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Seismotectonic segmentation of an active forearc region: Tectonic geomorphology of the Nahuelbuta Range region, Southern Chile (37.5˚-38.5˚S)

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The cause for seismotectonic segmentation of plate margins, especially in forearc environments is an unsolved problem in many tectonically active convergent margins. It is not known, for example over what timescales identified segment boundaries prevail as structural entities and which role they play in earthquake-rupture terminations. In Southern Chile, great earthquakes are forming rupture zones of up to 1000km length. Repeated ruptures and intervening seismic gaps document the propagation of displacement along seismotectonic blocks as well as their segmentation.

Here, we investigate the longevity of forearc segmentation to assess segment boundaries and their potential to infer past seismogenic deformation processes from long-term geomorphic evolution. Remote sensing and field studies of the Nahuelbuta Range show that the long-term deformation of the Chilean forearc is manifested by breaks in topography, sequences of differentially uplifted marine, alluvial and strath terraces as well as tectonically modified river courses and drainage basins.

We used SRTM-90-data as basic elevation information for extracting and delineating drainage networks. We calculated hypsometric curves as an indicator for basin uplift, stream-length gradient indices to identify stream segments with anomalous slopes, and longitudinal river profiles to identify knickpoints and other anomalies. In addition, we generated planimetry and relief indices as morphometric primary variables and identified old erosion surfaces by investigating topography with elevation-slope graphs, profiles, and DEMs.

Our preliminary analysis of the Coastal Cordillera indicates a clear segmentation between the northern and southern parts of the Nahuelbuta Range. The Lanalhue Fault, a NW-SE striking fault zone oblique to the plate boundary, defines the segment boundary. Furthermore, we find a complex drainage re-organisation in such as reversals in the Tirúa and Repocura basins. This includes a wind gap on the divide between these two basins east of the town Tirúa. The coastal basins lost most of their Andean sediment supply areas that existed in Tertiary and in part during early Pleistocene time. Between the Bío-Bío and Imperial rivers no Andean river is recently capable to traverse the Coastal Cordillera, suggesting ongoing Quaternary uplift of the entire range. From the spatial distribution of geomorphic surfaces in this region two uplift signals may be derived: (1) a long-term differential uplift process, active since the Miocene and possibly caused by underplating of subducted trench sediments, (2) a younger, local uplift affecting only the northern part of the Nahuelbuta Range that may be caused by the interaction of the forearc with the subduction of the Mocha Fracture Zone at the latitude of the Arauco peninsula.

Our approach thus provides results in our attempt to decipher the characteristics of seismotectonic segmentation of active convergent margins using long-term geomorphic indicators. Furthermore, it is expected that our ongoing assessment will eventually constrain repeatedly active earthquake-rupture zones.