ABSTRACT

In the southern margin of the Sausar Mobile Belt (SMB), which lies in the southern margin of the Central Indian Tectonic Zone (CITZ), a high-grade granulite-gneiss domain occurs in between green-schist facies Sausar supracrustals of the Sausar orogen, in the north and amphibolite facies cratonic domain of the South Indian Block in the south. Locally referred to as the Bhandara-Balaghat Granulite (BBG) domain, the granulite-gneiss domain is distinct from its footwall and hanging wall domains by its lithological assemblage and deformation history. The domain comprises of a suite of felsic, aluminous and Iron Formation granulites and garnet-cordierite gneiss, being intruded by gabbro, noritic gabbro, norite, orthopyroxenite, olivine gabbro, amphibolites and granites. The intelayered supracrustal granulites and metamorphosed mafic intrusives occur as pods and lenses within intensely tectonised felsic gneisses.

Six phases of deformation (BD_1 to BD_6) have been recorded in the BBG domain, the earliest of which (BD_1) produced a pervasive granulite facies banding (BS_1) in the supracrustal granulites. BD_2 is preserved as a rare BS_2 fabric in the felsic granulite and in interlayered garnet-cordierite gneiss - metanorite sequence. This was followed by a strong ductile shear zone deformation, BD_3, which produced southerly verging isoclinal folds (BF_3) and a strong mylonitic fabric (BS_3). Gabbro and early generation mafic dyke (Md_1) of gabbroic norite composition, which were emplaced prior to BD_3, were affected by this deformation. BD_4 produced moderately to steeply plunging upright to steeply inclined folds, along N to NNE axis. The broadly NNE-SSW trending structural grain of the BBG domain is controlled by the axial planar foliation, BS_4. The next deformation, BD_5 produced narrow, steep E-W striking ductile shear zone fabrics, in the northern margin of the BBG domain. The terminal deformation, BD_6, produced extremely localized recumbent folds and associated shallow, easterly plunging pucker axis lineation, in immediate contact with the Sausar Group of rocks. Of the six phases of deformations in the BBG domain, the first four phases had taken place in the granulite to upper amphibolite facies conditions, and pre-dated the Sausar orogeny, which deformed and metamorphosed the Sausar supracrustals. By contrast, the Sausar Group of rocks recorded only four phases of deformation, within the greenschist facies metamorphic condition. The sharp contrast in metamorphic and structural history across the two domains signifies that the contact between the granulites and the Sausar supracrustals is tectonic.

Applying sequences of prograde, peak and retrograde reaction textures, mineral chemistry, geothermobarometric results, petrogenetic grid and P-T pseudosection studies from the felsic and aluminous granulites and metamorphosed mafic dyke markers and geochronological constraints from the Pre-Sausar structural domain, three distinct older granulite facies tectonothermal events have been recorded from the BBG domain. The first event caused ultrahigh temperature (UHT) metamorphism (BM_1) ($T \sim 950°-1000°C$) at relatively deep crustal levels ($P \sim 8kbar$) and a subsequent post-peak near isobaric cooling P-T history (BM_2). BM_1 caused pervasive biotite-dehydration melting, producing garnet - aluminous orthopyroxene and sapphirine-spinel-bearing incongruent solid assemblages in felsic and aluminous granulites respectively. In the latter, such high temperatures have been additionally indicated by the stability of ternary alkali feldspar ($Or_{47-51}Ab_{44-47}An_{06}$). During BM_2, garnet-corundum and biotite-sillimanite assemblages were produced by reacting sapphirine-spinel-sillimanite and rehydration of garnet in the leucosomes respectively. BM_2 also caused extensive exsolution in the ternary alkali feldspar. The sequence of mineral reactions, when considered in the newly constructed KFMASH petrogenetic grid and NCKFMASH P-T pseudosection, suggest a counterclockwise (CCW) P-T path of evolution of the UHT event, having a prograde heating segment at relatively low pressure, and a post-peak near isobaric cooling history. Applying electron microprobe dating (EMP) techniques to monazites included in BM_1 garnet or occurring in low strain domains in the felsic granulites, the UHT metamorphism is dated at 2040-209 Ma. These findings provide the first tight constraint on the presence of an older crust, and a Palaeoproterozoic crustal history in the rocks of the CITZ.

The isobarically cooled, deep crustal UHT granulites were subsequently reworked by two distinct granulite facies metamorphic events (BM_3 and BM_4). BM_3 caused crustal attenuation of the Palaeoproterozoic granulites to ~6 kbar at T~725°C. In the felsic and aluminous granulites, this is marked by the decomposition of BM_1 garnet to orthopyroxene-plagioclase and BM_2 garnet to spinel+sillimanite±biotite symplectites respectively. P-T pseudosection modeling of two texturally well-constrained garnet-breakdown reaction domains in felsic granulites, in the system NCFMAS indicates that the crustal attenuation resulted from extension of near normal crustal thickness. A clockwise metamorphic P-T path, involving a phase of heating during decompression, being followed by a phase of cooling, also accompanying pressure fall has been suggested for this metamorphic event. The peak BM_3 metamorphism appears to be coincident with the emplacement of metagabbros. Gabbroic norite dikes were emplaced slightly later and at a relatively shallower crustal level, possibly along the retrograde cooling arm. Using newly formed monazite overgrowths, from the BM_3 symplectite and BS_2 structural domains, the timing of this metamorphism has been constrained at ~1525 Ma.

Subsequent metamorphism (BM_4) caused renewed growth of garnet-quartz symplectites, replacing orthopyroxene-plagioclase symplectites in the felsic granulites and formation of garnet-quartz-clinopyroxene coronas in metamorphosed mafic dykes. In both these rocks, the mineral assemblages had overgrown the BS_3 foliation. P-T pseudosection modelling in these rocks reveals a counterclockwise P-T path of evolution of the BM_4 event, involving a prograde burial to ~9.4 kbar, 760°C, followed by post-peak cooling to ~6.5 kbar, 500°C. Monazites dated from the BS_3 mylonite foliation yield an age of ~1450 Ma, which is correlated with the BM_4 event.

CCW P-T path of the UHT metamorphism does not support previous tectonic models of Palaeoproterozoic plate subduction, leading to the amalgamation of the North and South Indian Blocks. Such P-T paths could be produced by models of low crustal magmatic accretion of mantle-derived mafic magmas. Although, tectonic set up for the Palaeoproterozoic event is indeterminate at this stage, the short-lived Mesoproterozoic events, BM_3 and BM_4 can be best explained by back-arc extension, being followed by a regional tectonic thickening event due to collision with a possible arc component in the north. If true, this model would suggest that the main amalgamation in the CITZ had taken place in the early Mesoproterozoic. Nevertheless, the granulites were still at depth, corresponding to ~6.5 kbar metamorphic pressures, at the end of this amalgamation event. Their exhumation and tectonic juxtaposition with Sausar supracrustal were possibly achieved during the Grenville-aged Sausar orogeny. The present study, therefore, demonstrates that the footwall side of a younger orogen records significant information of older tectonothermal histories, the signatures of which are almost lost from the main part of the orogen.

KEY WORDS: Central Indian Tectonic Zone; Sausar Mobile Belt; Bhandara-Balaghat Granulite domain; Allochthonous Polycyclic domain; Aluminous granulite; Mafic dyke; Reaction Textures; Polymetamorphism; Counterclockwise metamorphic P-T path; Clockwise metamorphic P-T path; UHT metamorphism; Monazite chemical dating; Palaeoproterozoic metamorphic event; Mesoproterozoic metamorphic event; KFMASH petrogenetic grid; NCKFMASH and NCFMAS P-T Pseudosections.