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DUCTILE STRIKE-SLIP DUPLEXES IN MAGMATIC ARCS: AN EXAMPLE FROM THE SOUTHERN ANDES PLATE BOUNDARY ZONE

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INTRODUCTION

The concept of duplexes was first applied to structural geology to designate imbricate faults arrays associated with thrust tectonics (1). A duplex involves a set of imbricate faults that transfer the displacement from a floor thrust to a roof thrust. The development of extensional or contractional strike-slip duplexes associated with transcurrent tectonics, as analogy with their dip-slip counterparts, was suggested by Woodcock & Fischer (2). These authors argue that the formation of strike-slip duplexes is best understood as a kinematics response to imposed boundary constraints, rather than by the stress-control or bulk strain approaches usually applied to wrench tectonics. Examples of crustal-scale strike-slip duplexes associated with regional-scale ductile shear zones have been documented in the literature (3, 4).

In the Andean margin, the most recently proposed strike-slip duplex (4) consists of a system of arc-parallel and arc-oblique shear zones comprising the entire Mesozoic plutonic belt of the Coastal Cordillera of Northern Chile (Fig. 1a), associated with the Atacama Fault system (5). Although the duplex geometry and kinematics are mainly based on the analysis of satellite images, published field data (6, 7, 8) and our own field observations support the existence of such strike-slip duplex at various scales (see also 9).

The Liquiñe-Ofqui Fault Zone (LOFZ) in the Southern Chilean Andes main range (10, 11, 12) corresponds to a Cenozoic analog of the Mesozoic Atacama fault system of the northern Coastal Cordillera. Previous work (13) suggests that the LOFZ is associated with bulk transpressional deformation of the Southern Andes plate boundary zone. Cembrano *et al.* (12), based on the analysis of satellite images, identified two overstepping NNE-trending, largely straight lineaments, which are hundreds of kilometers long (from 39º to 44º and 44º to 47ºS, respectively). These are joined by several NE-trending, straight, *en échelon* lineaments whose lengths are of the order of tens of kilometers (from 44º to 46ºS) (Fig. 1b). Cembrano and Hervé (14) and Cembrano *et al.* (12) suggested that this regional–scale geometry corresponds to a crustal-scale strike-slip duplex (2). However, they presented little field and thermochronological evidence to further document these ideas.

In this work, we present new geometric, kinematic and chronological data that supports the existence of a crustal-scale strike-slip duplex in the Mio-Pliocene magmatic arc of the Southern Andes plate boundary zone. We further speculate that duplexes are a fundamental element of magmatic arcs.

EVIDENCES OF TRANSPRESSIONAL DEXTRAL DUPLEXING

Late Miocene-Pliocene ductile-to-brittle shear zones of the LOFZ (13,14), affect rocks of the Meso-Cenozoic Patagonian Batholith (NPB), Tertiary intra-arc metavolcanic-sedimentary rocks of the Traiguén Formation and the Paleozoic Basement (15-19). Ductile deformation is recorded in meter-wide subvertical mylonite zones with horizontal, oblique and vertical stretching/mineral lineations (20). At the regional scale, mylonites are organized into several shear zones according to their strike and location **(a)** ***NNE-striking shear zones*** (Puyuguapi (PSZ), Queulat (QSZ), Islas 5 Hermanas (HSZ), Isla Magdalena (MSZ) and Canal Costa (CZS) shear zones) and **(b)** ***ENE-striking shear zones*** (Río Cisnes (RSZ), Puerto Cisnes (PCSZ) and Río Mañiguales (ÑSZ) shear zones) (Figure 1b).

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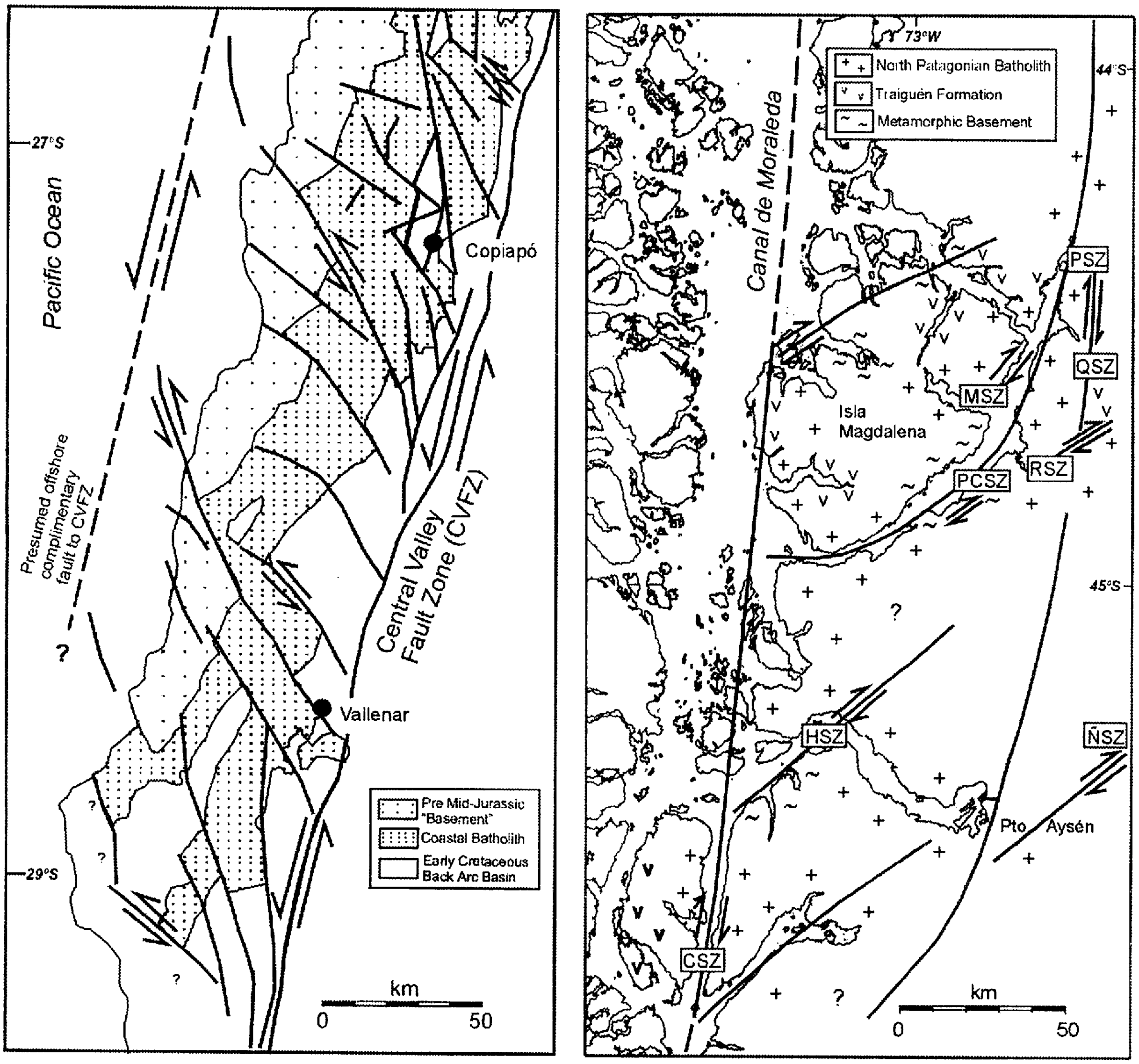

(a) (b)

Figure 1. a) Crustal-scale strike-slip duplex between 27°S and 29°S associated with the Cretaceous Arc and the Atacama Fault Zone (Modified from 4). b) Regional-scale geometry of the Liquiñe-Ofqui Fault Zone between 44°S and 46°S associated with the Miocene North Patagonian Batholith (Modified from 12). Rectangles indicate the studied shear zones. See explanation in the text.

(a) The ***NNE-striking shear zones*** contain high strain rocks with north-to northeast-striking subvertical foliation and subvertical (PSZ), oblique slip (QSZ and CSZ) and subhorizontal lineations (HSZ, MSZ). Kinematic indicators show reverse slip with variable components of dextral shear. Biotite $^{40}Ar/^{39}Ar$ dating of high strain mylonites (PSZ) suggest that high strain solid-state contractional (dextral) ductile deformation occurred at 3.8 ± 0.2 to 4.2 ± 0.2 Ma (13). A fine-grained muscovite $^{40}Ar/^{39}Ar$ analysis (HSZ), separated from high strain quartz-mica schist defines ages of 3-4 Ma (13).

(b) The ***ENE-striking shear zones*** correspond to mylonitic belts/brittle fault zones joining the overstepping NE-striking lineaments recognized by Cembrano *et al.* (12). East-to-northeast-striking moderately-dipping to subvertical foliations, horizontal to oblique-slip lineations and dextral (normal) kinematics indicators are observed (RSZ, PCSZ, ÑSZ). $^{40}Ar/^{39}Ar$ dating of solid-state deformation and recrystalization of muscovite in mylonitic rocks from RSZ is 6.2 ± 0.2 Ma (13).

In the other NNE and ENE-striking shear zones the absolute age of deformation remains unknown. However, the Miocene age of Traiguén Formation and Patagonian Batholith, which are the protolith of most mylonites, sets an upper limit for the timing of deformation (17, 18, 21).

CONCLUSIONS

Coalescence patterns of *en échelon* dextral strike-slip (normal) shear zones (PCSZ, RSZ, ÑSZ) with their enclosing oblique-slip reverse shear zones (PSZ, QSZ, MSZ, HSZ and CSZ) is consistent with dextral transpression as overall kinematics. We suggest that the geometry, kinematics and timing of intra-arc regional deformation in the Southern Andes from 44º to 46º S, are consistent with a Mio-Pliocene ductile strike-slip duplex represented by the Liquiñe-Ofqui Fault Zone in the Southern Chile.

According this, we suggest that the duplexes associated with strike-slip deformation would be a fundamental element in magmatic arcs. This way, magmas ascend and migrate through a network of pre-existing and/or newly created fractures that are oblique to the arc's main trend. These fractures correspond very well to Riedel shear and extension cracks as seen in analogue experiments of strike-slip deformation (22). The resulting crustal structure produced by the coalescence of Master faults, Riedel shears and extension fractures make up a strike-slip duplex (2) (Fig. 2).

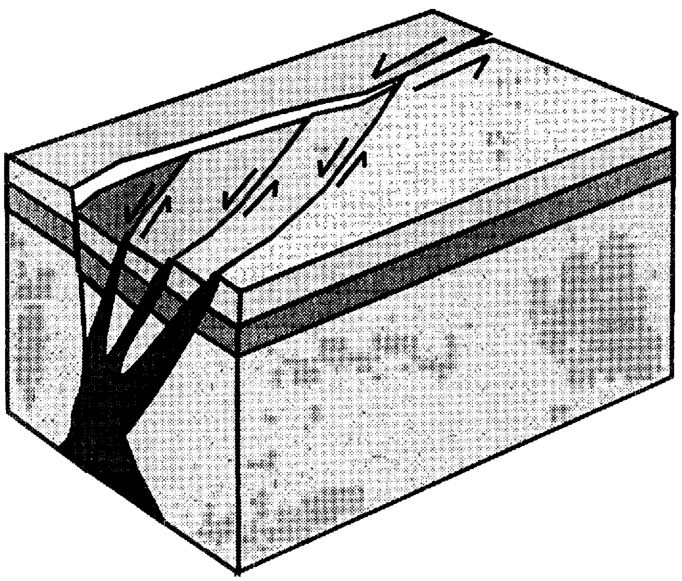

Figure 2. Example of three-dimensional architecture of a magmatic arc undergoing sinistral strike-slip deformation. See explanation in the text.

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