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Peraluminous magmas and the LCT pegmatitic Li paradox

ANDREA DINI[1], LUCA CARICCHI[2], FEDERICO FARINA[3], KALIN KOUZMANOV[2] AND FEDERICO PEZZOTTA[4]

[1]Istituto di Geoscienze e Georisorse - CNR
[2]University of Geneva
[3]Università degli Studi di Milano
[4]Museo Civico di Storia Naturale di Milano
Presenting Author: a.dini@igg.cnr.it

During the past two decades, detailed geochemical analyses of melt inclusions from both peraluminous and peralkaline-metaluminous felsic magmas provided new insights on evolution of volatiles and metals during fractional crystallization. Lithium, a critical element for the current energy transition, behaves very differently in the two magmatic systems. In peralkaline-metaluminous magmas, the incompatibility of Li in the structure of nearly all rhyolite minerals (e.g., feldspar, quartz and pyroxene) results in enrichment of residual melts (e.g. Benson et al., 2017). In magmas formed by partial melting of metasediments, the early crystallization of lithium compatible peraluminous minerals (e.g. biotite-siderophyllite, zinnwaldite and cordierite) produce an inverse trend of progressive Li depletion (e.g. Webster at al., 2004).

This behavior is somewhat surprising because LCT pegmatites, classically interpreted as extremely differentiated melts, are commonly associated with peraluminous and not metaluminous-peralkaline intrusions. To address such a lithium paradox, we studied young peraluminous granites and rhyolites from the Tuscan Magmatic Province focusing on the determination of Li (and other major and trace elements) in rock-forming minerals by bulk and in situ methods (EPMA, ICPMS and LA-ICPMS). The occurrence, at Elba Island (Tuscany), of the famous San Piero LCT pegmatite district (type locality of elbaite), associated with peraluminous granites and tourmaline bearing leucogranite, allowed to test the real connection between lithium-rich rocks and the presumed intrusive parent bodies.

The trans-crustal interplay between distinct metasedimentary sources at depth, P-T melting conditions, mechanisms of magma transfer, opening modes of emplacement structures and local geochemical differentiation, all play at variable extent to overcome the apparent paradox of a Lithium ore formed from a nominally Li depleted peraluminous magma. Moreover, lithium sequestered in early magmatic minerals (e.g. micas) of peraluminous intrusions could open new scenarios for future unconventional lithium resources.

Benson TR, Coble MA, Rytuba JJ and Mahood GA (2017) Lithium enrichment in intracontinental rhyolite magmas leads to Li deposits in caldera basins. Nature Communications, 8, 270.

Webster J, Thomas R, Forster HJ, Seltmann R and Tappen C (2004) Geochemical evolution of halogen-enriched granite magmas and mineralizing fluids of the Zinnwald tin-tungsten mining district, Erzgebirge, Germany. Minerali Deposita, 39, 452-472.