Analysis of limestone-marble syntexis reactions in the generation of some peralkalic magmas: reanalysis of Reginald Daly's insights 100 years later

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The theoretical analysis of how sedimentary limestone and marble could melt as a result of infiltrative contact metasomatism associated with silicate magma enables reconsideration of the limestone syntectic (complex assimilation) hypothesis for the origin of some peralkalic rocks. Reginald Daly's syntectic model published in detail in early 1918 fell out of favor because experimental evidence from the early 1960s suggested that: (1) limestone assimilation would increase P(CO_2) and cause solidification of the silicate intrusion; (2) there is a thermal barrier between silica-saturated and undersaturated magmas that would inhibit extensive desilication of the magma; and (3) the endothermic decarbonation reactions would require heat via magmatic crystallization of near-solidus magmas. However, these concerns were not as critical for high-T mafic melts relative to lower-T silicic melts, although most subsequent researchers dismissed syntexis because isotopic arguments also seemed robust. However, skarn-related limestone melts can interact much more easily with silicate magma, resulting in calc-silicate-forming (endoskarnlike) limestone syntectic (desilication-calcificationmagnesification processes) decarbonation reactions with compositional evolution into the silica-undersaturated field. If originally mafic in composition when syntectically modified, then the CO_2-bearing derivative peralkalic melt may subsequently react with the dominant volume magma or fractionate separately into a more evolved composition. As well, an increase in P(CO_2) within the modified silicate fraction coupled with compositional evolution to more silica-undersaturated compositions enhances the stability of the immiscible, extremely low viscosity carbonate melt fraction. In addition, dynamic interaction of these co-existing immiscible melts (analogous to the current hypothesis) would partition elements, as well as isotopic signatures, such that they would be virtually unrecognizable as having a crustal level syntectic origin, based on mass-balance principles and Rayleigh decarbonation isotopic equilibria, as they do in many infiltrative skarn systems. Rayleigh decarbonation significantly affects these key isotopic signatures such that they are almost indistinguishable from mantle magmas. Radiogenic and stable isotopic arguments against limestone/marble syntexis for the origin of some peralkaline magmas are shown to be equivocal. Other objections to syntectic processes are briefly re-examined, in particular the importance of these syntectic decarbonation processes in open versus closed subvolcanic systems. The syntectic scenario challenges the current (only) petrogenetic hypothesis of a mantle source for peralkaliccarbonatitic magma systems, while presenting evidence for a modified syntectic origin for some (hybrid) peralkalic magmas and associated secondary crustal carbonatites. This petrogenetic analysis supports the basic premise of Daly's limestone syntectic hypothesis for the origin of some peralkalic igneous rocks.

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