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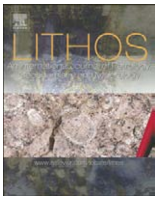

Are the Taitao granites formed due to subduction of the Chile ridge?

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ABSTRACT

The Taitao granites are distributed around the Late Miocene Taitao ophiolite (5.66 ± 0.33 Ma to 5.19 ± 0.15 Ma) exposed at the western tip of the Taitao peninsula, southern Chile, ~50 km southeast from the present day Chile triple junction. In this paper, we report sensitive high mass-resolution ion microprobe (SHRIMP) U–Pb ages for the Taitao granites to elucidate the temporal relationship between the ophiolite and granites, and discuss the origin of the granitic melts. Five intrusive bodies of the Taitao granites have U–Pb ages ranging from 5.70 ± 0.25 Ma (Tres Montes pluton in southeast) to 3.92 ± 0.07 Ma (Cabo Raper pluton in southwest). The Estero Cono, Seno Hoppner and Bahia Barrientos intrusions that fringe eastern margin of the ophiolite have U–Pb ages ranging from 5.17 ± 0.09 Ma to 4.88 ± 0.3 Ma. Recycled zircon cores are common only in the Tres Montes pluton. Our data indicate that the generation of the granitic melts started in the Tres Montes area when a short segment of the Chile ridge system started to subduct ca. 6 Ma ago. This magmatism involved contamination with sediments/basement rocks. A part of the subducting ridge center was emplaced to form the present Taitao ophiolite at ~5.6 Ma. Generation of granitic melts continued as the spreading center of the same ridge segment subducted, due perhaps to partial melting of the ophiolite and/or oceanic crust enhanced by heat from upwelling mantle beneath the ridge. Granitic magmas with various compositions developed during subduction of the ridge. Emplacement of the ophiolite and formation of continental crust took place almost simultaneously.

1. Introduction

"There may be granites and granites." Earth scientists after Read (1957) repeatedly confirmed the complexity involved in the genesis of granites. In this paper, we provide evidence for the generation of granitic magmas during ridge subduction.

The presence of young granite stocks at the tip of the Taitao peninsula (Fig. 1), the westernmost promontory of the Chilean coast, was first reported by Mpodozis et al. (1985). Five intrusive bodies of tonalite, granodiorite and granite, collectively referred to in this paper as the Taitao granites, are distributed around the Taitao ophiolite (Forsythe et al., 1986) exposed ~50 km southwest from the present day Chile triple junction. The five bodies of the Taitao granites are: the Estero Cono pluton (EC in Fig. 2), the Seno Hoppner pluton (SH), the Bahia Barrientos pluton (BB), the Cabo Raper pluton (CR) and the Tres Montes pluton (TM) from north to south (Fig. 2).

Fig. 1 shows that two oceanic plates, the Nazca plate in the north, and Antarctic plate in the south, separated by spreading ridges of the Chile ridge system, subduct beneath the South American plate with convergent rates of 9 cm/year and 2 cm/year, respectively (Cande et al., 1982; Cande and Leslie, 1986). Because the NNW-trending central axis of the Chile ridge is oblique to the NS-trending continental margin, three short spreading centers subducted repeatedly almost at the same latitude offshore the Taitao peninsula at around 6 Ma, 3 Ma and present (Cande and Leslie, 1986; Forsythe et al., 1986; Guivel et al., 1999). The Taitao ophiolite and granites are exposed where these ridge subduction events had taken place (Fig. 1). They emplaced into Pre-Jurassic meta-sedimentary rocks of the Los Chonos complex (Fig. 2).

The Taitao ophiolite consists of a complete sequence expected for oceanic lithosphere (Forsythe et al., 1986; Nelson et al., 1993; Bourgois

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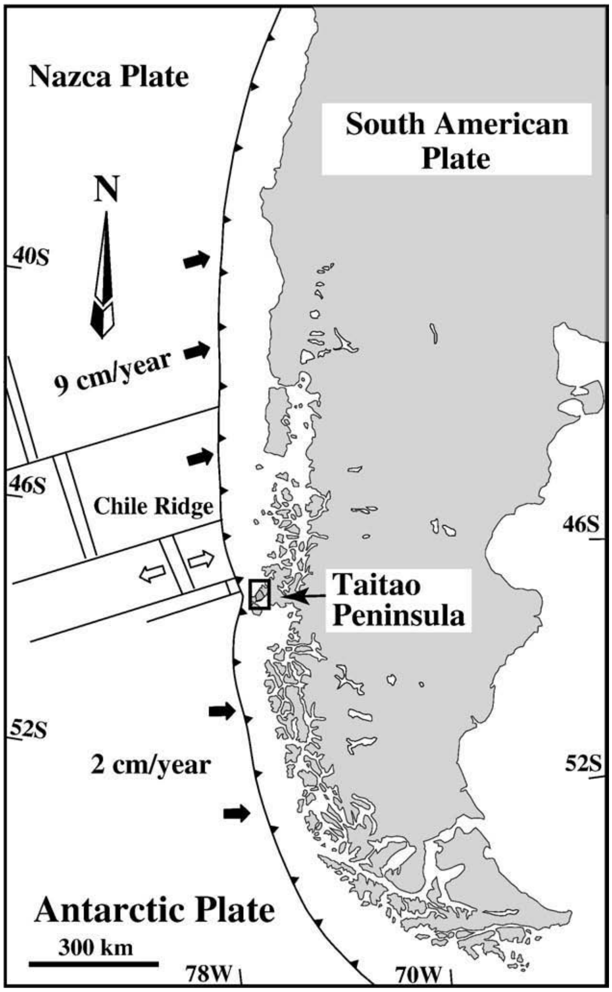

Fig. 1. Tectonic map of the Southeast Pacific margin. The Nazca plate and Antarctic plate separated by spreading ridges of the Chile ridge system, subduct beneath the South American plate with convergent rate of 9 cm/yr and 2 cm/yr, respectively. The Chile ridge system is disrupted by numerous fracture zones. Three ridge collision events took place offshore of the Taitao peninsula during 6 Ma–present.

et al., 1993; Guivel et al., 1999; Veloso et al., 2005; Anma et al., 2006; Shibuya et al., 2007): pillow lavas, pillow breccias and sheet flows, sheeted dike complexes, gabbros and ultramafic rocks from the top to the bottom of the sequence (Fig. 2). However, no metamorphic sole has been reported. Although there are discrepancies in petrology between the lower plutonic rocks with N-MORB compositions and upper volcanic rocks with enriched compositions (Kaeding et al., 1990; Lagabrielle et al., 1994; Le Moigne et al., 1996; Guivel et al., 1999), current petrological models favor a mid-ocean ridge (MOR)-origin for the Taitao ophiolite (Guivel et al., 1999; Lagabrielle et al., 2000). Shibuya et al. (2007) demonstrated the pattern of ocean-floor metamorphism of the ophiolite and compared it with other ophiolites and the oceanic crusts, and concluded that the Taitao ophiolite has many hydrothermal alteration features similar to those of MOR crusts.

The internal structure of the Taitao ophiolite, however, is not simple. The ultramafic rocks and gabbros are intensely folded and thrusted, and appear repeatedly as tectonic slices in the southeastern part of the ophiolite (Fig. 2). Sheeted dike complexes are exposed in two separate bodies that have contrasting dike trends: the one exposed along the Pacific coast trends NW–SE, and the other exposed in Estero Cono trends NNE–SSW. Volcanic sequences are exposed in two separate bodies (Fig. 2): the Main Volcanic Unit (MVU in Fig. 2) in the northern part and the Chile Margin Unit (CMU in Fig. 2) in the eastern part of the ophiolite (Guivel et al., 1999).

Veloso et al. (2005) reconstructed original orientations of internal structures in the Taitao ophiolite using paleomagnetic data to argue emplacement processes. Veloso et al. (2005) demonstrated that layered gabbros originally dipping eastward underwent folding, whereas the sheeted dike complexes and volcanic sequences underwent block rotation during the ridge subduction. They attributed the orthogonal trend of sheeted dike complexes to the block rotation; both originally trend NNE–SSW. Veloso et al. (2009) further discussed changes in stress fields during the block rotation. Anma et al. (2006) used sensitive high mass-resolution ion microprobe (SHRIMP) U–Pb and fission-track (FT) data of zircon separated from gabbros and a sheeted dike of the ophiolite (Fig. 2) to discuss rapid emplacement and northward migration of magmatic activity during the ridge subduction that took place ~6 Ma ago. Veloso et al. (2005) and Anma et al. (2006) concluded that it was an eastern part of the ridge segment that was emplaced to form the Taitao ophiolite. Anma et al. (2006) attributed ductile deformation of the ultramafic rocks and gabbros to basal shearing during subsequent subduction of the western part of the ridge just after the ophiolite emplacement. Obliquity between the current trend of the Chile ridge axis (NNW–SSE) and the original trend of the sheeted dike complexes (NNE–SSW) was attributed to ridge magmatism under influence of a transform fault nearby (Anma et al., 2006).

We use SHRIMP U–Pb data in this paper to demonstrate the temporal correlation between the emplacement of the Taitao ophiolite and Taitao granites. These radiometric ages are incorporated in geological observations and petrochemical data to assess the origin of the Taitao granites.

2. Previous age constraints

Radiometric age data of the Taitao ophiolite and the Taitao granites reported by previous workers are compiled in Fig. 2 (data based on Mpodozis et al., 1985; Guivel et al., 1999 and reference therein; Herve et al., 2003; Anma et al., 2006).

The radiometric ages for the Taitao granites were first determined by Mpodozis et al. (1985). They applied the K–Ar method on biotite separated from the Seno Hoppner, Cabo Raper and Bahia Barrientos plutons. Bourgois et al. (1992, 1993), and Guivel et al. (1999) applied the Ar–Ar dating technique on biotite, hornblende and feldspar separated from the Seno Hoppner and Cabo Raper pluton. The K–Ar and Ar–Ar data show the ages of the Seno Hoppner pluton range from 5.9 Ma to 5.2 Ma with error of less than ±0.5 Ma (except a feldspar Ar–Ar age with larger error), and those of the Cabo Raper pluton from 5.1 Ma to 3.3 Ma with error of less than ±0.8 Ma (except one data with larger error due to low concentration of K in hornblende). The biotite K–Ar age for the Bahia Barrientos pluton was determined to be 3.2 ± 1.2 Ma by Mpodozis et al. (1985).

Recently, Herve et al. (2003) applied SHRIMP U–Pb and FT techniques on zircon (plus apatite for FT) separated from Cabo Raper, Bahia Barrientos and Estero Cono plutons. The SHRIMP U–Pb age for the Cabo Raper pluton was reported to be 3.97 Ma to 3.84 Ma in an error range smaller than 0.14 Ma. Herve et al. (2003) also reported existence of a few inherited zircon of Cretaceous ages from the Cabo Raper pluton. Zircon FT ages (closing temperature of the zircon FT system ~300 °C) for the Cabo Raper pluton overlap the U–Pb ages within uncertainty error range, whereas apatite FT ages (closure temperature of the apatite FT system ~100 °C) indicate slightly younger ages. Zircon FT ages for the Estero Cono and Bahia Barrientos plutons were 3.49 ± 0.27 Ma and 3.47 ± 0.22 Ma, respectively (Herve et al., 2003).

The SHRIMP U–Pb ages of zircon separated from the rocks of the Taitao ophiolite were reported by Anma et al. (2006): 5.66 ± 0.33 Ma and 5.61 ± 0.09 Ma for gabbros and 5.19 ± 0.15 Ma for a NW–SE trending dacite dike. Mpodozis et al. (1985) reported a whole-rock K–Ar age from the Main Volcanic Unit to be 4.6 Ma and six whole-rock K–Ar ages ranging from 4.4 Ma to 2.5 Ma from the Chile Margin Unit