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Carbonate assimilation in open magmatic systems: the role of melt-bearing skarns and cumulate-forming processes

C. Freda (1), M. Gaeta (1,2), and T. Di Rocco (2)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Seismology and Tectonophysics, Rome, Italy (freda@ingv.it), (2) Dipartimento di Scienze della Terra, Sapienza Università di Roma

The geochemical characteristics of volcanic products in a variety of tectonic settings demonstrate that incorporation of crustal material into magmas is a relatively common process. Contamination of magmas by crustal components, in turn, can have a significant effect on magma composition and rheology. Despite this, the mechanism by which contamination occurs is still not well established and its efficacy is denied by some. In this study we focus on magma-carbonate interaction and on the rock shells (cumulates and skarns) formed at the contact between a magma chamber and its wall-rocks. We deduce that previous, unsuccessful attempts at carbonate assimilation-fractional crystallization (AFC) modelling can be related to the paucity of information about the cumulate zone in contact with skarns. We use one of the best examples of a magmatic plumbing system emplaced within a thick carbonate substratum (the Colli Albani Volcanic District in Central Italy) to demonstrate that a “skarn environment” can act as a source of CaO-rich silicate melts, and that the assimilation of these melts into the primitive magma is the main process responsible for magma contamination, rather than the ingestion of solid carbonate wall-rocks. In particular, by means of microtextural observations, mineral chemistry, whole-rock geochemical data and MELTS simulations we highlight the effect of high Ca-Tschermaks (CaAl2SiO6) activity in the melt on the stability of Cr-spinel, olivine, and clinopyroxene in cumulate rocks, define a reaction-cumulate zone where clinopyroxene crystallization is favoured, and model the magmatic differentiation processes active in this zone.