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Remobilisation of crustal CO_2 recorded in calc-silicate xenoliths from Merapi volcano (Indonesia)

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Interaction between magma and carbonate rocks is occurring at active volcanoes worldwide, with implications for the magmatic evolution of the host volcanic systems and volcanic CO_2 budgets. Calc-silicate (skarn) xenoliths represent remnants of this magma-carbonate interaction, and their detailed petrographic and geochemical study provides insights into the different processes operating in the border zone between magma reservoir and carbonate country rocks.

At Merapi volcano (Indonesia), abundant calc-silicate skarn xenoliths are found in pyroclastic deposits [1]. We identify two distinct xenolith types [2]: 1) Magmatic skarn xenoliths, representing fragments of entrained carbonate which is caught in the process of being metamorphosed within the magma itself, and 2) exoskarn xenoliths, which represent fragments of metamorphosed wall-rocks. The magmatic skarn xenoliths comprise distinct compositional and mineralogical zones with abundant Ca-enriched glass. These mineralogically distinct zones are controlled by Ca transfer from the limestone protolith to the magma and by transfer of magma-derived elements in the opposite direction. In contrast, the exoskarn xenoliths are unzoned and essentially glass-free, representing equilibration at sub-solidus conditions.

Distinct textural types of calcite occur across both xenolith groups, each representing a process or combination of processes operating during magma-carbonate interaction. In situ carbon and oxygen isotope data of these calcites provide unique evidence for decarbonation, magma-fluid interaction, and the generation of carbonate melts [3]. Extremely light $\delta^{13}C_{PDB}$ values down to −29.3‰ in the magmatic skarns demonstrate highly efficient remobilisation of crustal CO_2 due to decarbonation reactions. This process may influence the eruptive intensity of the volcano [4] and impact global carbon cycling. Residual calcite in the exoskarn xenoliths can be modelled as a two-step process involving fluid mixing followed by decarbonation. Calcite occurring in melt-like structures shows isotopic evidence for a crustal source modified by magmatic fluids to varying degrees.

References:

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