

X-ray CT and Raman spectroscopy analyses of polyphase fluid inclusions of quartz crystals from Tsushima granite

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Tsushima granite and the related rocks, southwestern Japan, are known for abundant aqueous polyphase inclusions with large daughter crystals of halite, sylvite, and carbonate. Kurosawa et al. (2012) analyzed chemical compositions of the polyphase fluid inclusions in quartz from miarolitic cavities at Tsushima granite with particle-induced X-ray emission (PIXE), and Kurosawa (2014) directly observed and analyzed the daughter minerals denuded by fracturing the quartz host by using SEM-EDS and identified the phase with Raman microspectroscopy. However, the three dimensional distribution and the morphology of daughter minerals, and the volumes of solid, liquid and vapor phases could not be revealed. Furthermore, it has the potential to transit for daughter mineral to another phase because of the dehydration and so on at fracturing the host to open the inclusion. On the other hand, X-ray computed tomography (XCT) method is the non-destructive analysis and provides the various three dimensional information such as the morphology and the volume. Recently, a linear attenuation coefficient (LAC), which depends on mass density, chemical composition and incident X-ray energy, can be calculated by the synchrotron radiation XCT (SR-XCT) and mineral phase can be inferred from the LAC value. In the present study, we analyzed the polyphase fluid inclusions in quartz crystals from a miarolitic cavity at the Tsushima granite with SR-XCT, Raman microspectroscopy, and SEM-EDS to identify the daughter mineral phases and estimate the chemical composition of daughter minerals and the liquid phases and volume ratios of solid, liquid and vapor phases.

Results from SR-XCT and Raman spectroscopy of two polyphase-inclusion samples, 1A and 1B, show presence of daughter crystals of halite, sylvite, saltonseaitite (K₃NaMnCl₆) siderite, and Fe-OH mineral (goethite?) in the inclusions. The crystals of saltonseaitite, siderite, and Fe-OH mineral, were not reported by the previous SEM-EDS observations (Kurosawa, 2014). Saltonseaitite was first reported by Kampf et al. (2013) and was first observed in Japan. In addition, crystals of calcite and Fe-Cl mineral reported by Kurosawa (2014) could not be observed in this study. The calculated LAC from liquid phase value has the larger value than that calculated from the saturated solution of NaCl or KCl. Thus, it needs to add about 8 mol% Fe to saturated solution of NaCl. We also estimated the volume ratios of the solid, liquid and vapor phases and the bulk chemical composition of each sample. The ratio of vapor to whole inclusion had different values between two neighboring polyphase-inclusions, although the ratios of solid and liquid phases and bulk chemical composition were almost same. This suggests the possibility that these inclusions had been captured at the different period, because fluid inclusions formed at the same generation have usually almost the same volume ratios among vapor and liquid phases. Furthermore, we dug in the quartz to directly observe and analyze the daughter phase in other polyphase-inclusion sample using focused ion beam. Daughter crystals of hematite and unknown phases, which could not be detected in XCT samples, were observed. Because there is a possibility of transiting from Fe-OH mineral observed by XCT and Raman spectroscopy to hematite in vacuum condition.

Kurosawa et al. (2012) 2012 Annual meeting Japan Association of Mineralogical Sciences (Japanese), Kurosawa (2014) 2014 Annual meeting Japan Association of Mineralogical Sciences (Japanese), Kampf et al. (2013) *American Mineralogist*, 98, 231.

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