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Metasomatic Reaction Zones: Archives of Crustal Cooling and Fluid rock interaction in Precambrian shields

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Precambrian shields, largely made up of metamorphic rocks, are characterized today by stable continental geotherms. Studies of these rocks (e.g., geothermobarometry) generally focus on the characterization of the peak metamorphic conditions (and P-T paths adjacent to the thermal peaks) that resulted from tectonic and other thermal perturbations. The process of subsequent cooling to ambient geotherms is accompanied by significant fluid-rock interaction and elemental mass transport, but these are poorly understood - even if these may be associated with important processes such as ore genesis. We have studied metasomatic reaction zones (*MRZ*) that formed at well-defined lithological contacts between mafic dike-like bodies and the pelitic country rocks in the Proterozoic North Singhbhum Mobile Belt, India, to throw light on this aspect.

The observed sequence on outcrop scale is: dike-like bodies (*amphibole-plagioclase-quartz-epidote-chlorite-Fe-oxides*)–Zone 1 (*amphibole-epidote-calcic-plagioclase-quartz-chlorite*)–Zone 2 (*Zone 1 assemblage minus amphibole*)–pelitic schist (*muscovite-quartz-plagioclase-biotite-garnet-chlorite*).

Thermobarometry yields metamorphic conditions of 6–8.5 kbar and 550–565°C for the pelitic schist. Whole-rock Ti/Cr discontinuity at the Zone 1 – dyke interface indicates that the *MRZ*s were derived from the pelitic schist. Reaction of the pelites with saline fluids that had equilibrated earlier with the dike assemblage is able to produce the MRZ sequence during cooling to ~ 400 °C at pressures of 1.6-2 kbar, as indicated by reaction path modelling (EQ3/6) and confirmed by hydrothermal experiments. The assemblages in the different zones may be produced by variable time-integrated fluid to rock ratios, which in turn may be obtained at progressively distal parts from a fluid source. This process was accompanied by (i) significant mobility of elements, including those traditionally considered to be immobile (e.g., REE and HFSE), controlled by the respective mineral assemblages in the zones, and (ii) deformation and strain during the relaxation period accommodated by different deformation styles (i.e., slip systems in quartz) compared to those due to regional deformation found in the country rocks. An interplay between such deformation, resulting in the formation of cross-cutting as well as intergranular vein networks, and chemical reaction facilitated the process of mass transport and mineralogical transformation during crustal cooling.