The Liquiñe Ofqui Fault Zone: a major Cenozoic strike slip duplex in the Southern Andes

José CEMBRANO and Francisco HERVE

Departamento de Geología - Universidad de Chile
Casilla 13518 Correo 21, Santiago-CHILE

RESUMEN
La zona de falla Liquiñe-Ofqui (ZFLQ) se extiende por casi 1000 kms en los Andes del sur. Rocas deformadas ocurren a lo largo de la ZFLQ, que coincide con el eje Mioceno del Batolito Norpatagónico y con cuencas extensionales terciarias. Un movimiento dextral en el rumbo y luego normal, es consistente con la convergencia entre las placas de Nazca y Sudamérica que ha variado de oblicua a casi ortogonal.

KEY WORDS: Southern Andes, strike-slip duplex, Cenozoic.

INTRODUCTION
The overall deformation resulting from converging plates is partitioned into strain, displacement along discrete faults and block rotation (Lamb and Bibby, 1989; Jackson and Molnar, 1990). Attempts to assess the contribution of these three components of deformation along different mountain belts (Dewey and Lamb, 1992) face the problem that short and long-term slip rates, distributed strain, and the amount and sense of block rotation are generally poorly constrained. This is the case in the Chilean Andes, where hundred-kilometer long crustal lineaments, regarded as major long-lived strike-slip fault systems, have been causally linked to the margin parallel component of oblique subduction of the Nazca (Farallon) plate beneath South America (Hervé, M., 1976; Beck, 1988; Pardo Casas and Molnar, 1988).

The most relevant tectonic feature of the southern Chilean Andes, the 1000 km long Liquiñe-Ofqui fault zone (LOFZ), has been lately the subject of geologic, geochronologic and paleomagnetic research. An updated synthesis of all available relevant information about the LOFZ is given below.

GEOLOGICAL SETTING
Geometry
The Liquiñe-Ofqui fault zone is represented by a series of NNE-trending crustal lineaments, mainly corresponding to aligned glacial valleys and fjords.

Their spatial arrangement as observed in satellite images, aerial photographs and geologic maps (Fuenzalida & Etchart, 1975; Hervé et al., 1979; Thiele et al., 1986) allows the distinction of three categories of lineaments based on length and shape: straight long segments; en échelon features; and curved splays.

The main trace of the LOFZ is represented by two NNE-trending straight segments with a left step in between. These two main segments are linked by a series of NE-trending en échelon lineaments resulting in an extensional strike-slip duplex geometry (as described in
Fig. 1  Sketch map of main lineaments of the LOFZ. Position of the holocene volcanoes (black dots), the trench, the triple point (black triangle) and of the slip directions of the Nazca Plate approximate.
Woodcock and Fisher, 1986). The third important element is a series of NW-trending, concave to the southwest, oceanward splays off the two main segments (Fig. 1).

The LOFZ, along most of its main trace, runs through plutonic rocks of the Meso-Cenozoic North Patagonian batholith, metamorphic rocks of the Paleozoic Accretionary Complex and Cenozoic volcanosedimentary units (Hervé, 1976; Parada et al., 1987; Cembrano, 1992). The Miocene belt of the North Patagonian batholith has a close spatial relationship with the main trace of the LOFZ, as does the holocene southern Andes volcanic chain. It has been suggested that the LOFZ is a deep-seated structure cutting through the lithosphere, favouring magma rising and emplacement. (Parada et al., 1987; Pankhurst et al., 1992).

NS-trending strips of fault rocks, crop out in discrete areas along the LOFZ, between extensive exposures of non-deformed rocks. A steeply-dipping foliation striking NNW characterizes the mylonites. Limited available data on mineral stretching lineations and fault striae are consistent with lateral displacement.

Mid-Tertiary extensional basins (Bartholomew and Tarney, 1986) and holocene volcanoes are spatially compatible with the extensional duplex geometry described.

Paleomagnetism

Paleomagnetic data on rock units adjacent to the LOFZ (Garcia et al., 1988; Cembrano et al., 1992; Rojas et al. in press) have shown a pattern of crustal block rotation consistent with the LOFZ geometry and motion, characterized by small counterclockwise rotations west of the LOFZ and small to moderate clockwise rotations within and to the east of the LOFZ. Beck et al. (in press) propose that the observed pattern is the result of small north-south displacement of blocks along curved splays west of the LOFZ, giving rise to counterclockwise rotation in contrast with distributed dextral shear producing clockwise rotations within and to the east of the LOFZ. Large-scale north-south transport - as found in the US western Cordillera- has not been documented, but available data do not rule out a few hundred km of lateral offset.

Nature and timing of motion

Hervé (1976) proposed that it was a Cenozoic fault zone with both pre-Oligocene dextral and Late Tertiary normal up-on-the-east motions. The main evidence for the early strike-slip component was a steeply-dipping mylonitic foliation along with a conjugate set of NNE-trending dextral and ENE-trending sinistral mesoscopic faults found in a 3km wide NNE-trending belt of fault rocks. The normal, up-on-the-east motion, was interpreted from the fact that deeper crustal levels crop out east of the LOFZ main trace. At 41°S the LOFZ juxtaposes weakly deformed Miocene and Cretaceous plutonic rocks (Drake et al. 1992). At 42°S, NNW striking foliations, subhorizontal mineral lineations and structural asymmetries found in both Mi-Pliocene granitoid and their Paleozoic metamorphic wallrocks document a right lateral ductile shear zone of pre-Pliocene age (Cembrano, 1992).

High uplift rates have been calculated for the LOFZ by Thiele et al. (1986) for the last 10 Ma and, up to 9 mm/year, by Hervé and Ota (in press) for the late Holocene, respectively.

CONCLUSIONS

The LOFZ is represented by two major NNE-trending crustal lineaments along which isolated outcrops of ductilely-brittly deformed rocks occur. Purely geometric considerations of spatially related en échelon and curved oceanward features can be assimilated to a strike-slip extensional duplex and associated splays.

Field evidence from within the LOFZ is consistent with a right lateral shear zone with sharp variations in the nature of rock deformation along strike.

The fact that both the Miocene plutonic rock belt and Recent volcanoes spatially coincide with the LOFZ suggests that the structure has exerted control on magma rise and emplacement.

Paleomagnetic data show a pattern of block rotation consistent with the geometry and sense of motion assigned to the LOFZ.

Right lateral followed by normal motion on the LOFZ reflects the Nazca-South America convergence which varied from highly oblique to nearly orthogonal during the Cenozoic.

Acknowledgements

Projects FONDECYT 1931096 (J.C.) and 92/0914 (F.H.) are financing current research on the subject.
REFERENCES


Pardo-Casas, F. and P., Molnar, 1988, Relative motion of the Nazca (Farallon) and South American plates since Late Cretaceous times, Tectonics, 6, 233-248.


Thiele, R., Hervé, F., Parada, M.A. and Godoy, E. 1986, La megafalla Liquiñe-Ofqui en fiordo Reloncavi (41°30’S), Chile, Comunicaciones (Universidad de Chile, Santiago) 37, 31-40.