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Mineralogical changes driven by Li-rich pegmatite-derived fluids in strongly metasomatized host granites: evidence from the Gonçalo Pegmatite Field (Portugal)

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Geochemical halos surrounding evolved pegmatites can have considerable implications for the exploration of critical metals, which are essential for the energy transition. The escape from the pegmatitic melts into the host rocks of an exsolved, aqueous phase enriched in certain mobile elements can generate significant chemical anomalies, aiding in the identification of buried pegmatitic bodies enriched in rare elements. At the Gonçalo open pit (Guarda, Portugal), a lepidolite-rich pegmatite dyke is currently being mined. This dyke intrudes into a two-mica granite composed of quartz (30–40%), K-feldspar (20–35%), plagioclase (20–35%), biotite (7–15%), muscovite (2–4%), with minor apatite, monazite, zircon, and ilmenite. Nevertheless, in the first few centimetres of the host rock on both sides of the pegmatite, an irregular greisenized band was formed due to interactions with fluids released from the pegmatitic melt. In contrast, the strongly metasomatized (greisenized) granite consists of quartz (50–55%) and Li-Al/Li-Fe micas (40–45%), along with variable amounts of apatite, fluorite, tourmaline, rutile, feldspars, monazite, zircon, and ilmenite, reflecting a marked difference from the original paragenesis. The greisenized samples show near-total (or total) feldspar consumption, releasing Si, Al, Ca, K, Na, and P into the fluid phase. The metasomatizing fluids were likely rich in P and F in origin, which together with the liberated Ca, could have facilitated the crystallization of metasomatic apatite and fluorite. The widespread formation of fine-grained, pale-coloured Li-micas is notable and can be attributed to the release of Si, Al, and K during feldspar decomposition. This would have enabled the increased mica content in the greisenized granite. The excess of Si contributed to the higher proportion of quartz observed in the metasomatized granite. Crystallization of tourmaline is commonly associated with biotite relics, while the destabilization of primary ilmenite (typically related with primary biotite) resulted in the formation of metasomatic rutile and fine ilmenite needles. These mineralogical and geochemical transformations could provide valuable insights into the nature of the metasomatizing fluids, which, being already enriched in Li, F, and B, infiltrated the host granite and were capable of mobilizing effectively Si, Al, Fe, Mg, and Ca.