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Geomorphic Effects in Western Peru due to Subduction of the Nazca Ridge

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The subduction of oceanic lithosphere with strong relief, such as ridges may induce superimposed tectonic and geographic effects on continental margins which are different than effects caused by the subduction of the surrounding "normal" oceanic plate von Heune et al., (1991). These ridges and seamounts are generally believed to have been sourced at hotspots on or near a mid-ocean ridge and tend to be aseismic and more buoyant than the surrounding ocean floor. Pilger et al., (1981) suggested therefore that this buoyancy will lead to low-angle subduction. Jordan et al., (1983) later commented that the dip of the subduction angle may control the topography and geology of the overlying area.

The area of the Peruvian coastal margin offers unique possibilities to study the interaction of the different processes involved. The Nazca Ridge located on the oceanic Nazca Plate is being subducted in an essentially east-west direction underneath the South American Plate. There is a clear trend towards a south east passage of the collision zone over the last 10-12 Myrs. The subduction of the ridge is thought to result in enhanced exhumation rates of the upper crustal section overlying the slab in comparison to neighbouring areas. Additionally it has been proposed that tectonic erosion would be enhanced in areas affected by ridge subduction Hampel et al., (2004). This might lead to further modifications of the coastal areas such as enhanced subsidence following passage of the ridge. Drainage patterns are likely to record at least some of these changes. Spence et al., (1999) therefore suggested that “the subducting Nazca Ridge would provide a continually refreshed topography over the shallow subduction zone“.

In order to test and quantify the processes a Digital Elevation Model was created, covering the area of the Peruvian coastal margin extending from 9˚ to 18˚S and from 73˚ to 79˚W. Four ridge parallel swaths were chosen with a width of 60km each covering areas north, over and south of the ridge. Within these swaths the minimum, the maximum and the mean altitude were determined. To perform analysis of the geomorphology three areas of similar size were selected. They cover coastal sections north, over and south of the current position of the Nazca Ridge. For these three regions a topographic grain analysis was performed to reveal the preferential flow direction of rivers.

South of the ridge a surprisingly uniform slope rises from the deep sea trench up to the Western Cordillera at almost 5000 meters. At the coastal margin beween 14˚ and 15˚S, the Peru-Chile trench is almost obliterated as the Nazca Ridge subducts southeastwards under the South American continent. Onshore a 900 meter high Coastal Cordillera is formed and an almost 100 km wide coastal plain dominates. As the coastline trailing to the North subsides the coastal plain submerges increasingly.

In South Peru rivers flow primarily perpendicular to the coast. Due to the ridge-induced uplift of the coastal plain in central Peru the rivers are forced to change direction resulting in three main directions towards the South, Southwest and West. North of the ridge the drainage pattern is more diffuse. Directions range from South to West but no longer have strong preferential orientations. However an additional coast-parallel component flowing towards the Northwest is recognised. This is in perfect agreement with the subsiding coastline of the trailing the ridge. This geomorphological analysis supports the notion that subduction of the Nazca Ridge leaves a clear signature in the evolution of the Peruvian coastal topography.