TECTONIC TRANSPRESSION ALONG THE SOUTHERN SEGMENT OF THE ATACAMA FAULT-ZONE, CHILE

M. Pincheira[1], R. Thiele[2], L. Fontboté[1]

[1]Mineralogisch-Petrographisches Institut. INF 236. 6900 Heidelberg, West Germany; [2]Departamento de Geologia y Geofisica, Universidad de Chile, Casilla 13518, Correo 21, Santiago, Chile

Resumen

Los análisis cinemático y de esfuerzo-deformación de las megafallas Los Colorados y La Sosita-Huantemé, las cuales son representativas del segmento sur de la Zona de Falla Atacama, sugieren una dinámica de fallamiento transpresivo, con movimiento sinistral, asociada a la evolución del margen Pacífico de Sudamérica. Ambas megafallas son el resultado de un cizallamiento regional, convergente, primario, según una dirección N20°E

Key Words:Tectonic transpression, Atacama Fault, Lower Cretaceous, Chile

Introduction. This paper analyses the generation and evolution of an area, considered to be representative of the southern segment (28°-29°S) of the Atacama-Fault-Zone (AFZ). The studied area is located at the eastern flank of the Coastal Range, where the AFZ control the distribution of the major iron-mines of the region.

The region comprises volcanic and sedimentary rocks of Lower Cretaceous age. These sequences were deposited at the transitional zone between a volcanic-arc and a back-arc-basin. Overlaying and interfingering from volcanic and calcareous rocks is usual. The Lower Cretaceous paleogeography appears to have been controlled by crust thinning processes associated to probable extensional fractures which subsequently led into the AFZ. The Mesozoic rocks from the region are deformed and intruded by granitoids of Valanginian-Aptian ages. These units host the largest iron mines of the country. At the studied sector a spatial coincidence between the sheared zone and the actinolitic alteration band (mainly affecting intrusive and volcanic rocks) associated to the iron mines is observed. The geologic evolution of the region allows to establish that tectonic, magmatic, and metallogenic episodes discussed in this study took place close to each other during Lower Cretaceous and extended probably up to early Upper Cretaceous.

The analyzed fault-zone represents a periodically reactivated structure. It forms a lineal-megastructure defined by an anastomosing system of fractures and folds, which divides the region into two separate north-south blocks. West of the AFZ the sequences have been deposited in a transitional range between a volcanic-arc and a back-arc-basin. The calcareous sequences east of the AFZ represent a marine platform environment. The sheared zone displays an intrincate system of tight folds and échelon faults which contrasts with the relatively simple deformation style of the Mesozoic sequences characterized at regional scale by a wide N-trending synclinorium.

Megastructures and associated sinistral transcurrent fault system. The megafault "Los Colorados" extends at least from the Boquerón-Chañar and Los Colorados mines to south of the Huasco river (Fig.1); "La Sosita-Huantemé" fault zone extends from the "Chañar-Quemado" mine to the south through the mines "La Sosita", "Huantemé", and "El Algarrobo". The fault zone is usually 20-30 m thick, occasionally, as at the Boquerón-Chañar mine, it can reach up to 600 m thickness. At several points the faults cut and limit Mesozoic intrusive rocks.

Different types of cataclastic rocks, including protomylonites and mylonites, have been found. They develop on sedimentary, volcanic, and plutonic rocks. The occurrence of flow textures in deep plutonic rocks suggests generation at relativelly high temperature allowing ductile flow and partial recrystallization. Despite the subhorizontal shear pattern, all involved rocks exhibit vertical slickensides which correspond to later vertical motions. As a result of the vertical movements the western coastal block is uplifted with respect to the eastern one. These last movements control the recent phisiographic evolution of the region.

A sinistral fault system is directly associated with the generation of the megafault and displays a typical "en échelon" pattern (Fig.1). Poles of the sinistral faults plot according two main strikes: N30°-56°W (north sector) and 20°-40°W (south sector). This sinistral system displaced the megafault up to 500-1000 m. The fold axes of the Neocomian sequences and the main iron orebodies and plutonic rocks are also displaced.

Relative timing of deformation episodes. Emplacement of plutonic rocks appears to be controlled by the AFZ. Syntectonic intrusion during Lower Cretaceous along the AFZ was also postulated at Quebrada Saladito, 200 km to the north, by Naranjo et al. (1984). Radiometric dating on rocks intruding shear mylonitic zones associated to the AFZ at this location show that the shear movement has a minimum age of of 131 Ma (Naranjo et al. 1984). In the area of the present study intrusive radiometric ages give values between 124 and 108 Ma (Montecinos, 1983; Pichon, 1981). It appears that intrusive activity and fracturing along the AFZ are concomitant processes. The main processes producing the iron mineralization (massive subvertical lenticular vein magnetite-rich deposits) took place in the same time range. Radiometric ages of postore dikes and veins at Los Colorados (110 Ma; Pichon, 1981) and at Boquerón Chañar mines (128 Ma; Zentilli, 1974) support this. Moreower, it appears that the formation of actinolitic zones and iron bodies takes place along fractures of a first distensive phase, still without shear component, as indicated by intergrowths of magnetite and actinolite typical for open-space deposition. Subsequently, at the beginning

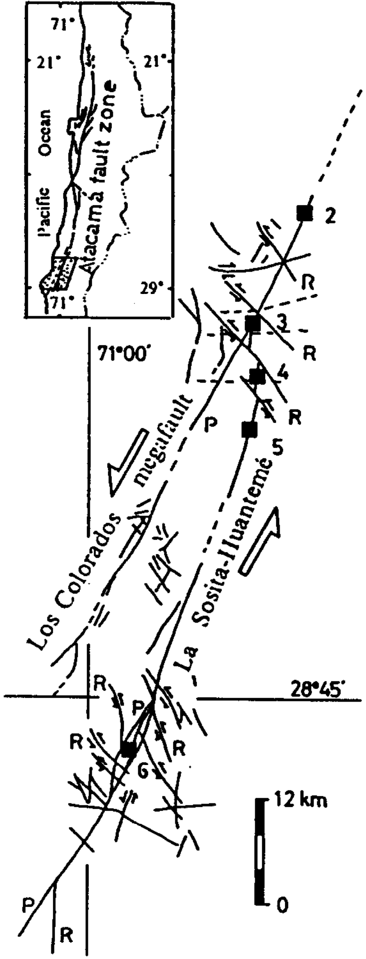

Fig. 1: Fault pattern at the studied zone:

R = Riedel's faults, P = P-shears, ■ main iron deposits; 1 = Boquerón Chañar, 2 = Los Colorados, 3 = Chañar Quemado, 4 = Sositas, 5 = Huantemé, 6 = El Algarrobo.

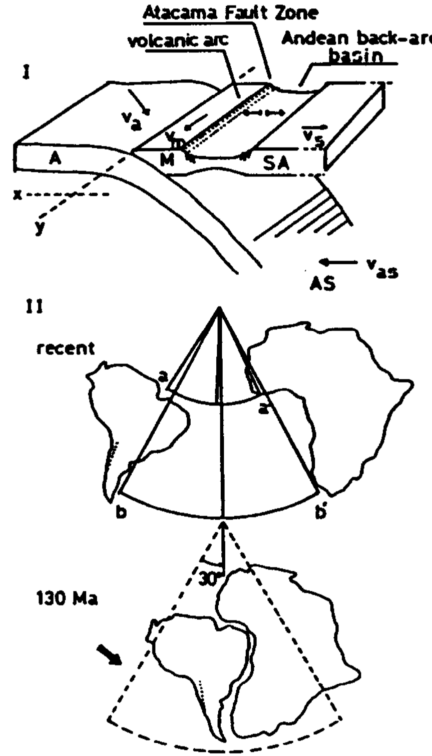

Fig. 2: I: Schematic diagramm of subduction geometry (Uyeda, 1983):

AS = asthenosphere with velocity v_{as}, A = Aluk Plate with v_a velocity, SA = South American Plate with velocity v_s, M = volcanic-arc microplate with velocity v_m. If v_{as} is small, backarc spreading occurs when v_s has a landward (retreat) component (i.e. "low stress" Mariana subduction type). If the landward plate (SA) has oceanward velocity component, no backarc spreading takes places (i.e. "high stress" Chilean subduction type). II: Opening angle of the South Atlantic Ocean with a rotation of about 30° from Lower Cretaceous to Recent.

of the tectonic transpression, sinistral transcurrent faults sheared ore and host rocks. During early Upper Cretaceous shear movement with features of ductile-rigid regime persisted. Finally, during later Upper Cretaceous and Tertiary, vertical displacements under rigid-rupture conditions took place, which are illustrated by vertical slickenside surface.

Strain-stress analysis. Transpression experimental studies show that along shear zones folds, thrusting, and fault systems develop according to a determinate model (Harland, 1971; Naylor et al., 1986). Related to simple shear folds and faults develop with a typical "en échelon" pattern, the orientations of which show a rotational effect with respect to the sheared zone in function of the deformation grade. An anastomosing system of longitudinal faults consisting of several generations of synthetic Riedel (R) and associated P shear faults develops in a final stage. This model can be applied for the present study. The lineal megastructure shows effects of horizontal compression, and the distribution of the associated sinistral structures indicates that the whole fault system represents a sinistral shear zone. Reference points that could indicate the magnitude of the horizontal displacement were not recognized.

Origin of the deformation. The analyzed structures belong to a transpressive tectonic stage associated with the openning of the South Atlantic Ocean, about 130 Ma (Popoff, 1988). At that time the Pacific continental margin was affected by horizontal stress of great magnitude, which could originate shear zones as the AFZ. The principal stress direction must have had a similar direction to that of the lithospheric convergence between the Pacific Plate and the South American Plate. The AFZ probably started as a extensional fracture zone at the west margin of the Neocomian back-arc basin. Subsequently, between 110 and 85 Ma, i.e., as the expansion rates of the Pacific lithosphere rose up to 18 cm/year (Frutos, 1981), the distensive regime at the back-arc domain was replaced by compresive regimes in accordance with Uyeda's (1982) "high stress" Chilean subduction model (Fig.2). Subsidence in the back-arc domain ended and tectonic transpression was favored.

FRUTOS, J. (1981) Tectonophysics, 72, p. T21-T32.

HARLAND, W. (1971) Geological Magazine, Vol. 108, N°1, p. 27-41.

MONTECINOS, D.P. (1983) These, Doct. Ing., Univ. Paris XI (Orsay), 191 p.

NARANJO, J.A.; HERVE, F.; PRIETO, X.; MUNIZAGA, F. (1984) Revista Comunicaciones, 34, p. 57-66.

NAYLOR, M.A.; MANDL, G.; SIJPESTEIJN, C.H.K. (1986) Journal of Sructural Geology, Vol. 8, p. 737-752.

PICHON, R. (1981) These, Doct. 3eme Cycle, Univ. Paris XI (Orsay), 326 p.

POPOFF, M. (1988) Journal of African Earth Sciences, Vol. 7, No. 2, p. 409-431.

UYEDA, S. (1982) Tectonophysics, N°. 81, p. 133-159.

UYEDA, S. (1983) Episodes, Vol. 1983, 2: 19-24.

ZENTILLI, M. (1974) Ph. D. Thesis, Queens Univ., Canada, 394 p.