American Mineralogist, Volume 107, pages 1717–1735, 2022

Carbon flux and alkaline volcanism: Evidence from carbonatite-like carbonate minerals in trachytes, Ulleung Island, South Korea

ShuangShuang Chen[1,2], Minghua Ren[3,*], Hyejeong Lee[3], Eugene Smith[3,§], Shichun Huang[3,†], Seung Gu Lee[5,‡], TaeJong Lee[5], and Rui Gao[1,2]

[1]School of Earth Sciences and Engineering, Sun Yat-sen University, Guangzhou 510275, China
[2]Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), Zhuhai 519080, China
[3]Department of Geoscience, University of Nevada, Las Vegas, Nevada 89154, U.S.A.
[4]Department of Earth and Planetary Sciences, The University of Tennessee, Knoxville 37996, U.S.A.
[5]Geology Division, Korea Institute of Geoscience and Mineral Resources, 124 Gwahak-ro Yuseong-gu, Daejeon 34132, South Korea

Abstract

Carbon flux metasomatism in the subduction environment is an important process, but it remains poorly understood. The paucity of exposed lower crust and upper mantle rocks in continental arcs renders xenoliths a major target for studying the slab-derived carbon cycle. This study of the carbonate phases in volcanic rocks from three drill cores in Ulleung Island, South Korea, sheds light on the interaction of carbon flux in the upper mantle and lower crust in a back-arc setting. The volcanic rocks from Ulleung Island range in composition from trachybasalt to trachyte and contain abundant euhedral pseudomorphic carbonate grains, ulvöspinel-hosted and biotite-hosted carbonate-silicate melt inclusions, and irregular carbonate globules. Integrated petrographic and geochemical studies of a variety of phenocrysts, carbonate phases, and carbonate-silicate inclusions in biotite and ulvöspinel indicate that recharging of carbon flux affected magma evolution. Carbon and oxygen isotopes of the pseudomorphic carbonate grains overlap with mantle values, indicating a carbonatite-like origin of the carbonate phases. The (MgO,FeO,CaO)-rich silicates in ulvöspinel-hosted silicate inclusions and pseudomorphic carbonate grains likely represent a primary melt, which formed from the partial melting of carbonated eclogite of the subducted slab within the mantle wedge beneath Ulleung Island. A petrogenetic model is proposed to illustrate that the crystal mush in the magma chamber was intruded by carbonate-rich liquids and caused alteration of cumulate crystals to generate the euhedral pseudomorphic carbonate grains. The extrusive magma captured those pseudomorphic grains and erupted to form the trachybasalt-trachyte units. The observed carbonate phases and their geochemical characteristics indicate that carbon flux metasomatism played a fundamental role in this back-arc magmatism.

Keywords: Euhedral pseudomorphic carbonate grains, carbonate-silicate melt inclusion, carbon flux, trachytic magma, Ulleung Island