Continental crust formation and metamorphism during the Neoarchean–Paleoproterozoic: an example from the Nilgiri Block, southern India

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Earth is a unique planetary body with an evolved felsic continental crust on its surface. Had this continental crust not evolved, Earth’s crust would have been basaltic/gabbroic in composition, and covered almost completely by water. It is important to understand how the mafic crust, which formed after the differentiation of Planet Earth transformed to one that is felsic in composition. Presently active processes capable of transforming crust from mafic to felsic composition, on a large scale, are subduction and subsequent arc magmatism. However, whether such processes were active during the Hadean–Archean eon is highly debated. Field evidence from major cratons show that partial melting of the earlier formed mafic crust (e.g., processes like sagduction) formed felsic continental crust. Thus, understanding when subduction-related process started on the planet is important. Here we present evidence from metamorphosed magmatic rocks such as pyroxenite, metagabbro, two-pyroxene granulite, charnockite, hornblende-biotite gneiss and rhyolite from the Nilgiri Block, southern India. U-Pb zircon age data shows that all these rocks formed during the late Neoarchean (core ages between 2600–2500Ma) and that they underwent subsequent metamorphism during the early Paleoproterozoic (rim ages between 2500–2450Ma). If felsic rocks formed from the partial melting of earlier formed mafic rocks, the mafic rocks should be older. Since all these rocks were formed and metamorphosed simultaneously, it is possible that protoliths of these rocks formed through melt differentiation followed by partial melting in the mantle wedge during the subduction-related arc magmatic process. An enrichment in light field strength elements and REE compared to heavy ones, and Nb-Ta depletion are common signatures in rocks formed through the arc magmatic process, where fluids or melts formed from subducted basaltic crust and the overlying sediments enrich the mantle wedge in lighter elements. Further, during metamorphism, these rocks could partially melt and form granitic melts. However there is no field evidence that suggests partial melting during metamorphism in these rocks. Textural relations and vein networks of silicate-oxide-sulfide-phosphate minerals in these rocks suggest that they could have possibly metasomatized in the presence of saline fluids during the early Paleoproterozoic. Such saline fluids could have been released during the waning stages of the magmatic process, probably due to the collapse and mixing of the accretionary wedge to the mantle wedge.

Keywords: Arc Magmatism, Metamorphism, southern India

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