VOLCANISM AND TECTONICS OF THE PLEISTOCENE-HOLOCENE VOLCANIC ARC, SOUTHERN ANDES (40.5°-41.5°S)

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INTRODUCTION

The volcanic arcs, especially those which are emplaced at convergent margins, present a complex configuration which is expressed in their geometry and temporal evolution of magmatism. Although volcanic arcs conform to a margin-parallel belt on a continental scale, these belts consist of many transverse chains that comprise different types of volcanic centres (stratovolcanoes, flank and monogenetic cones). This internal anisotropy can reflect, in the sense of Nakamura (1997), the overpressure of the regional stress field. However, Fedotov (1981) has analized these variations from the thermodynamic point of view relating the building of stratovolcanoes/monogenetic cones to the magmatic input rate from the asthenosphere. Takada (1994) developed an 'output stress' diagram which incorporates the combined effect of strain rate and magmatic input in volcanic regions of continental scale.

We document this effect in the Southern Andes, where the architecture of the volcanic arc includes NE-SW and NW-SE transverse chains of morphologically and geochemically heterogeneous volcanic centres. These transverse alignments are associated with a long-lived structural system.

VOLCANIC CENTRES AND STRUCTURES

This study relates to the arc segment between 40.5° and 41.5°S (FIG.1). It concerns the Carrán-Los Venados group, a chain of 70 basaltic cones and maars of N50E orientation; the Cordillera Nevada-Cordón Caulle- Puyehue volcanic chain, a line of colapsed stratovolcanoes, fissural vents of rhyolitic composition, and monogenetic cones; the Grupo Casablanca, a basaltic stratovolcano together with flank and monogenetic cones of NE-SW orientation; and the Osorno-Puntiagudo chain, a group of stratovolcanoes and cones of the same orientation. The Liquiñe-Ofqui Fault behaves as an axis of

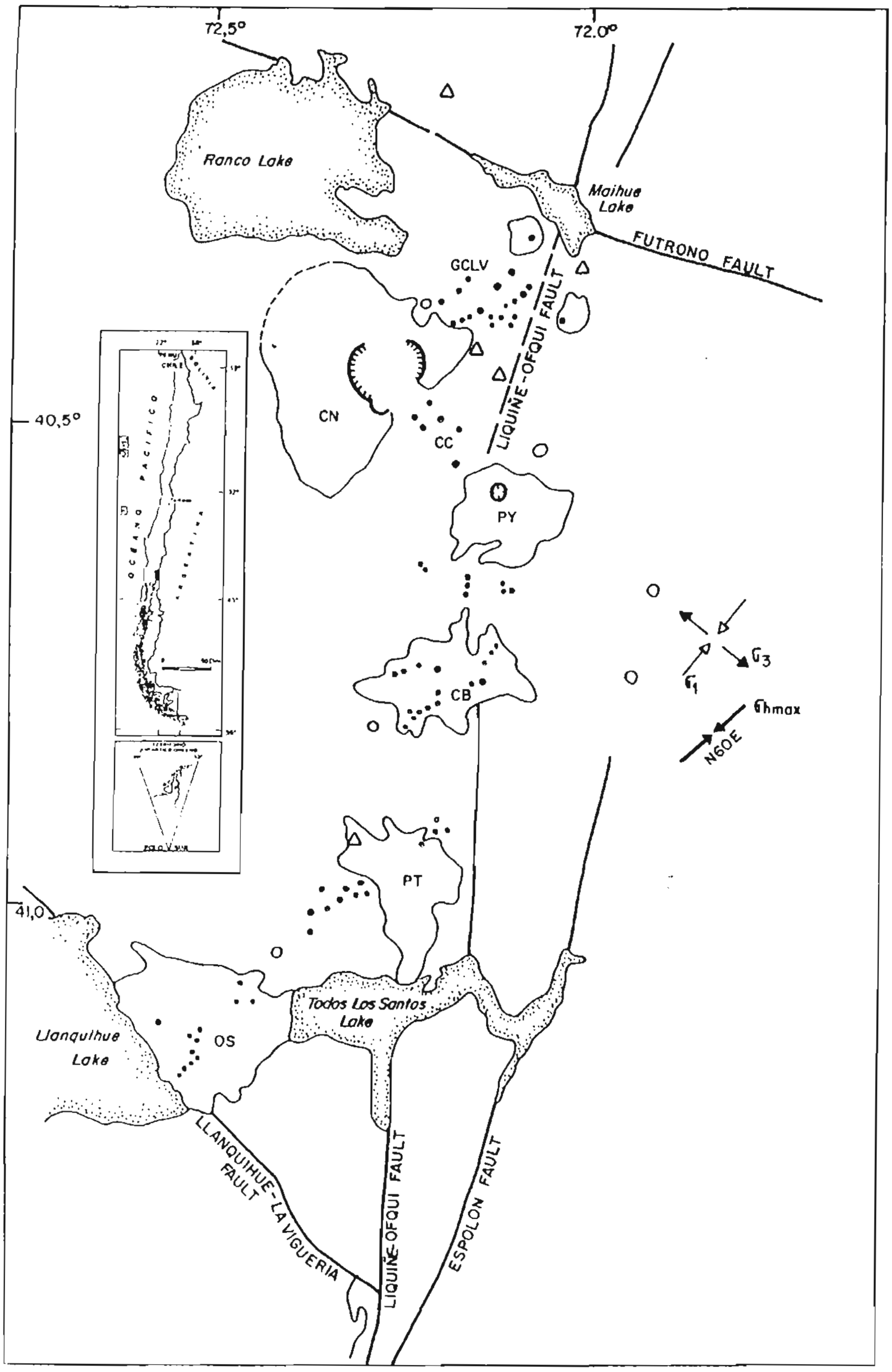

FIG.1. Volcanic centres and structures in 40.5°-41.5° segment of Southern Volcanic Zone. Chile.

Key: GCLV: Grupo Carrán-Los Venados; CN: Cordillera Nevada; PY: Puyehue; CB: Casablanca; CC: Cordón Caulle; PT: Puntiagudo; OS: Osorno.

- ○ Plio-Pleistocene volcanoes
- ● Holocene pyroclastic cones, domes and fissural vents
- →← Holocene σ_{hmax} axis
- Miocene-Pliocene σ_1-σ_3 axis (*e.g.*, Lavenu *et al.*, 1997)
- △ 1992-1995 crustal earthquakes (depth: 10-30 km; M:4.1-4.9)

longitudinal symmetry and in its trace are also located some of the centres which form the transverse chains.

The orientation of volcanic alignments is roughly coincident with structures recognized in the basement, but whose kinematics are only partially known in this area. The studied segment is delimited by a structure of N120E orientation, the Futrono Fault, which corresponds to a major limiting structure of the continental margin, and is possibly the western expression of the Gastre System (Coira *et al.*, 1975). The southern limit is the Llanquihue-La Viguería Fault of N40W orientation and unknown kinematics. The Liquiñe-Ofqui Fault (*e.g.*, Hervé, 1976; Cembrano y Hervé, 1993, Cembrano, 1996) is also exposed; the Miocene-Pliocene kinematics of this fault are consistent with a dextral transpressive regime (Lavenu *et al.*, 1997). Two crustal earthquakes located outside the segment are the sole record of the instantaneous deformation on this arc segment and their focal mechanisms (*e.g.*, Chinn and Isacks, 1983; Barrientos y Acevedo, 1992) are consistent with the inversion of mesoscopic structural data of basement rocks.

The present data show that the monogenetic cones, likewise the flank cones of the stratovolcanoes, are placed at a NE-SW orientation or isolated within the Liquiñe-Ofqui Fault. The stratovolcanoes are located in both NE and NW chains, and the more siliceous centres, although scarce, have a preferential NW orientation. In addition, although there no permanent seismic stations in the area, stations outside the zone have recorded five crustal earthquakes of 4.1-4.9 magnitude with depths between 10 and 30 km since 1995.

DISCUSSION

The above observations suggest important questions with respect to volcanic activity in the region. Cembrano and Moreno (1994) proposed a model of strain partitioning, and interpret the tranverse chains as expressions of compressive and extensional domains in the arc. Lavenu *et al.* (1997), in addition to proposing a partial strain partitioning model, suggest the coincidence of basement structures and volcanic chains. Alaniz-Alvarez *et al.* (1998) have shown, for the Transmexican Volcanic Belt, the importance of structural reactivation, and they explain the difference in volcanic morphology as a function of strain rate (desplacement) of pre-existing structures. In agreement with this model, we conclude that in the studied arc segment, the NE-SW structures are well-orientated for reactivation in the current regional stress field, whereas those of NW-SE orientation are misorientated in a factor of 0.23. As the strain rate is unknown in the volcanic arc, and the strain partitioning considerations have a strict value for pre-pliocene rocks, the relation between volcanism and deformation is still not well understood.

CONCLUSSIONS

The geometry and architecture of this volcanic arc segment show clearly the effect of the action of an homogeneous regional stress field upon the volcanic structures. At the same time, the pre-fractured nature of the basement causes the preferential reactivation of NE-SW structures, leading to local distortions of the deformation regime. In addition, local factors such as weight and internal anisotropy of stratovolcanoes have an important effect on the force balance.

In the present study, we expect to bring together the record of mesostructural kinematics, to analyze the volcanic morphology and its relation to the deformation regime, and to design a field experiment of the record of natural crustal earthquakes in order to quantify the instantaneous deformation in this segment.

The above tools will allow us to develop a methodology of regional study of volcanological behaviour of an arc segment, and to develop individual models relating to the evolution and hazards associated with single volcanic centres.

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