subducting plate. However, at the coastal margin of central south Peru, between 14 and 15°S, it is almost obliterated where the Nazca Ridge subducts eastwards under the South American continent (Fig. 1). The effects seen on the change in the geomorphology of the trench can be seen on the continent as the bouyant ridge extends underneath. The drainage patterns of the rivers are for example rerouted over the ridge. Further, a very obvious feature is the coastline, which is extended westwards at the point where the northern margin of the ridge meets the trench and the coastal continental geology is different from this point southwards. Here Late Eocene to Recent sediments lie unconformably on the Precambrian Arequipa Massif. The present day subduction angle is segregated into zones of variable dip with a direct correlation to the position of the ridges at the coastal margins. The changes in slab dip are gradual – there do not appear to be sharp tears in the subducting slab. The region in Peru between 12 and 18°S extends from a flat slab to a steeper slab geometry, and includes the region of the advancing Nazca Ridge. Thus, south-central Peru (12-18°S) provides an ideal position for such a study as it combines "normal" subduction of the Pacific Plate with an intervening ridge subduction. The immediately obvious effects of this approaching ridge seen along the trench should also be measurable inland where the bouyant ridge extends eastwards under the Andes. Specifically, we expect youngest low-T exhumation ages to be on the area overriding the ridge and immediately north.

However, because the Nazca plate is subducting at 080°, and the Nazca Ridge is trending 045° the collision point is migrating southwards at about 10cm a^{-1}. Spence et al. (1999) suggest that the subducting Nazca Ridge would provide a continually refreshed topography into the shallow subduction zone. Depending on the response time of the surface evolution the youngest ages will be either over the ridge or in the region north trailing the southern movement. Specifically, because of the SE-ward shift of the zone where the ridge collides with the continent, through time, we expect successively younger exhumation ages in the same direction on the overriding plate. The area south of the ridge, which has not been affected by the buoyancy is expected to yield oldest low-T exhumation ages. In support of this hypothesis geomorphological data reveal a very clear distinction in the drainage patterns. North of the Nazca Ridge, the drainage is directed dominantly normal to the coast in rivers that are broad and that contain abundant aggradational conglomerates. On the ridge, the river system is complex and appears to have been redirected southwards.

In order to test our hypothesis outlined above and by interpreting the ongoing surface processes we are undertaking a program of low temperature thermochronology combined with analysis of digital elevation models. Samples were collected from Lima to Chala in cross sections normal (NE-SW) to the coastline (Fig.1), in order to cover the regions north, on and south of the Nazca Ridge. The altitudes of the samples vary from 0 to 2500 meters above sea level. They are from the Coastal Batholith Cretaceous intrusives and the Precambrian gneisses of the Arequipa massif.

Preliminary fission track data suggest slight variations in ages which however do not seem to be caused due to the passage of the underlying ridge as it traversed from north to south. Fissiontrack data from the Lima region show a bimodal tracklength distribution whereas the data from the San Juan region just on the southern edge of the Nazca Ridge is unimodal. However modeling of the data nonetheless shows a very similar history. For the sample from Lima a rapid uplift in Eocene is followed by burial and renewed uplift in Miocene times is asumed. This fits well with the known Eocene ages of the sediments covering the Batholith northeast of Lima. In the more southern area of San Juan modeling of tracklength data also suggests uplift in the Eocene reburial and uplift during the Miocene. Miocene Sediments of the Pisco Formation east of San Juan support this model. The data further leads to the assumption that considerable amounts of sediments had to be eroded during the last 10 to 15 Ma. Further data will be presented

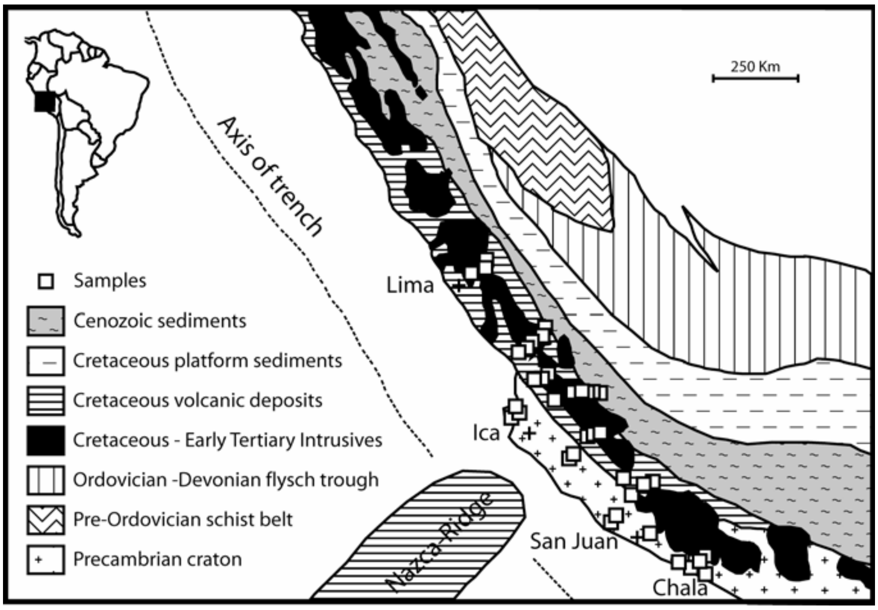

Figure1: Geology of the Southern Peruvian Andes (Pitcher 1978, modified), including sample locations of the present study.

REFERENCES :

Pilger, R.H., (1981): Plate reconstructions, aseismic ridges, and low-angle subduction beneath the Andes. GSA Bulletin, Part I, v. 92, 448-452.

Pitcher W.S., (1978): The anatomy of a batholith. Journal of the Geo. Soc. of London, 135 part 2: 157-182.

Spence, W., Mendoza, C., Engdahl, E.R., Choy, G.L. and Norabuena, E., (1999): Seismic subduction of the Nazca Ridge as shown by the 1996-97 Peru earthquakes. Pure and Applied geophysics, 154: 753-776.

von Heune, R., and Scholl, D. W., (1991): Observations at convergent margins concerning sediment subduction, subduction erosion, and the growth of continental crust. Rev. Geophys, 29: 279-316.