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Structural, geochronological, magnetic and magmatic constraints of a ridge collision/ridge subduction-related ophiolite

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A mid-oceanic ridge system subducts underneath South American plate at latitude 46S off Chilean coast, forming a ridge-trench-trench type triple junction. At ∼ 6 Ma, a short segment of the Chile ridge system subducted in south of the present triple junction. This ridge subduction event resulted in emplacement of a young ophiolite (5. 6 to 5. 2 Ma) and rapid crustal uplift (partly emerged after 4.9 Ma), and synchronous magmatism. This ophiolite, namely the Taitao ophiolite, provides criteria for the recognition of ridge collision/ridge subduction-related ophiolites. Aiming to establish recognition criteria, we studied distribution of structures, magnetic properties, geochemical characteristics, and radiometric ages of the Taitao ophiolite and related igneous rocks.

The Taitao ophiolite exhibits a classic Penrose-type stratigraphy: ultramafic rocks and gabbros (collectively referred as plutonic section hereafter) in the south, and sheeted dike complex (SDC) and volcanic sequences in the north. Composite foliations developed in the plutonic section, which were folded. SDC were exposed in two isolated blocks having orthogonal strikes of dike margins. Geochemically, gabbros have an N-MORB composition whereas basalts of the volcanic sequence have an E-MORB composition. U-Pb ages of zircons separated from gabbros, SDC and sediments interbeded with billow lavas implied that the center of magmatic activities migrated from the plutonic section to volcanic section during ∼5.6 Ma and ∼5.2 Ma. Zircon fission track ages of gabbros coincide with U-Pb ages within error range, implying rapid cooling. Demagnetization paths for SDC and lavas form a straight line, whereas those from the plutonic section are Z-shaped and divisble into two components: low coercivity and high coercivity. Restored orientation of gabbro structures imply that the magnetization acquired while gabbroic structures were folding. Thus, magma genesis and emplacement of the plutonic section of ophiolite took place almost instantaneously.

The ophiolite is surrounded by synchronous (5.7 Ma to 5.2 Ma) granitic intrusions with various compositions. Our data indicates that the granitic melts started forming near the conjunction of the subducting ridge and transform fault. Generation of granitic melts continued as the spreading center of the same segment subducted, due to partial melting of the oceanic crust and subducted sediments at amphibolite-facies conditions. The obduction of the Taitao ophiolite also accompanied volcanism in the Chile Margin that migrates from west (5.2 Ma) to east (4.6 Ma) at a rate of 5 cm/y as a fracture zone subducted.

A ridge collision/ridge subduction-related ophiolite has a short-life. The most intrinsic recognition criteria for such ophiolite must be hot emplacement of plutonic rocks, that represent magmatism at the axial magma chamber in the spreading ridge environment, into cold forearc region, which results in rapid cooling of the deep plutonic section (U-Pb ages coincide with cooling ages within an error range), and pervasive high temperature ductile deformation (after magmatic flow) throughout gabbro. Folding continued until the rocks were cooled to Curie T of magnetite (∼580C) in the case of the Taitao ophiolite. A ridge collision/ridge subduction-related ophiolite may accompany block rotation of volcanic sequence, because of high viscosity contrast between hot plutonic section and overriding volcanic section that has already cooled and solidified. It may also accompany acidic intrusions with various compositions and basaltic volcanisms due to subduction of fracture zones.