Modes and impact of crustal contamination: Example of the Sondalo gabbroic complex (Central Alps, SE Switzerland - N Italy)

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Keywords: magmatic system, crustal contamination, diffusion, hybridization, partial melting

Magmatic differentiation requires a variable combination of fractional crystallization and/or crustal contamination that influences the liquid line of descent, as well as the composition and the final paragenesis of resulting magmatic rocks. However, the vectors of crustal contamination and how they influence the magmatic differentiation remain poorly constrained, notably because the depth at which they are active are usually hardly accessible. Several processes have been invoked in the literature: (1) small-scale diffusion; (2) energetically costly partial melting of crustal material coupled with magma hybridization; (3) The dissolution of crustal rocks by reactive bulk assimilation. Instead of focusing on the deepest crustal levels, we here explore crustal contamination processes active in the intermediate continental crust. We use the example of the Sondalo gabbroic complex that intruded the metasedimentary Campo unit, both exposed in the Central Alps.

The Sondalo gabbroic complex is a Permian intrusion of tholeiitic affinity (troctolite and norite, 300±12 and 280±10 Ma by Sm-Nd) that evolved towards calc-alkaline intermediate bodies (diorite and granodiorite, 289±4 - 285±6 Ma by U-Pb on Zrn). Mafic melts intruded the Campo unit composed of fertile amphibolite-facies micaschist and paragneiss (Ms-Bt-St-Grt-Pl stable), attesting of a (supposed) Carboniferous prograde P-T paths (5.5 - 6 kbar/600°C-650°C). The emplacement of this intrusion caused a HT-contact metamorphism reaching partial melting of host rocks at 289±4 – 288±5 (U-Pb on Zrn) Ma and in-situ formation of Crd-Grt-Sil-Spl granulite-facies restite composing large septa. Field and petrological observations coupled with geochemical bulk rock major and trace element analyses show the contribution of host-rock contamination, by: (1) mafic magmas of tholeiitic affinity becoming progressively calc-alkaline; (2) the increase in modal amount of garnet, biotite and cordierite in magmatic rocks around metasedimentary septa, stabilized by the influx of some major elements (e.g., SiO₂, K₂O, Al₂O₃ and H₂O) in the noritic mush; (3) liquid line of descent departs from theoretically predicted compositions (with both equilibrium and fractional crystallization) with enrichment in elements typical for crustal rocks (i.e., K₂O and Al₂O₃ at high Mg#).

Field observations and bulk rock major and trace elements composition highlight that crustal contamination is achieved through a combination of vectors having a variable spatial extent. Their
respective weight is, however, still difficult to constrain. The middle crust seems to be the ideal location for crustal assimilation because host-rocks are fertile and the mafic magmas benefit from a high and durable thermal regime that appears to favor physical and chemical interactions. Further constraints will be brought by in-situ trace element analyses and Sr-Nd isotopes to estimate their respective influence on hybridization.