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The composition of I-type granites: a consequence of mineral entrainment at the source?

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I-type granitoids show a compositional variability in their maficity (FeO_t+MgO content), from 3 wt.% to 9 wt.%, and in other elements, with negative trends for incompatible major elements like Si, K and Na and positive trends for compatible major elements like Ca and Ti with increasing maficity [1,2]. Similar trends have also been observed in S-type granites and these have been explained as a function of the nature and amount of residual minerals (mostly peritectic) entrained to the melt from the partially melted source [3, 4]. Consequently, it is likely that I-type granitoids can also be formed by the entrainment to the melt of variable amounts of peritectic minerals from the partially melted protolith, of likely andesitic composition, and that this entrainment explains the characteristic negative trend for A/CNK with increasing maficity of I-type granites [1, 2].

To test this hypothesis, a preliminary study using thermodynamic modelling was carried out. The software PERPLEX [5], including appropriate thermodynamic databases and solution models for granitic s.l. systems, was chosen for the calculations. The bulk composition used as the protolith was the andesitic mel2 composition [6]. For this preliminary study, only one single pressure of 1.5 GPa and only one model of mineral entrainment, where all residual minerals were allowed to entrain, were investigated. The temperature range was chosen to be between 900 ºC and 1200 ºC, in agreement with the expected high temperatures of formation of these magmas [6]. The modelled magma compositions were finally compared with published analyses of I-type granites of the Peninsular Ranges Batholith [7].

The results of the calculations show that, for the chosen model of entrainment of minerals, the magmas modelled between 900 and 1000 ºC match the maficity of the granites. These magmas reproduce the negative or positive trend of each compositional variable of the granites with increasing maficity, including the A/CNK. However, the modelled magmas contain a higher amount of Si, Na and K and a lower amount of Ti, Al and Ca than the granites. These latter elements are hosted mainly in peritectic phases, meaning that the peritectic phases may entrain preferentially over non-peritectic phases. In general, this work supports the initial hypothesis, but more modelling on other pressure or mineral entrainment model is required to fully verify it.

[1] Clemens, J.D., et al, 2011, Lithos 126, 174-181. [2] Clemens, J.D. and Stevens, G., 2012, Lithos 134-135, 317-329. [3] Stevens, G. et al., 2007, Geology 35, 9-12. [4] Garcia-Arias, M. and Stevens, G., 2017, Lithos 277, 131-153. [5] Connolly, J.A.D., 2009, G-cubed 10, Q10014. [6] Castro, A. et al., 2010, Journal of Petrology 51, 1267-1295. [7] Lee, C.-T.A. et al., 2007, Earth and Planetary Science Letters 263, 370-387.