Generation of I-type granitic rocks by melting of heterogeneous lower crust

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Hammerli et al. (2018) described a particular case of complex migmatites from the Hidaka Metamorphic Belt (HMB, Japan) as a potential heterogeneous lower crust source of I-type granitic rocks. These migmatites are formed by a cm to m scale stacking of mafic (gabbroic) granulites and metasedimentary (pelitic and psammitic) layers. The authors based their interpretation on the isotopic signatures of Hf, Nd and O in accessory minerals apatite and zircon in leucosomes and veins from the composite migmatites. They infer from the observed heterogeneities that melts extracted from the metasedimentary layers of the migmatite “interact” with the interlayered mafic granulites giving rise to hybrid melts of I-type affinity. Although the mechanisms of interaction is not described, the conclusion is that metasediments interlayered at the lower crust contribute to the supracrustal isotopic components that are identified worldwide in arc-magmas and, in particular, in I-type granite batholiths. It is possible that such a hybrid source, composed of metasediments and mafic granulites, can produce a hybrid melt of I-type affinity. In fact, experiments on mixed sources at lower crustal pressures and ca. 1000 °C (Castro et al., 1999; Patiño Douce, 1995) lead to similar conclusions. However, it is very unlikely that a crustal migmatite complex as that described in the HMB be a model universal source to I-type batholiths for several reasons.

(1) Metasedimentary rocks are almost absent at the lower crust, which is dominantly composed of mafic and intermediate granulites according to studies of lower crust xenoliths and exposed arc-crust sections. Even in the case of the HMB, the lower crust is not exposed and a composition similar to that of the outcropping complex is assumed to exist below (Shimura et al., 2004).

(2) Melts (leucosomes) form discrete veins of varied compositions in the described migmatites. These melts can be extracted to form hypothetically small granitic bodies as those described in the HMB. However, the formation of batholiths requires larger melt fractions at temperatures much higher than those recorded by mineral equilibria in the studied rocks (ca. 800 °C and ~6 kbar; (Komatsu et al., 1994)).

(3) I-type granitic associations, mainly composed of granodiorites and tonalites, come from water-undersaturated magmas that equilibrated at temperatures of ca. 1000 °C (Castro, 2013 and references herein), which are not recorded in regional-scale migmatitic complexes.

As crustal assimilation is only effective at local scale, it is clear that a mixed source is required to explain the isotopic features of I-type granites. However the location and melting of such a hybrid source at the lower crust is uncertain. A fourth explanation for the generation of I-type granitic batholiths from a hybrid (mantle-crust) source is by melting of subducted mélanges within the mantle. According to thermomechanical models of active margins (Gerya and Yuen, 2003; Gerya et al., 2004), sediment-basalt mélanges start to form at the subduction channel and evolve mechanically to Rayleigh-Taylor instabilities and then to silicic diapirs that intrude into the suprasubduction mantle, where they become into granitic magmas that are finally relaminated at the lower arc-crust or continental margin. Melting experiments of such subducted mélanges (Castro et al., 2010; Cruz-Uribe et al., 2018) confirm that large amount of melt, with compositions matching the geochemical and isotopic features of I-type batholiths, can be formed by this mechanism.

REFERENCES CITED


