LONG-TERM AND SHORT TERM TECTONIC EROSION AT THE PERUVIAN ACTIVE MARGIN BETWEEN 9°S AND 15°S: EVIDENCE FROM BATHYMETRY DATA AND 3D SANDBOX ANALOGUE MODELLING

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ABSTRACT

Bathymetric, wide-angle and reflection seismic data were acquired between 5°S and 15°S off Peru during RV Sonne cruise SO-146 GEOPECO in spring 2000 to image the Nazca Plate and the continental slope at different latitudes as well as the present collision zone of the Nazca Ridge and the Peruvian trench. Data sets acquired in preparation of ODP Leg 112 and during a French cruise have been added (Fig.).

At 8°S to 9°S, the oceanic crust is extraordinarly rough with a relief of up to 800 m between narrowly spaced highs. Locally, the highs and lows have slope angles steeper than 20°. As the roughness does not increase towards the trench, the structures are inherited and not caused by the bending of the plate. The sediment input along the margin varies, but never exceeds a thickness of about 300 m. The great variety of structures, which are all oblique to the strike of the trench, have different directions and do not seem to be related to each other or the current convergence direction. Surface deformation found at the very steep lower slope occurs at a very small local scale inferring mass wasting and the slope being at failure everywhere. Observed linear trends may result from the oblique convergence direction. The transition to the upper slope is marked by numerous steep gullies. At 10°S, where the Mendana Fracture Zone enters the trench, the oceanic crust is also characterized by high roughness but has a completely different pattern with parallel ridges are crossed by trenchparallel normal faults. The lower slope shows ridge-shaped features that are not related to the directional structures on the plate. At 13°S and 12°S, the Nazca Plate has a rough topography with trench-parallel normal faults. The steep lower slope shows erosional features. The roughness of oceanic plate and lower slope is of small scale, however, compared

to other margins, the latter is still extraordinarily steep and rough. A small wedge is revealed by the wide-angle seismic data. The sea floor of the adjacent mid slope terrace is cut by numerous narrow furrows and canyons which may result from mass wasting through surficial erosion. A probable slump has also been identified in the mapped. On the upper slope, the Lima Basin opens towards the lower slope and comprises a pronounced drainage system.

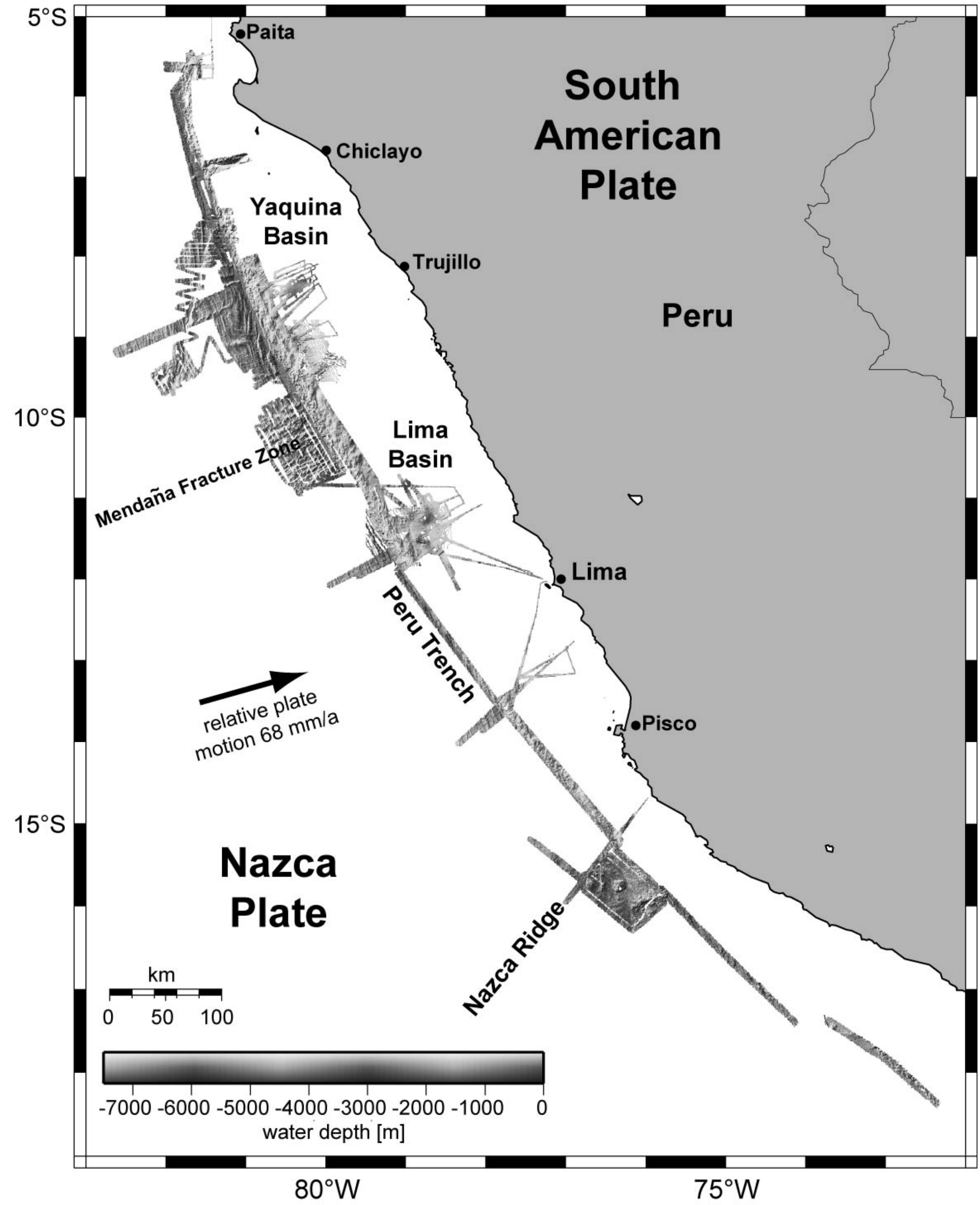

Fig.: Bathymetric data acquired during the RV Sonne cruise SO146-GEOPECO. In the Lima and Yaquina Basin area, data from the French SEAPERC cruise and data collected in preparation of ODP Leg 112 has been added.

Compared to the rough relief of the Nazca Plate, the Nazca Ridge has a rather smooth surface, as imaged at the southeastern flank of the ridge. The sediment cover on the ridge does not exceed a thickness of 300 m. Several volcanic structures of different size and elevation are located on the flank of the ridge. Towards the trench, an increasing number of trenchparallel normal faults caused by the bending of the plate into the subduction zone occur. The trench is characterized by a rugged surface and little to no sediment fill. Where the crest of the ridge enters the trench, the water depth decreases to 5000 to 5300 m compared to a water depth of 6500 m and more south of the intersection area. The lower continental slope is very steep and shows features typical of erosion.

To quantify the roughness of the sea floor, in general several factors contributing to the roughness have to be taken into account: the incremental mean surface slope, the distance coefficient, i.e. the ratio of surface length to base line length, the magnitude of the peaks and the void volume. A comparison between bathymetric profiles at different latitudes shows that they have a steep slower slope, escarpements and basins in common, but that their roughness differs significantly. The roughness of the oceanic crust increases from south to north and is significantly higher than at the Nazca Ridge. As the oceanic crust is older in the south than in the north, the roughness of the oceanic crust is not a function of the age. High values of distance coefficients indicating high rouhgness coincide with sections that have a steep slope. Towards the shelf, the slope angle variations and distance coefficients decrease, with exception of the areas around the escarpements.

The bathymetry data set is the base for characterizing the mechanics of the Peruvian margin. In terms of the taper stability field, the margin can be classified as near or at failure everywhere. To further determine the parameters which control the mechanics of the margin, 3D sandbox experiments with an accretive phase at the beginning and an erosive phase afterwards have been carried out. In an experiment with 20° obliquity, which simulates the setting off central Peru, with high basal friction and no sediment input produces an wedge that is at failure throughout. The effect of the oblique convergence direction is not very pronounced. The slope shows a morphology, e.g. escarpements, that is characteristic for a erosive regime. Small ridges of similar size as the structures at 9°S that have been attached to the subducting "plate" are not mirrored in the slope during their subduction.

The analogue experiments suggest that long term tectonical erosion is governed by the nature of the plate interface in absence of sediment supply. The conditions for tectonic erosion are a large dip of the subducting plate, a steep lower slope, no sediment input and high sea floor roughness accompanied by surficial wass masting and the development of a characteristical morphology of the slope (e.g. escarpements). All these factors are met off Central Peru. Therefore, this margin can be classified as long term tectonically erosive. Regarding the tectonic evolution of the Peruvian margin, the Nazca Ridge has caused short term erosion of the continental slope, however, this effect is superposed on a long-term tectonic erosion.