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Active shortening, surface deformation and Late Neogene coastal geomorphology of the Arauco Region, Chile

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Introduction

The south-central coast of Chile is affected by large subduction earthquakes that have successively ruptured three main seismotectonic segments in the past: the Valparaiso, Concepción, and Valdivia segments (e.g., Lomnitz, 1970). We focus on the Arauco Peninsula, located within the overlap between the Concepción and Valdivia segments. This area corresponds to a geophysical, geomorphic, and structural anomaly. We use geomorphic analysis, ^{14}C dating, crustal seismicity (Bohm et al., 2002) and industry offshore seismic reflection lines provided by ENAP, Chile, to show that crustal-scale seismogenic faults bound the peninsula and control the evolution of late Quaternary coastal landforms in the Isla Mocha-Arauco-Concepción area. Furthermore, our field observations and interpretation of seismic reflection lines reveals syntectonic sedimentation documenting ongoing shortening since the late Pliocene and that extensional faults at surface represent complex systems of hinge grabens reflecting bending-moment strain and local gravitational collapse associated with folding and uplift.

Crustal-scale reverse faults - seismic reflection profiles

The ENAP offshore seismic reflection lines cover the continental shelf of the Arauco region. Our interpretation of these lines reveals high-angle blind reverse faults, associated fault-propagation folds, and related syntectonic sequences. The seismic stratigraphy correlated with ENAP boreholes (Mordojovich, 1981) and the geometry of growth strata documents ~8% of late Pliocene to Recent shortening and landward migration of the deformation. Our mapping of these structures coincides with the coastal geomorphology and shows that the Arauco Peninsula is bounded by NW-striking structures to the south, and NE-striking faults to the north. This convergence focuses shortening and surface uplift, ultimately resulting in the emergence of the Arauco Peninsula during the Quaternary.

Surface deformation and crustal faulting

The highest coseismic uplift during the last two M>8 earthquakes (Darwin, 1851; Plafker and Savage, 1970) occurred in the areas where the highest late Quaternary uplift rates have been reported, at Isla Mocha ~5 m/ka (Nelson and Manley, 1992), and Isla Santa Maria ~3 m/ka (Melnick et al., 2004). Moreover, our mapping of offshore seismic lines and field observations shows that reverse faults control the uplift and geomorphological evolution of these islands and of the elongated peninsulas in the area (Melnick et al., 2004). These observations demonstrate that megathrust earthquakes can trigger faults in the upper plate, which in turn exert a control on the distribution of surface deformation during and between such events. Therefore, these faults must be taken into account when inverting geodetic data into slip on the plate interface thrust. Such upper plate faults may contribute to the inconsistence between slip values obtained for the 1960 event (Barrientos and Ward, 1990) and the slip budget expected from the plate convergence rate and historic earthquake recurrence (Stein et al., 1986).

The Arauco Peninsula is an integral part of the Nahuelbuta range, which is cored by Paleozoic granites intruding Paleozoic metamorphic basement. NW-striking ductile shear zones from the late Paleozoic represent crustal-scale discontinuities bound the Arauco peninsula (Echtler et al., 2002). These shear zones are overprinted by brittle faulting thus, we infer that they have been reactivated during the Tertiary and Quaternary aiding forearc segmentation and localizing uplift over an area where underthrusting of sediments and related uplift may occur.

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References

Barrientos, S., Ward, S. 1990. The 1960 Chile earthquake – Inversion for slip distribution from surface deformation. Geophysical Journal International, 103, 589-598.

Bohm, M., Lüth, S., Echtler, H., Asch, G., Bataille, K., Bruhn, C., Rietbrock, A., Wigger, P. 2002. The Southern Andes between 36° and 40°S latitude: seismicity and average seismic velocities. Tectonophysics, 356, 275-289.

Darwin, C. 1851. Geological observations on South America. Smith, Elder and Co., London. 768 p.

Echtler, H., Glodny, J., Gräfe, K., Rosenau, M., Melnick, D., Seifert, W. y Vietor, T. 2003. Active tectonics controlled by inherited structures in the long-term stationary and non-plateau South-Central Andes. EGU/AGU Joint Assembly. Nice April 2003, EAE03-A-10902.

Lomnitz, C. 1970. Major earthquakes and tsunamis in Chile during the period 1535 to 1955. Geologische Rundshau, 59, 938-960.

Melnick, D., Bohm, M., Bookhagen, B., Echtler, H., Krawcyk, C, Manzanares, A., Moreno, M., Strecker, M. 2004. Active Faulting, Surface Deformation and Subduction Earthquakes at Isla Santa Maria, South-Central Chile. Eos Trans. AGU, 85(47), Fall Meet. Suppl., Abstract T13C-1380.

Mordojovich, C. 1981. Sedimentary basins of Chilean Pacific Offshore. In: Halbouty, M.T. (ed.): Energy Resources of the Pacific Region.- American Association of Petroleum Geologists Studies in Geology. Vol. 12, p. 63-82.

Nelson, R., Manley, W. 1992. Holocene coseismic and aseismic uplift of the Isla Mocha, south-central Chile. Quaternary International, 15/16, 61-76.

Stein, S., Engeln, J.E., DeMets, C., Gordon, R.G., Woods, D., Lundgren, P., Argus, D., Stein, C., Wiens, D.A. 1986. The Nazca-South America convergence rate and the recurrence of the great 1960 Chilean earthquake, Geophy. Res. Lett, 13, 713-716.

Plafker, G., Savage, J.C. 1970. Mechanism of the Chilean earthquake of May 21 and 22, 1960. Geological Society of America Bulletin, 81, 1001-1030.