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Kaersutite megacrysts in the Permian mafic dikes of the Panticosa pluton (Pyrenees, Spain)

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Several mafic dikes crosscut the Palaeozoic granitic pluton of Panticosa and its Devonian metasedimentary country rocks. The dikes arrange in two swarms: 1) a N-S oriented system with a calc-alkaline affinity and 2) an E-W oriented system with an alkaline affinity; the alkaline dikes sometimes cut the calc-alkaline ones.

The alkaline dikes are classified as diabases and lamprophyres. They are mainly composed of micro- to phenocrysts of calcic plagioclase, Ti-rich clinopyroxene, olivine pseudomorphs and opaque minerals, defining doleritic to microporphyritic rock textures. Vesicles are common in these dikes, normally filled by chlorite ($\pm$ calcite).

Megacrysts of brown amphibole have been recognised in some of the alkaline dikes. They are Ti-rich calcic amphiboles classified as kaersutite (Krs). They are up to 8 cm in size (3-4 cm on average), so they are visible to the naked eye. In contrast, the rock groundmass is fine grained (300-400 μm). This size difference between the megacrysts and the groundmass suggests that the former crystallised below the emplacement level.

The Krs megacrysts present markedly anhedral habits, with ellipsoidal, reniform or amoeboid shapes. Their contacts with the groundmass are rounded and sharp and no overgrowth rims have been recognised. These contacts are slightly jagged and show accumulations of opaque minerals. These accumulation zones can reach 400 μm in thickness, leaving an amphibole relict in the core area. Furthermore, some of the megacrysts are permeated by the rock groundmass. These textural aspects suggest a resorption of the megacrysts due to disequilibrium with the host magma.

The composition of the Krs megacrysts has been determined by EMP (major elements) and LA-ICP-MS (trace elements). The megacrysts present very homogeneous compositions: TiO_2 (7.5-5.2 wt. %), Al_2O_3 (13.6-11.8 wt. %), CaO (11.3-10.2 wt. %), Na_2O (2.9-0.9 wt. %), K_2O (1.3-1 wt. %) and mg# (Mg/(Mg+Fe^{2+}+Fe^{3+}+Mn) per formula unit, 0.78-0.67).

The concentrations in Rare Earth Elements (REE) are considerably high ($\sum$REE = 642-938 ppm). They are 45 to 165 times enriched over the primitive mantle; this enrichment is greater for the LREE. Primitive mantle – normalised multielemental diagrams show clear positive anomalies in Nb-Ta and Ba, whilst the main negative anomalies correspond to Rb, Th, U and Pb.

The liquid in equilibrium with the Krs megacrysts shows La/Lu_N values of 4.5-7.8 and a strong negative anomaly in Sr. Furthermore, the relatively high Nb-Ta contents and the low Rb concentration point to HIMU (or EM-1)–type magmas. This signature strongly contrasts, however, with the normalised patterns of the whole rock of the dikes.

Thermobarometric calculations suggest a deep origin for the Krs megacrysts: 1105-1032 ºC and more than 7 kbar, indicating that they crystallised at a depth of ca. 25 km.

According to the petrographic and geochemical results, the Krs megacrysts are not cognate with their host groundmass and should be considered xenocrysts. They crystallised at deep levels and were afterwards incorporated into the ascending magma batch which carried them up to the emplacement level.