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Carbonate minerals in trachytes, Ulleung Island, South Korea; implications for Carbon recycling in subduction zones

SHUANGSHUANG CHEN[1], **MINGHUA REN**[2], HYEJEONG LEE[2], EUGENE SMITH[2], SHICHUN HUANG[2], SEUNG-GU LEE[3], TAEJONG LEE[3] AND RUI GAO[1]

[1]Sun Yat-sen University

[2]University of Nevada, Las Vegas

[3]Korea Institute of Geoscience and Mineral Resources

Presenting Author: minghua.ren@unlv.edu

Ulleung Island in South Korea was formed by Pleistocene to mid-Holocene explosive eruptions in the back-arc of the Japan Trench. In some Ulleung Island volcanic rocks recovered by exploration drilling for geothermal investigations, carbonate minerals occur as euhedral pseudomorphic carbonate grains (0.2-3 mm in size), ulvöspinel-hosted carbonate-silicate inclusions (10-100 micrometers in size), biotite-hosted carbonate and carbonate-silicate inclusions with hexagonal shape (10-100 micrometers in size) and irregular shape (10-100 micrometers in size), and irregular carbonate globules (0.1-2 mm in size). Carbonate phases contain euhedral apatite and Fe-oxide microcrystals. Pseudomorphic carbonate grains with orthorhombic symmetry occur in the matrix and in biotite with sharp contacts. All carbonate-silicate and carbonate inclusions in biotite possess K-rich felsic rings between biotite and the included materials. Carbon and Oxygen isotopes for the euhedral pseudomorphic carbonate grains indicate a magmatic origin with $\delta^{13}C$ (VPDB, ‰) ranging from -3.98 to -5.76, and $\delta^{18}O$ (SMOW, ‰) from 4.43 to 11.49. Based on the petrographic and isotopic evidence, we suggest that carbonatite and silicate melts mixed during the magmatic evolution of the volcanic system. The carbonatite magmas probably originated by deep mantle melting related to subduction of the Pacific Plate and then rose to the lower crust where they mixed with silicate magmas. These observations suggest that there may be a significant accumulation of carbon in the lower crust in the back-arc of the Japan Trench, and probably all back-arc settings in general. Any future modeling of terrestrial carbon circulation and recycling should account for this potential carbon reservoir. Additionally, these carbonates may react with magmas rising from the mantle and release CO_2, which can lead to highly explosive eruptions in some of the world's most populated areas.