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Petrology of skarn and cumulate rocks: a record of magma-carbonate interaction phenomena

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The study of storage, cooling, and fractionation of magmas into the crust can be addressed by examination of crystal-rich granular lithic clasts of cognate material, containing variable amounts of interstitial glass coexisting with the crystal framework as well as of accessory and accidental lithic clasts. Although textural modifications during ascent are possible, lithic clasts can still represent snapshot of the magma chamber/host rock interface before eruption, thus, providing details on crystallization, differentiation and degrees of interaction between magma and wall rocks at shallow level. We aim to shed light on magma-carbonate wall rock interaction focusing on the petrology of cumulate and skarn rocks by using as case study a suite of mafic and calcite-bearing lithic clasts from the Colli Albani Volcanic District.

By means of phase relations, bulk rock chemistry, phase compositions, and stable isotope data we have recognised two types of skarns and three types of cumulates. Cumulates are in general characterised by a self-supporting interlocking framework of cumulus clinopyroxene$\pm$olivine and may contain either spinel (a) or intercumulus phlogopite and glass (b) or glass (c). Skarns can be divided in exoskarns, characterised by the occurrence of abundant calcite (12-80 vol.%) and endoskarns characterised Ca-Tschermak-rich mineral phases and rare pools of glass.

Exoskarns formed by solid state reactions in a metasomatised dolostone protolith at temperature of about 800 °C as inferred by thermometers based on oxygen isotope fractionation during clinopyroxene-calcite reaction.

Endoskarns are characterized by textural and chemical features attesting an origin from differentiated magmas experiencing exoskarns assimilation. Thermobarometers based on clinopyroxene-liquid equilibrium estimate crystallization conditions at temperature and pressure intervals of 250-300 MPa and 1081-1126 °C, respectively.

Cumulates, the (a) type, originate and form when a relatively primitive magma interacts with carbonate wall-rocks in a system open to CaO-contamination whereas types (b) and (c) form at the interface between a carbonate-bearing rocks (either skarn or carbonate wall-rock) and a differentiated magma. By means of volatile contents in melt inclusions and thermobarometers based on olivine-liquid and clinopyroxene-liquid equilibria we estimate a forming temperature and pressure for cumulates of 1067-1144 °C and 140-300 MPa, respectively.

Textural and geochemical features of cumulates and skarns indicate that magma-carbonate interaction can not be considered a one step process exhausting just after the formation of skarn shells. Magma and carbonate rocks, when in contact, continuously interact leading to the formation of exoskarns, endoskarns, cumulates, and differentiated melts. Most likely the first products of magma/carbonate interaction process are exoskarns and type (a) cumulates. Then, interaction between exoskarns (and/or carbonate rocks) and differentiated magmas (by means of carbonate and/or CaO-rich melt assimilation) produces endoskarns and types (b) and (c) cumulate.