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Differentiation of potassic, silica-poor magma systems and implications on eruptive styles: the Pozzolane Rosse event (Alban Hills, Central Italy)

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Conventionally, the degree of explosivity increases with increasing SiO_2 content, both in terms of eruption intensities and magnitudes: i.e., low-viscosity mafic magmas feed effusive or mildly explosive eruptions, whereas high-viscosity silicic magmas feed large explosive eruptions. The products of major explosive eruptions from the Alban Hills ultra-potassic volcanic district, however, represent a striking exception. The juvenile fraction of these pyroclastic flow deposits (with volume in the order of tens of km^3) is K-foiditic in composition, with SiO_2 contents as low as 42wt%. Here we report a petrological study of the Pozzolane Rosse eruptive event (456 ka), which emplaced an early lava flow, a plinian-style fallout layer and then a large pyroclastic flow. The lava flow is K-foiditic in composition and contains magmatic calcite. The pyroclastic deposits are made up of abundant, lapilli- to block-sized, scoria and cored scoria, along with lava, thermally metamorphosed sedimentary-, and rare granular lithic inclusions. The scoria clasts show low to intermediate vesicularity and contain dominant leucite and scarce clinopyroxene phenocrysts, as well as fresh glass foiditic to tephritic in composition showing the lowest SiO_2 ($<$42wt%) and highest MgO ($>$5wt%) contents found in the Alban Hills pyroclastics so far. Two groups of glasses can be distinguished on the basis of their K_2O/Na_2O ratio: i) glasses occurring in the fallout layer ($K_2O/Na_2O<2$ ratio, foiditic to tephritic in composition)

and ii) those in the pyroclastic flow ($K_2O/Na_2O>2$ ratio, mainly foiditic in composition). The differentiation process from a parental, phono-tephritic magma (i.e., the most primitive composition outcropping in the Alban Hills) to the $K_2O/Na_2O>2$ glass composition is driven by the crystallization of clinopyroxene+leucite, coupled with the assimilation of about 7wt% of calcite from country rocks, while further differentiation to the $K_2O/Na_2O<2$ composition is mainly driven by a significant increase of leucite in the fractionating mineral assemblage. The enhanced leucite stability field during this late differentiation step can be related to depressurization triggered by the magma withdrawal as a consequence of early lava effusion and/or to a significant reduction of water solubility induced by a CO_2 increase in the magma due to carbonate assimilation. Such intense leucite crystallization may result in dramatic volatile pressurization and thus in increasing magma viscosity that leads to a change in eruptive dynamics from lava effusion to pyroclastic activity, thus offering an explanation to the high degree of explosivity so unusual for SiO_2-poor magmas.