CRUSTAL-SCALE POP-UP STRUCTURE AT THE SOUTHERN ANDES PLATE BOUNDARY ZONE: A KINEMATIC RESPONSE TO PLIOCENE TRANSPRESSION

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INTRODUCTION

The southern Andes plate boundary zone records a protracted history of bulk transpressional deformation during the Cenozoic. Transpression has been causally related to either oblique subduction or ridge collision (e.g. Hervé, 1976; Beck, 1988; Nelson et al. 1994; Cembrano et al. 1996). However, few structural and chronological studies of regional-scale deformation are available to support one hypothesis or the other.

The present work addresses along and across-strike variations in the nature and timing of plate-boundary deformation to better understand the Cenozoic tectonics of the southern Andes. A general objective was to gain insights into the geometry and kinematics of transpressional deformation at obliquely convergent plate margins. Five transects were mapped along the southern Andes, from 39°S to 46°S (Figure 1). Bulk mineral separates from high strain rocks with good field and microstructural kinematic constraints were selected for conventional furnace ^{40}Ar-^{39}Ar stepwise dating. Highly strained (dynamically recrystallized?) single minerals and/or mineral aggregates were dated in situ by using the laser technique on polished rock slabs.

KINEMATICS AND TIMING OF DEFORMATION

The northernmost, Liquiñe transect (39°S), documents ductile deformation of pre-Late Cretaceous age. Brittle deformation is represented by a regional, high angle, northeast-trending reverse fault that places greenschist facies mylonites against an undeformed Miocene granitoid. In contrast, Late Cenozoic brittle faulting of Cretaceous and Miocene plutons is well developed farther south at Reloncaví (41°S), where contractional and strike-slip kinematics are documented. At Hornopirén (42°S), Late Cenozoic ductile to brittle dextral strike-slip deformation along northeast striking shear zones was continuous from syntectonic pluton emplacement at 10 Ma, to low temperature, solid-state deformation at ca. 4.3 Ma. Brittle faults indicate that dextral strike-slip deformation remained active after 3 Ma. Puyuhuapi and Aysén transects (44-46°S), document a remarkable increase in the contractional component of ductile and brittle deformation. At Puyuhuapi (44°S), north-south trending, high-angle contractional ductile shear zones that developed from plutons, coexist with moderately dipping dextral-oblique shear zones in the wallrocks. In Aysén (45-46°), top to the southeast, oblique thrusting predominates to the west of the Cenozoic magmatic arc, whereas dextral strike-slip shear zones develop within it.

New ^{40}Ar-^{39}Ar data from mylonites and undeformed rocks from the five transects (Table 1) suggest that dextral strike-slip and contractional deformation occurred at nearly the same time but within different structural domains along and across the orogen. For instance, ^{40}Ar-^{39}Ar laser dating on highly strained synkinematic biotite from plutonic rocks with S-C fabrics at 42°S documents dextral ductile shear at 4.3±0.3 Ma. Similar ages were obtained on both high strain pelitic schists with dextral strike-slip kinematics (4.4±0.3 Ma, laser on muscovite-biotite aggregates, Aysén transect, 45°S) and on mylonitic plutonic rocks with contractional deformation (3.8±0.2 to 4.2±0.2 Ma, fine-grained, recrystallized biotite, Puyuhuapi transect). Oblique-slip, dextral reverse kinematics of uncertain age is documented at the Canal Costa shear zone (45°S) and at the Queulat shear zone at 44°S. Published dates for the undeformed protholiths suggest both shear zones are likely Late Miocene or Pliocene, coeval with contractional and strike-slip shear zones farther north.

CONCLUSIONS

Coeval strike-slip, oblique-slip and dip-slip deformation on ductile shear zones of the southern Andes suggests different degrees of along- and across-strike deformation partitioning of bulk transpressional deformation. The long-term dextral transpressional regime appears to be driven by oblique subduction. The short-term deformation is in turn controlled by ridge collision from 6 Ma to present day. This is indicated by most deformation ages and by a southward increase in the contractional component of deformation. Oblique-slip to contractional shear zones at both western and eastern margins of the Miocene belt of the Patagonian batholith define a large-scale pop-up structure by which deeper crustal levels exposed in the Main Range have been differentially exhumed since the Pliocene. The overall geometry and kinematics of regional-scale shear zones obtained in three-dimensional analog and numerical models of transpression (e.g. Schreurs and Coletta, 1998; Braun and Beaumont, 1995) are strikingly similar to those we have described for the southern Andes plate boundary zone (Figure 2).

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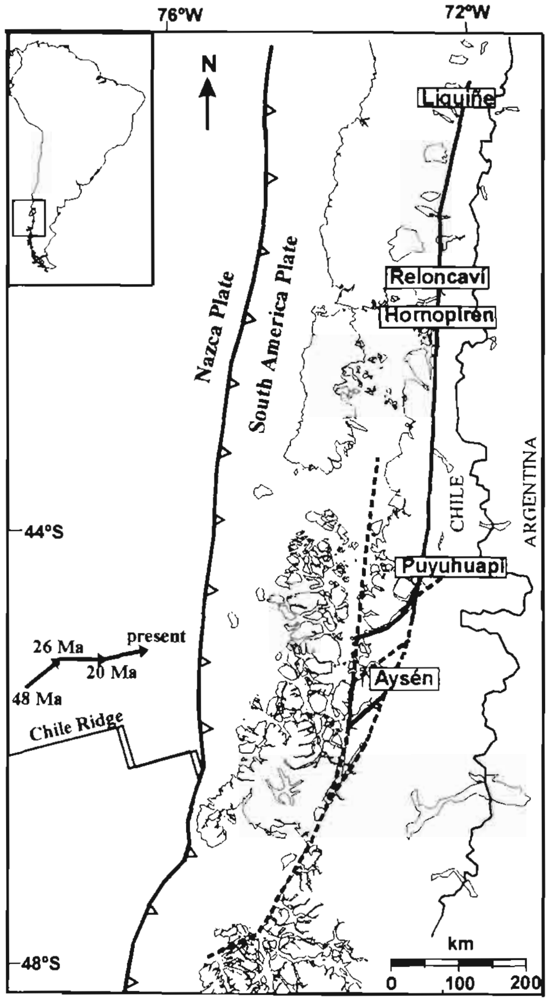

Figure 1. Geodynamic setting of Southern Andes plate boundary zone. Transect location is shown.

Sample	Transect	Rock type	Material	Age (Ma) ± 1σ
94JC54	Liquiñe	crosscutting dike	amp	100±2
94JC13	Hornopirén	S-C tonalite	bt (Laser spots)	4.35±0.05
95JC1	Puyuhuapi	mingled gd-diorite	bt	3.5±0.2
95JC1	Puyuhuapi	mingled gd-diorite	amp	20.2±0.2
95JC2	Puyuhuapi	mingled gd-diorite	bt	1.6±0.2
95JC4	Puyuhuapi	mingled gd-diorite	amp	37.4 ± 3
95JC4	Puyuhuapi	mingled gd-diorite	bt	5.3 ± 0.3
95JC6	Puyuhuapi	granodiorite	amp	14.4 ± 0.6
95JC6	Puyuhuapi	granodiorite	bt	14.4 ± 0.3
95JC12	Puyuhuapi	granodiorite	amp	discordant
95JC12	Puyuhuapi	granodiorite	bt	13.3 ± 0.2
96GA01	Puyuhuapi	mylonite	bt (bulk)	4.2 ± 0.2
96GA03	Puyuhuapi	mylonite	bt (bulk)	3.8 ± 0.2
95GA04	Puyuhuapi	mingled gd-diorite	bt (bulk)	4.2 ± 0.1
96GA26	Puyuhuapi	bt-ms schist	ms	6.2 ± 0.2
95JC14	Aysén	bt granite	bt	5.7 ± 0.2
95GA17	Aysén	schist	ms (bulk)	no result
95GA17	Aysén	schist	ms+bt bands (laser spots)	4.6-9.4Ma
95GA19	Aysén	schist	ms (bulk)	4-10Ma, 5.1± 0.2(tga)
95GA19	Aysén	schist	ms+bt bands (laser spots)	4.4 ± 0.3

Table 1. Summary of new ^{40}Ar-^{39}Ar age date for the studied transects

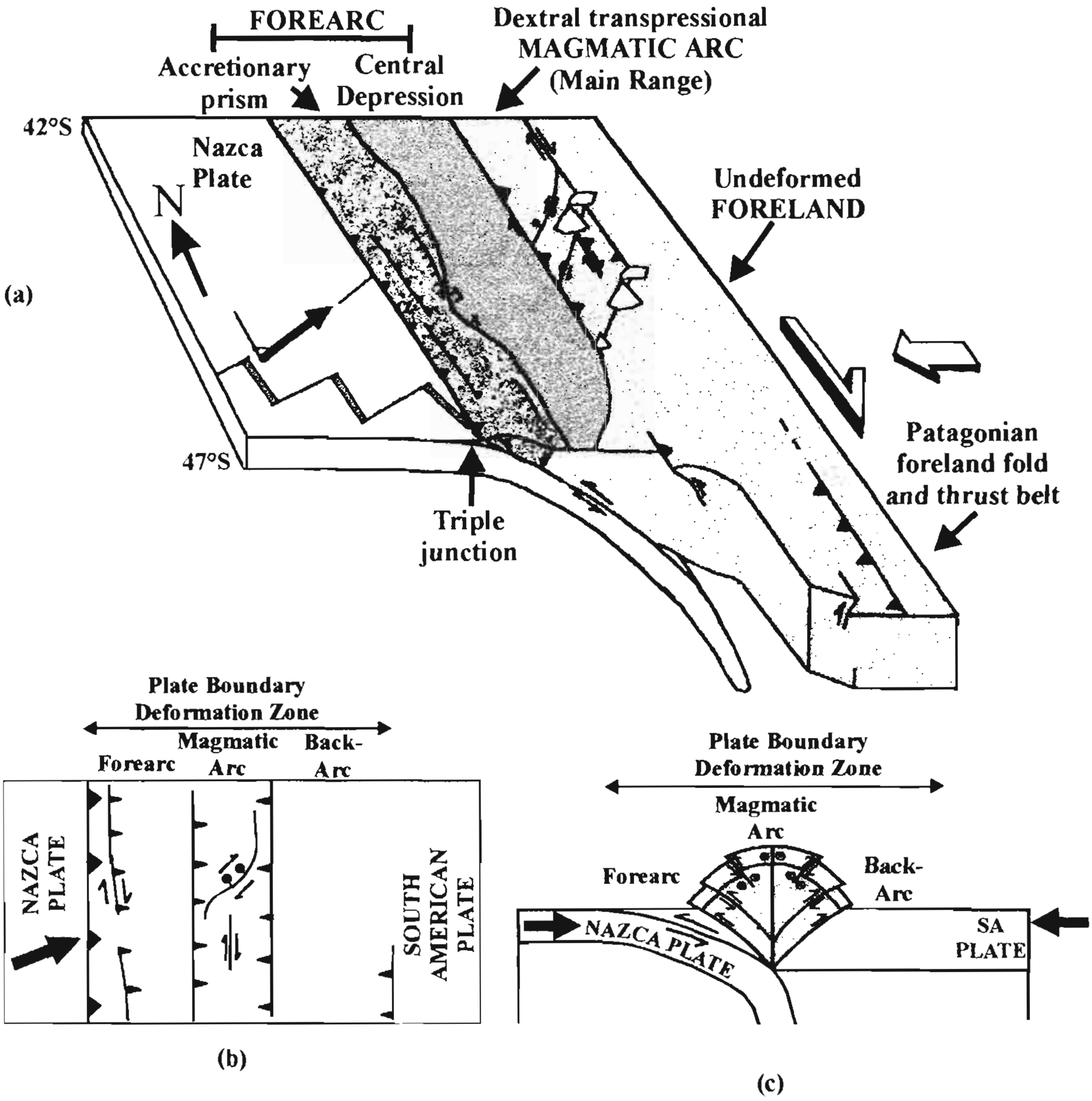

Figure 2. (a) Three-dimensional cartoon showing the regional-scale geometry and kinematics of deformation at the Southern Andes plate boundary zone; (b) Plan view of the plate boundary zone showing that transpressional deformation is mainly accommodated through regional-scale, east-dipping and west-dipping oblique-slip reverse shear zones flanking the Cenozoic plutonic belt of the North Patagonian Batholith; (c) Same as (b) but in sectional view.