EXTENSIONAL STRESS REGIME IN THE ANTOFAGASTA COASTAL AREA (NORTHERN CHILE)

B. DELOUIS[1], H.PHILIP[2], L. DORBATH[1,3]

1. Institut de Physique du Globe, 5 rue R. Descartes, 67084 Strasbourg-Cedex, France
2. Lab. de Géophysique et de Tectonique, Univ. Sci. Tech. Languedoc, Pl. E. Bataillon, 34060 Montpellier-Cedex, France
3. ORSTOM, 213 rue La Fayette, 75480 Paris-Cedex 10, France

KEY WORDS : neotectonic, Atacama Fault System, stress regime

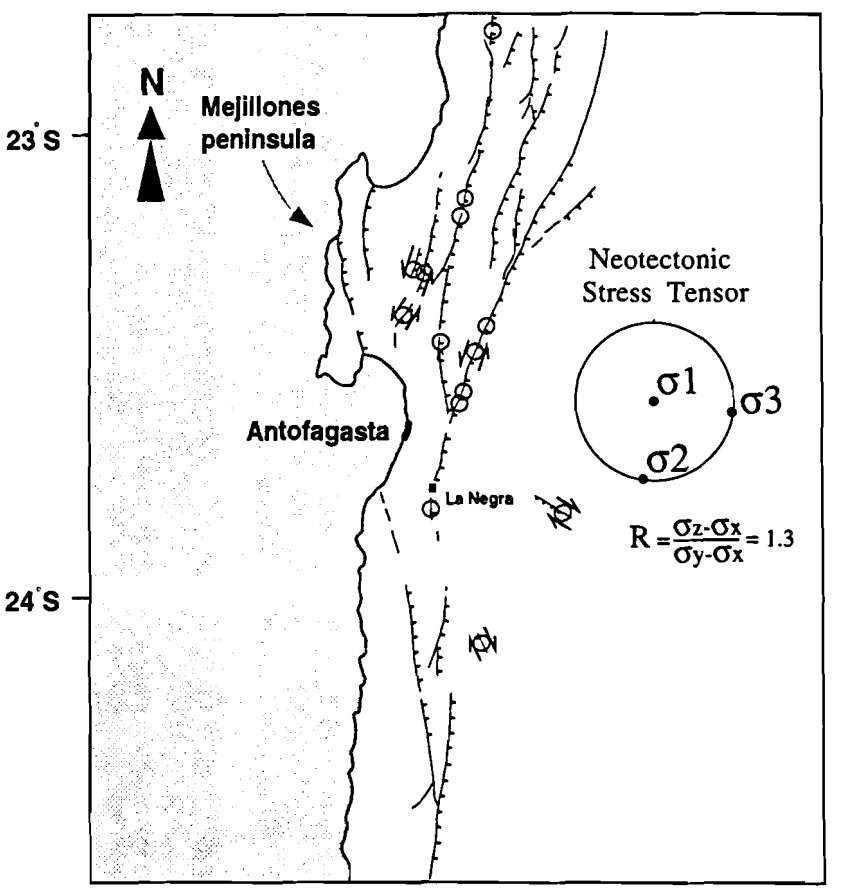
Recent works in the area have demonstrated that the Atacama Fault System has undergone left-lateral displacement contemporaneous with the development of the Jurassic - early Cretaceous magmatic arc in the present coastal cordillera (Naranjo et al., 1984; Herve, 1987a; Thiele and Pincheira, 1987; Scheuber and Andriesen, 1990). It has been indicated that part of the Atacama Fault System has been reactivated since late Tertiary with a dominant vertical componant of displacement (Arabasz, 1971; Okada, 1971; Herve, 1987b; Naranjo, 1987). Armijo and Thiele (1990) showed that many faults are presently active in the region. Acording to Armijo and Thiele (1990)' s work normal faults would characterize only the westernmost part of the coastal area, in particular the Mejillones Peninsula and the coastal scarp, though left-lateral displacement would be predominent along the Atacama Fault System near Antofagasta. However, an extensive study of aerial photographs covering the Antofagasta region lead us to think that normal faulting is indeed dominant in the whole coastal region, including the Atacama Fault System in the coastal cordillera. A neotectonic Field work has been designed to acquire an overview of the fault kinematics in the area, concentrating in places where faults cut into alluvial formations.

Field observations confirm that normal faulting prevails, although horizontal components of relative displacement, both left-lateral and right-lateral, are observed at some places. The orientation of pure normal faults ranges between N350° and N20°. Tensile cracks are often observed parallel to the main scarp of those faults. The lateral component is observed to vary with the azimuth of the faults. Faults oriented more towards the NW-SE have a right-lateral component while those oriented more to the NE-SW have a left-lateral component. Therefore, the component of relative displacement varies quite coherently with the strike of the faults and is indicative of EW extension. To quantify the stress regime we applied to the field observations an algorithm of inversion of the stress tensor orientations and shape factor. Results clearly indicate an extensional stress regime with the σ_3 (minimum stress compression) horizontal, striking in the EW direction, and σ_1 (maximum stress compression) vertical . Figure 1 shows the main studied faults. Sites where relative displacement could be accounted for without ambiguity and which where included in the stress tensor inversion are indicated by the small circles.

Normal faulting is attested too by the widespread 'half-graben' structure observed at the decakilometric scale. Footwall scarps commonly reach a height of several hundreds of meters. A modelization of the topography has been carried out over an area where several 'half-graben' interacts, forming a sequence of westward tilted blocks, using a simple model consisting of faults

embedded in an homogeneous elastic medium. The angle of the slip vector on the faults is given by the stress tensor found above. On the other hand, the amount of slip in each fault segment has been determined by a trials and errors procedure so has to obtain a good fit between the observed topography and the calculated surface deformation. Though many aspects of the tectonic processes are neglected in this simple model, such as isostasy, erosion, sediment filling and viscous relaxation of stresses at depth, the actual topography could be reasonably well fitted if we add to the topographic effect of the faults a regional topographic trend. Our simple model does not pretend to unicity but shows how the characteristic short wavelentgh (10-20 km long) features of topography in the area can be controled by the known big faults, under EW extention.

THE EXTENSIONAL STRESS REGIME IN THE ANTOFAGASTA COASTAL AREA



O : place of neotectonic data for stress inversion

Figure 1 : main studied faults in the Antofagasta coastal area. Ticks indicate the downthrow direction of normal faulting. Double arrows indicate the horizontal component of displacement at places where it has been locally observed.

The forearc region near Antofagasta seems to have been under an extensional tectonic regime for a long time (since Miocene ?). The erosional rate in this desertic region is particularly slow and allows an exceptional preservation of the tectonic structures. However, some scarps much fresher than others attest of repeated ruptures under EW extension in the very recent (historical ?) time. Field observations show the compatibility of faulting in the whole coastal area, up to 40-50 km East of the coast, with the EW extension. The existence of an extensional stress regime at a convergent plate boundary may seem contradictory. However, extension may occur as a local modification of the general compressional state caused either by some crustal bending effect or by a transient disturbance of the stress field following the occurrence of very strong subduction earthquakes.

REFERENCES

Arabasz, W.J., 1971. Geological and geophysical studies of the Atacama Fault Zone in Northern Chile. Ph.D. Thesis, California Institute of Technology, 264 p. Pasadena, U.S.A.

Armijo, R. and Thiele, R., 1990. Active faulting in northern Chile: ramp stacking and lateral decoupling along a subduction plate boundary ? Earth and Planetary Science Letters, 98 : 40-61.

Hervé, M., 1987a. Movimiento sinistral en el Cretacico inferior de la zona de falla Atacama al Norte de Paposo (24°S), Chile. Revta geol. Chile, 31: 37-42.

Hervé, M., 1987b. Movimiento normal de la falla Paposo, zona de falla Atacama, en el Mioceno, Chile. Revta geol. Chile, 31: 31-36.

Naranjo, J. A., 1987. Interpretation de la actividad Cenozoica superior a lo largo de la zona de falla de Atacama, Norte de Chile. Revista geol. Chile 31, 43-55.

Naranjo, J. A., Hervé F., Prieto, X., Munizaga, F., 1984. Actividad Cretacica de la falla Atacama al Este de Chanaral: milonitizacion y plutonismo. Comucicaciones Univ. de Chile, Santiago.

Okada, A., 1971. On the neotectonics of the Atacama fault zone region - Preliminary notes on Late Cenozoic faulting and geomorphic development of the Coast Range of Northern Chile . Bull. Dep. Geogr., Univ. of Tokyo, 3: 47-65.

Scheuber, E., and Andriessen, P., 1990. The kinematic and geodynamic significance of the Atacama fault zone, northern Chile. Journal of Structural Geology, 12: 243-257.

Thiele, R., and Pincheira, M., 1987. Tectonica transpresiva y movimiento de desgarre en el segmento Sur de la zona de falla Atacama, Chile. Revta geol. Chile, 31: 77-94.