Isotopes and microstructures from calcite veins of the Izu-Bonin fore arc and the Amami-Sankaku basin: vein formation conditions, ages and deformation

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Five drill cores, drilled by International Ocean Discovery Program (IODP) expeditions (351 and 352) in 2014 from the outer Izu-Bonin (IB) fore arc and the Amami-Sankaku basin (ASB) near the Kyushu-Palau ridge, were selected to improve the understanding of supra-subduction zones (SSZ) as a birthplace of ophiolites.

On the basis of vein samples, hosted in boninites, fore arc basalts (FAB) and FAB-like rocks, vein precipitation and deformation conditions were investigated. In this contribution we present stable (δ18O and δ13C), clumped (Δ47) and Sr isotopes (87Sr/86Sr), rare earth elements (REE) and microstructures of vein precipitates.

Veins formed predominantly as a consequence of hydrofracturing resulting in the occurrence of complex vein systems and breccias. Extensional veins occur only subordinately. The most abundant vein mineral is (low Mg-) calcite determined by Raman spectra and electron microprobe analyses. Minor amounts of zeolite observed in vacant places and selvages result from alteration of volcanic glass during interaction with a fluid.

Morphology and growth patterns of the vein precipitates define four major types: type I veins reflect neptunian dykes indicated by micritic infill. Type II veins are characterized by blocky carbonates that locally exhibit growth zonation and deformation microstructures. Type III veins display syntaxial growth and elongated blocky carbonates. They occur predominantly as asymmetric syntaxial veins, locally showing more than one crack and seal event. Type IV veins are defined as antitaxial fibrous carbonates.

Stable isotopes and first clumped isotope data of all vein types hosted in IB fore arc and ASB rocks point to marine carbonates that precipitated at temperatures around 20°C and up to 70°C, respectively. Additionally, REE patterns indicate a seawater fluid that was locally modified by fluid-rock interaction. 87Sr/86Sr isotope data give maximum ages of vein formation between 52 and 49 Ma for IB and ASB, respectively. Furthermore, isotopes indicate ongoing vein formation and precipitation for at least 25 Ma.

Blocky carbonates from type II veins display microstructures like deformation twins, undulatory extinction and subgrain boundaries. Twin densities indicate differential stresses around 110 ± 20 MPa. Based on high differential stresses, deformation temperature is considered to be lower than 100°C, probably due to high strain rates. EBSD analyses indicate a maximum rotation of subgrain boundaries around 15°.

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