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In situ radiogenic isotope data reveal complex open-system magma evolution at the Pleiades Volcanic Field (Antarctica)

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The Pleiades Volcanic Field (PVF), northern Victoria Land (Antarctica), is a group of monogenetic volcanic cones and one of the most compositionally diverse (erupted magmas range from alkali basalts to trachytes) volcanic suites of the McMurdo Volcanic Group. Volcanic activity in the PVF spans ~850 ka to recent times, and the erupted products define two distinct evolutionary lineages: (1) a mildly Na-alkaline series and (2) a strongly Na-alkaline trend, unusual for a dominantly monogenetic field.

Here we combine whole-rock Sr-Nd-Pb isotopes with new high-spatial-resolution in situ $^{87}Sr/^{86}Sr$ data obtained by laser ablation using a NEOMA MS/MS MC-ICP-MS to unravel magma differentiation, recycling and mixing processes in this complex alkaline system.

Mafic samples display OIB-like trace element signatures and low $^{87}Sr/^{86}Sr$ (0.7032–0.7037) coupled with high $^{143}Nd/^{144}Nd$, consistent with derivation from a subcontinental lithospheric mantle source. As differentiation proceeds, the two series diverge isotopically. The strongly alkaline lineage shows nearly invariant Sr-Nd isotope ratios, consistent with closed system fractional crystallization. In contrast, the mildly alkaline series records increasing $^{87}Sr/^{86}Sr$ (up to 0.7052) and decreasing $^{143}Nd/^{144}Nd$ (down to 0.51277), indicating significant assimilation of shallow crustal material.

In situ $^{87}Sr/^{86}Sr$ analyses document pronounced intracrystalline isotopic heterogeneities between mineral cores and rims, typically correlated with oscillatory, reverse and complex zoning patterns. These provide evidence for multiple events of magma recharge, recycling of crystals, and mixing between melts characterized by different degrees of evolution and distinct radiogenic signatures.

Assimilation and/or fractional crystallization modelling requires primitive magma volumes that are, at least, an order of magnitude greater than erupted products, which implies prolonged storage times and repeated replenishments of mafic magmas residing a different depths within a vertically structured plumbing system. The PVF thus represents not a simple cluster of monogenetic centres, but the exposed expression of a polygenetic, multilevel magmatic system, whose temporal evolution should be considered also in the light of variable ice load in response to climatic fluctuations.