
Is There a Link Between Orogenic Collapse and Lithium-Bearing Pegmatites?

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Lithium-bearing pegmatites and S-type granites are widely recognized as the products of partial melting of supracrustal rocks at depth. Such melting is commonly attributed to crustal thickening during orogenesis. However, pegmatites and granites are typically emplaced during the late stages of orogeny, and many pegmatite-bearing regions also display evidence for syn- to post-orogenic extension. Such evidence includes thinned lithosphere, low-angle detachment structures, metamorphic core complexes, and basins infilled with coarse clastic sediments, along with steep metamorphic gradients and gently dipping structural fabrics, likely signifying ancient detachment faulting. Examples include the Orange River Pegmatite Belt of South Africa and Namibia, pegmatites in the Monashee Metamorphic Complex of the Canadian Cordillera, and possibly pegmatites in the Himalayas, Cote d'Ivoire, Elba Island in Italy, the Lewisian Gneiss Complex of Scotland, and the western Superior craton of Canada.

We argue that extensional collapse of thickened orogenic crust provides a key environment for the formation of lithium-bearing pegmatites. In this model, earlier subduction and/or crustal stacking during accretion and collision introduces fertile, hydrous sedimentary and volcanic source rocks to depth. Subsequent slab breakoff and/or delamination drives asthenospheric upwelling, with the associated heat pulse possibly inducing partial melting in the overlying orogenic crust and forming some early granites and pegmatites. Breakoff or delamination also gravitationally destabilizes the thickened orogenic belt. The resultant orogenic collapse involves rapid tectonic exhumation of hot, deep crust, leading to decompression melting and the formation of the main generation of granites and pegmatites, while the extensional regime and associated faults and shear zones enable melt mobility and emplacement in the mid- to upper crust. In many instances, extensional collapse is accompanied by a transition to transform tectonics, and coeval or later strike-slip faults may provide additional transport pathways and structural traps for the pegmatite-forming melts.