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Melt extraction in the lower continental crust and implications for element redistribution, Ivrea Verbano Zone, Italy.

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Partial melting and melt migration are fundamental processes for the differentiation of the continental crust, the generation of felsic melts and the redistribution of the heat-producing elements. A key parameter for quantitative models is the amount and temperature of melt extracted from residual granulite facies rocks. However, quantifying melt extraction is challenging because it requires constraints on the protolith composition and the temperature-time evolution.

In this study, we investigate melt extraction from the felsic metasediments of the Ivrea Verbano Zone, Val d'Ossola. Within the ICDP-DIVE project, two boreholes were drilled along the lower crustal sequence and a representative bulk rock dataset was acquired for the felsic metasediments. The tectono-stratigraphically shallower borehole targets upper amphibolite-facies lithologies. Here, felsic lithologies ("kinzigites") have generally experienced <10 vol% melt loss. The deeper borehole targets granulite-facies residual felsic rocks ("stronalites") that experienced temperatures of 850-900°C.

We used a mass balance approach to quantify the degree of melt extraction from the stronalites to match the compositions of the kinzigites. The systematic down-hole sampling shows that kinzigites have a greater geochemical variability towards high silica contents compared to stronalites with melt-residuum reintegrated compositions. This suggests that the composition of the protolith varies with crustal depth.

Major element calculations show that melt extraction in stronalites can be highly heterogeneous, with the degree of melt loss in different samples ranging from low (<10 vol%), intermediate 20-30 vol%, to extreme values up to 50%. All stronalites show a depletion of Th and U compared to the kinzigites. Since the Th and U concentrations of anatectic melts are temperature dependent, mass balances imply that some rocks experienced significant degrees (30-40 vol%) of melt extraction during prograde metamorphism, associated with a strong enrichment in ferromagnesian elements. In other cases, lower degrees of melt loss occurred only close to peak temperatures (850-900°C), leading to subtle variations in major elements but similarly high degrees of depletion in Th and U. The comparison of the Zr, Hf, La and Ce concentrations of the kinzigites and the stronalites allows to investigate the role of different phases in controlling the trace element re-distribution during melting.