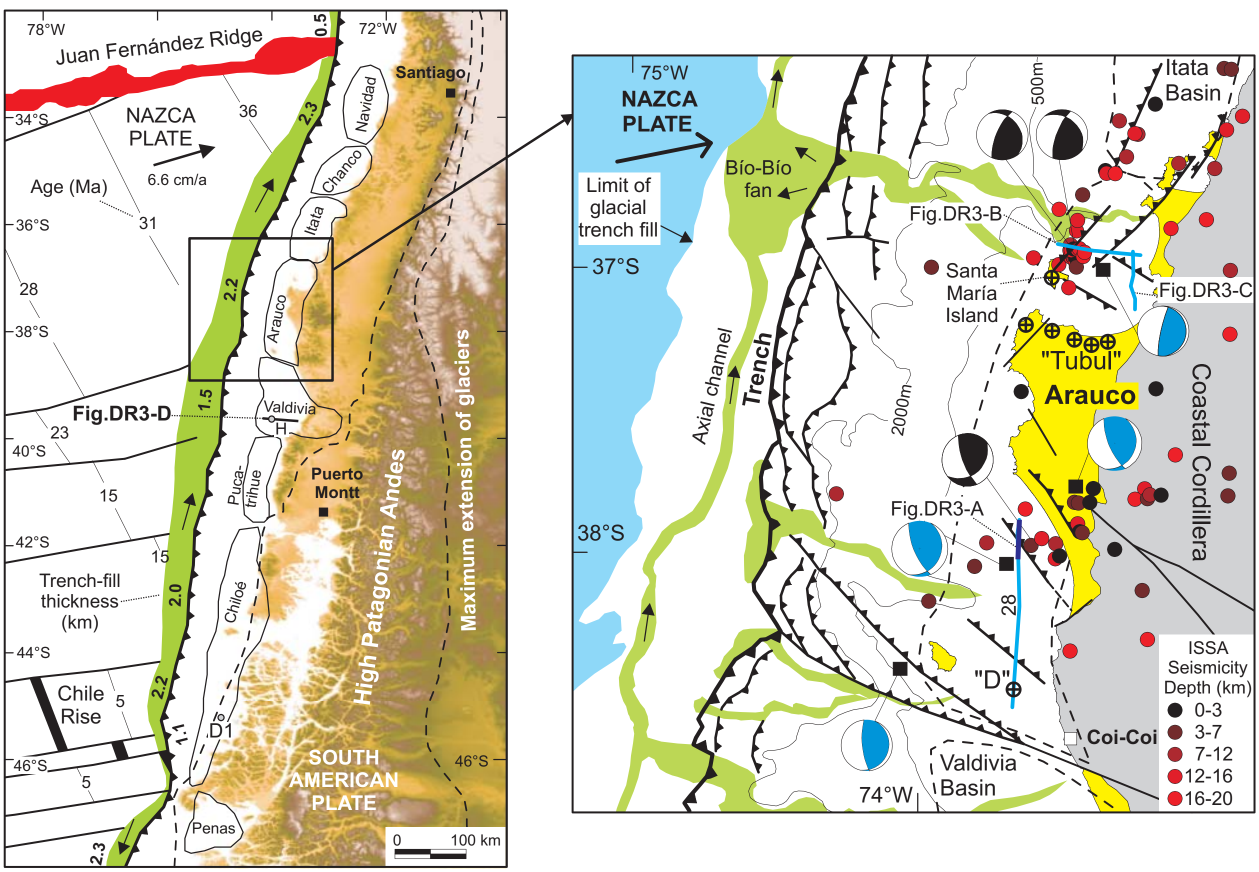
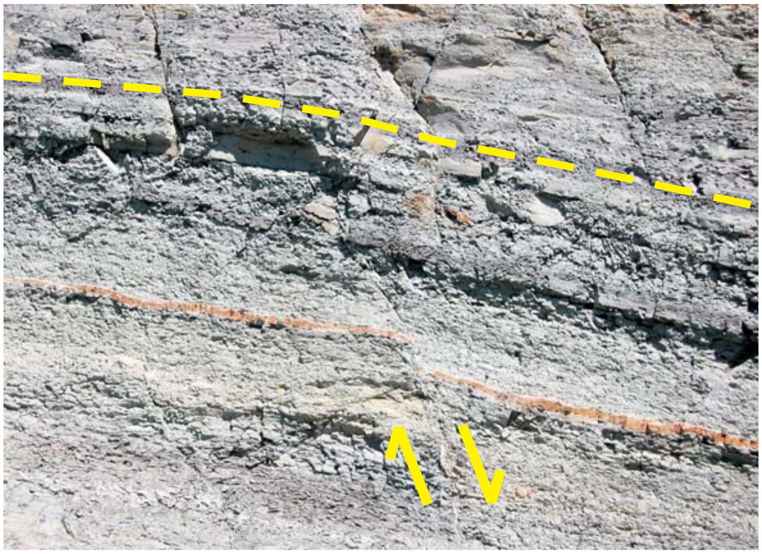
Methods and data sources

Structural field observations were combined with time-migrated reflection-seismic profiles obtained from ENAP (Empresa Nacional del Petróleo - the Chilean state oil company), and published stratigraphic, sedimentologic, and paleontologic data from forearc basins in south-central Chile (García, 1968; Biró, 1979; Pineda, 1986; Martínez-Pardo, 1990; Le Roux and Elgueta, 1997; Le Roux and Elgueta, 2000; Nielsen and DeVries, 2002; Finger et al., 2003; Nielsen et al., 2004; Encinas et al., 2005; Nielsen, 2005; Finger et al., 2006). About forty reflection profiles were inspected and the seismic stratigraphy of selected lines was correlated with the available exploration boreholes from ENAP (Mordojovich, 1974; Mordojovich, 1981; González, 1989; Arcos and Elgueta, 1993). Multibeam bathymetry and depth-migrated reflection profiles from the trench and slope regions (Reichert et al., 2002; Rauch, 2005) were used to interpret along-strike variability and deformation of the trench fill. Crustal seismicity and focal mechanisms from the ISSA (Integrated Seismological experiment in the Southern Andes) temporary network in the Arauco region were integrated with data from the NEIC and USGS catalogues and reflection profiles to identify active faults and define the present-day stress regime of the forearc. The ISSA experiment deployed 62 three-component broadband instruments and 16 OBH/OBS between January and March 2000 in the 36-40°S region (Bohm et al., 2002; Bruhn, 2003; Bohm, 2004). Recent data from the TIPTEQ network, which deployed 140 onshore stations and 30 OBH/OBS in the same region and has been operating since November 2004, shows that the faults identified with the ISSA data (Melnick et al., 2005) continue its strong activity nucleating up to mb=5.2 shallow events (Rietbrock et al., 2005).



Regional map of forearc basins in south-central Chile and tectonic setting of the Arauco Basin. Location of ENAP seismic-reflection profiles shown in Figures 2 and DR3. ENAP exploration wells used to correlate the seismic stratigraphy are also shown (Mordojovich, 1974; Mordojovich, 1981; González, 1989; Arcos and Elgueta, 1993). Trench and slope interpreted from SPOC swath bathymetry and depth-migrated reflection profiles (Reichert et al., 2002; Rauch, 2005), shelf from ENAP seismic-reflection profiles and coastal exposures (Melnick et al., 2005). Depth-coded seismicity and black focal mechanisms from the ISSA network (Bohm et al., 2002; Bruhn, 2003). Blue focal mechanisms from shallow (<15 km) earthquakes of the NEIC and USGS catalogues.

Figure DR1

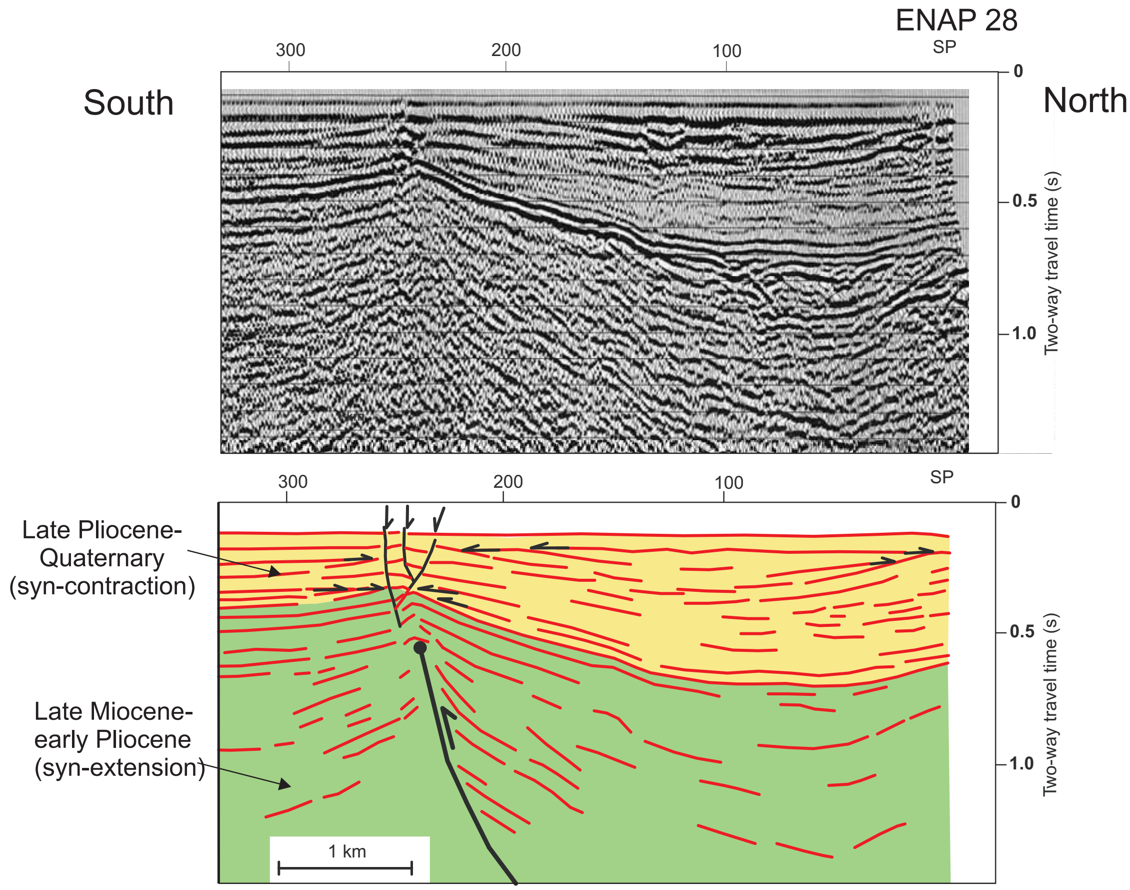


Syntectonic deposition accross a normal fault in the late Miocene-early Pliocene lower bathyal siltstones of the Ranquil Formation. Stratigraphy and age in this region studied by Encinas et al. (2005), Finger et al. (2003), Nielsen et al. (2004), Nielsen (2005) and Finger et al. (2006). Slip is 0.5 meters.

Syntectonic deposition accross a normal fault in near-shore, coal-bearing facies of the Eocene Trihueco Formation. Stratigraphy and age studied by Pineda (1986) and LeRoux and Elgueta (1997).

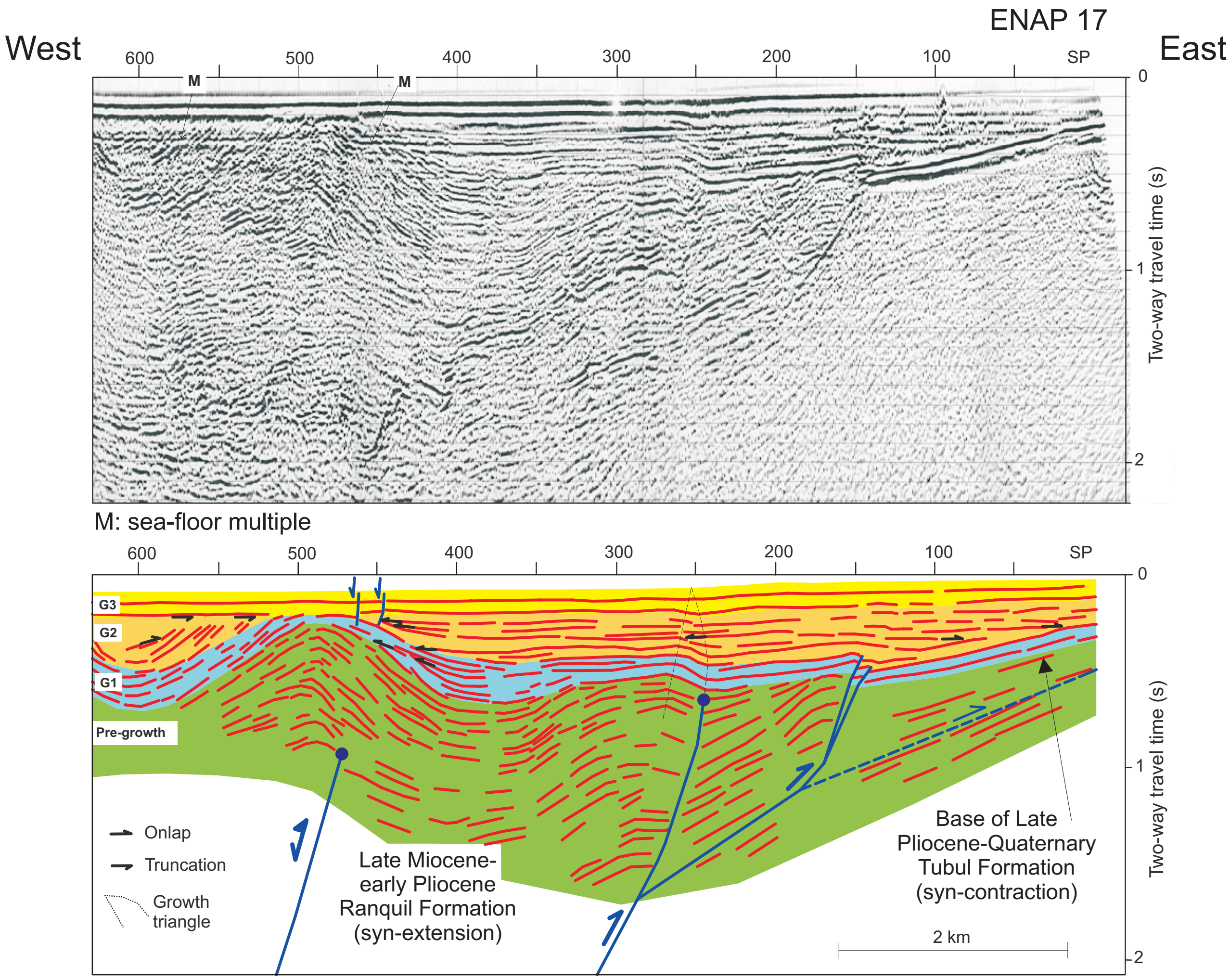
Unconformity between the late Miocene-early Pliocene lower bathyal siltstones of the Ranquil Formation and late Pliocene-Pleistocene near-shore sandstones of the Tubul Formation, Arauco Basin, in the area studied by García (1968), Biró (1979), Pineda (1986), Finger et al. (2003), Nielsen et al. (2004), Encinas et al. (2005), Nielsen (2005) and Finger et al. (2006). The stem lying on the beach is 3 meters long.

Figure DR2



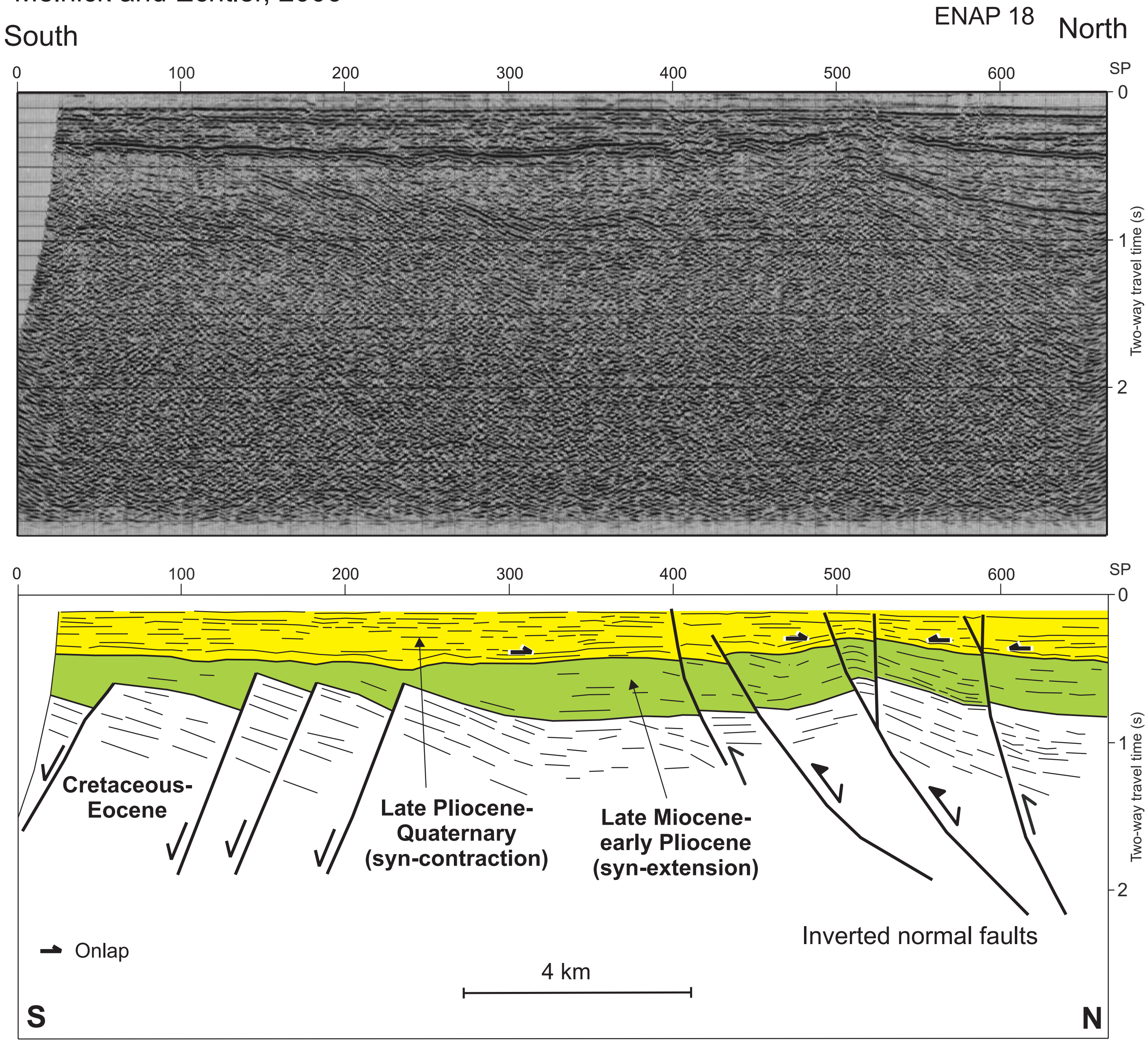
ENAP reflection-seismic Profile 28 is north-south–oriented and located south of the Arauco Peninsula. The image shown here corresponds only to the northern part of the profile (see Fig. DR1 for location). The stratigraphy is correlated with ENAP borehole 'D', located farther south along the same line (Mordojovich, 1981; González, 1989; Bangs and Cande, 1997). Profile 28 images the late Miocene-early Pliocene Ranquil Formation, which is formed by parallel discontinuous reflectors, unconformably overlain by the late Pliocene-Quaternary Tubul Formation. The latter unit exhibit onlaps, thickness increase of continuous reflectors and a wedge-top geometry. In this light, the Ranquil unit is interpreted as a pre-growth unit and the Tubul Formation as syngrowth sequence. Here, syntectonic deposition has been controlled by a northwest-striking, landward-dipping reverse fault that blinds at ~0.5 s depth (two-way travel time) propagating an anticline. A small hinge graben developed at the tip of the anticline, probably reflecting bending-related extension. Shallow seismicity of the ISSA and TIPTEQ temporary networks cluster below this structure, and focal mechanisms are compatible with shortening along a northwest-striking fault. Continuous syntectonic deposition of the Tubul Formation indicates that shortening has be steady since the late Pliocene.

Figure DR3-A



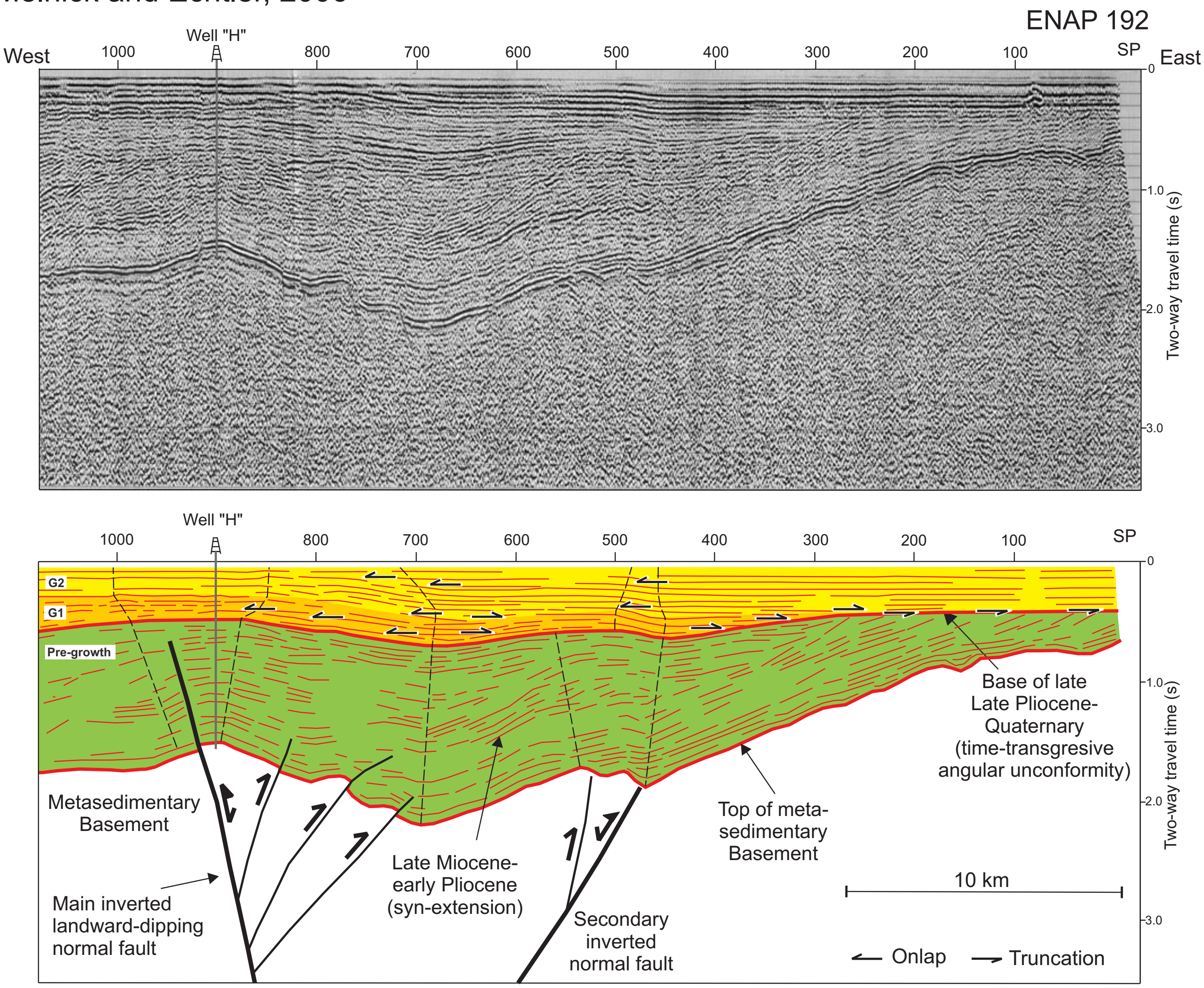
ENAP reflection-seismic profile 17 is east-west–oriented and located in the Arauco Bay area, immediately north of the Santa María Island (see Fig. DR1 for location). This profile images a thrust-top basin filled by the late Pliocene-Quaternary Tubul Formation. Syntectonic deposition has been controlled by a master seaward-dipping reverse fault and two splaying branches forming a ramp-flat-ramp structure. The pre-growth basal unit has no internal truncations nor thickness change and is overlain by the syntectonic sequence. We differentiate three growth units in this sequence (G1,G2,G3), which reveal eastward propagation of the deformation coeval with slip along the western master fault, and continuous deformation since the Late Pliocene. The inflection of the axial surfaces, or kink bands, above the monocline at SP 150 define the onset of growth. The apex of this growth triangle is at the present surface, which is depositional, and allows to infer that this structure is actively growing (Suppe et al., 1992). Two small normal faults are located above the anticline at shotpoint 450, interpreted as bending-related extension.

Figure DR3-B



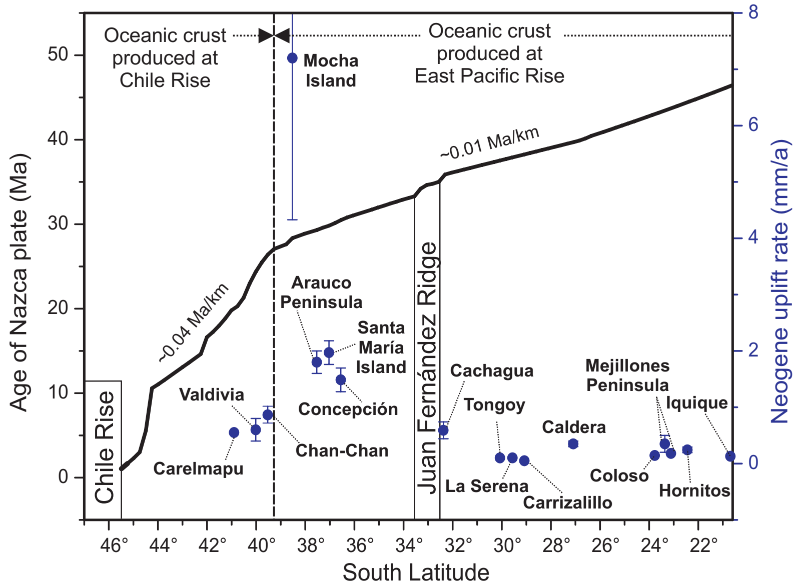
ENAP reflection-seismic profile 18 is north-south–oriented and located in the Arauco Bay area east of the Santa María Island (see Fig. DR1 for location). In the southern sector, between shotpoints (SP) 50 and 250, this profile images south-dipping normal faults displacing the Eocene Millongue and late Miocene-early Pliocene Ranquil Formations, which are unconformably covered by subhorizontal sediments of the late Pliocene-Quaternary Tubul Formation. The stratigraphy has been correlated with ENAP wells Tubul-1 and Tubul-Este-1 (Arcos and Elgueta, 1993), which are located immediately to the south onshore (see Fig. DR1 for location), as well as exposed rocks along the coast to the east and a borehole at Santa María Island. Synextensional deposition of the late Miocene-early Pliocene Ranquil Formation deposition occurred in half-grabens bounded by domino-like south-dipping normal faults. In the northern sector, reverse faults and folds affect the sequence between SP 400 and 600, which we interpret as inverted domino-like normal faults similar to the faults imaged in the southern sector but with an opposite dip angle. The late Pliocene-Quaternary unit exhibits growth strata above these faults and folds. In this sector of the Arauco Basin, late Miocene-early Pliocene deposition occurred in two hemigrabens with opposite polarity limited by a central horst. Only the northern hemigrabens were inverted during late Pliocene-Quaternary compression. Some of the reverse faults seem to cut the uppermost reflectors indicating recent activity.

Figure DR3-C



ENAP reflection-seismic Profile 192 is east-west–oriented and located in the Valdivia Basin (see Fig. DR1 for location). This profile was originally interpreted by Mordojovich (1981, Fig. 13), but our structural understanding differs. The stratigraphy is constraint by borehole "H", which reached the Paleozoic metasedimentary basement at a depth of 1717 m below the sea floor. We interpret that a main landward-dipping normal fault, located at shotpoint (SP) 900, controlled extension and subsidence during deposition of the late Miocene-early Pliocene unit, which increases in thickness toward the center of the basin at SP 700. A secondary normal fault was probably located at SP 500. Tectonic shortening produced inversion of the normal fault at SP 900, as the reflectors at the base of the late Miocene unit are clearly offset in a reverse sense. An anticline developed in the hanging wall and three shortcutting secondary structures that offset the base of the Miocene unit as well. Two small flexures formed above the faults at SP 500. Basin inversion is recorded by the late Pliocene-Quaternary unit, which exhibits onlaps, thickness increase, and upward decreasing dip angles, interpreted as syntectonic deposition coeval to shortening. We differentiated two growth sequences, G1 and G2. The first is related to slip along the main fault at SP 900 and growth of the above-lying anticline. The base of this sequence onlaps against the late Miocene unit between SP 400 and 250. Sequence G2 is related to activity of both the main fault at SP 900 and the secondary fault at SP 500. The base of this sequence truncates the Miocene unit east of SP 200 forming a time-transgressive angular unconformity (Suppe et al., 1992), which we relate to syndeformation erosion prior to the onset of late Pliocene deposition. The inflection of kink bands denote the onset of shortening.

Figure DR3-D



Age of the Nazca plate at the trench and Neogene uplift rates along the coast of Chile. Uplift rates decrease north of the Juan Fernández Ridge, which we relate to the lack of significant trench fill and subduction erosion. No clear correlation between slab age and coastal uplift rate is observed in these data. The kink in the age curve is caused by the transition between oceanic crust formed at the Chile Rise to the south and at the East Pacific Rise to the north (Tebbens and Cande, 1997). Uplift rates compiled from: Carelmapu - Atwater et al. (1992); Valdivia - Pino et al. (2002); Chan-Chan - Pino and Navarro (2005); Mocha Island - Kaizuka et al. (1973), Radtke (1989), Nelson and Manley (1992); Arauco - Kaizuka et al. (1973) and Melnick et al. (2005); Isla Santa María - Melnick et al. (2005), Bookhagen et al. (2005); Tongoy - Le Roux et al. (2006); Carrizalillo - Le Roux et al. (2005); Caldera - Marquardt et al. (2004); Mejillones Peninsula - Ortlieb et al. (1996a), Marquardt (2005); Hornitos - Ortlieb et al. (1996b); Concepción, La Serena, Cachagua, Coloso, Iquique - Radtke (1989). Age of the Nazca plate from Müller et al. (1997).

Figure DR4

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