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Style of Palaeoarchaean tectonics from the SE Kaapvaal and Singhbhum Cratons: Constraints from Metamorphic Studies and Zircon Geochronology

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Direct evidence of Palaeoarchaean collisional tectonics in terms of orogenic metamorphism have so far solely been reported from the Barberton, De Kraalen and Witrivier greenstone belts of SE KaapvaalCraton. These terrains record a high-pressure ($\sim$14 kbar) metamorphic event at $\sim$3.2 Ga, indicative of a geothermal gradient of $\sim$15°C/km. Clockwise P-T paths have been recorded from these terrains and other medium pressure amphibolite-facies greenstone belts in the SE KaapvaalCraton, providing conclusive evidence for the operation of collisional tectonics during the Palaeoarchaean period.

In this study we present new evidence for Palaeoarchaean high-grade metamorphism from the SE Kaapvaalcraton (Ulundi greenstone belt remnant). We also present for the first time evidence of a high-pressure metamorphic event from the SinghbhumCraton, India.

In the Ulundi greenstone belt, calc-silicate boudins occur within hornblende-bearing amphibolites that are tectonically interleaved with tonalitic to granitic gneisses dated at between 3.39 and 3.27Ga using SHRIMP U-Pbon zircon. The boudins contain Grt-Cpx-Pl-Qtz. Garnet often contains epidote inclusions. Epidote-quartz bearing symplectites replace garnet-clinopyroxene-plagioclase at their margins. Garnet and clinopyroxeneare mostly homogeneous in composition: Grs65Alm28Sps05 and Di16Hd84 respectively. XAn content of Pl is $\sim$53 mol%. Average P (calculated by THERMOCALC) as obtained from the set of independent reactions formed with garnet-clinopyroxene-plagioclase core compositions and composition of epidote inclusions in garnet indicate that peak metamorphism occurred at $\sim$6.3 kbar. Such pressure value corresponds with a reference temperature of $\sim$500°C. Age of the associated foliated granite indicates that possibly the metamorphic event occurred at $\sim$3.27 Ga The geothermal gradient corresponding to such peak PT conditions is $\sim$30°C/km, similar to that recorded in many other Archaean terrains.

In the SinghbhumCraton, supracrustals of the Older Metamorphic Group are tectonically interleaved with tonalitic gneiss dated at 3.45 Ga. Amphibolite enclaves preserve a Grt-Cpx-Qtz bearing assemblage. Garnet and clinopyroxene occur as porphyroblasts and are replaced at margins and fractures by hornblende-epidote. Both garnet and clinopyroxene are homogeneous in composition: Grs36Alm58Sps07Prp07 and Di55Hd45 respectively. In order to constrain the P-T conditions of peak metamorphism a P-T pseudosection has been constructed in the system NCFMASH, from the whole rock (XRF) bulk composition of the sample. The pseudosection reveals stability of plagioclase-absent garnet-clinopyroxene bearing assemblages at pressures above 12 kbar. Modal isopleths indicate formation of garnet and clinopyroxene at the expense of amphibole, epidote and plagioclase with progressive increase in temperature and pressure. Isopleth thermobarometry conducted from the intersections of the compositional isopleths of garnet-clinopyroxene (considered to be in textural equilibrium) indicates P-T conditions of $\sim$15.5-16.5kbar, 600-650°C, corresponding to a geothermal gradient of $\sim$15°C/km. This metamorphic event may have taken place between 3.3-3.2 Ga as suggested from the K-Ar ages of amphibole and biotite in the associated supracrustal units.

The study thus reveals that in the Palaeoarchaean time tectonic processes related to crustal thickening were operative both in SE Kaapvaal and Singhbhum Cratons.