

Deep crustal radiogenic heat production: the message from anatectic melt inclusions

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The model of crustal differentiation via anatexis and extraction of anatectic melts to shallower levels, producing a residual lower crust and an upper crust enriched in incompatible elements, implies an overall decrease of radiogenic heat production with depth¹. Phase equilibrium modelling coupled with solubility expressions for accessory minerals is often used to support the view that melt loss leads to a depletion of heat-producing elements (HPE - U, Th, and K) in the residuum, as the anatectic melt is assumed to be saturated in these elements². However, some empirical studies of the radiogenic heat production (HP) of deep crustal levels now exposed at the surface show a different picture, because similar, high heat production values have been measured in rocks at both sub- and suprasolidus conditions³.

Because anatectic melt inclusions (MI) record the pristine composition of melts produced in the lower continental crust, they may provide further insights into this debate. Here, we evaluate K₂O, Th, and U data and calculate the radiogenic HP from 13 case studies worldwide (10 of metasedimentary origin and 3 of mafic origin, with peak temperatures ranging from 700 to 1000 °C). The MI are compared with a granite database and model predictions. The comparison clearly shows similarities in the behavior of MI and granites. An asymmetric distribution with a shift toward lower values is observed for U and HP. The most significant discrepancy is observed for Th. Instead, a remarkable difference is observed for both U and Th when the MI data set is compared with model predictions. The MI data suggest that depletion of HPE in the deep crust should occur within the source terrain during melt generation, but only ultrahigh-temperature (UHT) metamorphism and formation of UHT anatectic melts may mobilize sufficient amounts of HPE, resulting in a residual lower crust depleted in HPE.

References

¹Rudnick & Gao 2003 <http://doi.org/10.1016/B978-0-08-095975-7.00301-6>

²Yakymchuk & Brown 2014 <https://doi.org/10.1144/jgs2013-115>

³Alessio et al. 2018 <https://doi.org/10.1130/G39970.1>