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ACKNOWLEDGEMENT. We thank Dr Sarath Guttikunda (Urban Emissions.Info) and Dr Shoibal Chakravarty (National Institute of Advanced Studies, Bengaluru) for their suggestions during data estimation phase of this study.

Received 2 March 2017; accepted 5 April 2017

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Dolomitic carbonatite from the Chotanagpur Granite Gneiss Complex: a new DARC (Deformed Alkaline Rocks and Carbonatite) in the Precambrian shield of India

The Chotanagpur Granite Gneiss Complex (CGGC) of the East Indian Shield records a protracted geological history ranging from Palaeo- to Meso- to Neoproterozoic time[1,2]. It is commonly believed that the whole of the CGGC behaved as a unified crustal block at least from 1600 Ma (ref. 3). The E–W to ENE–WSW trending North Purulia Shear Zone (NPSZ) dissects and geographically divides the CGGC into the northern and southern blocks[4]. The NPSZ exposes diverse rock types, including khondalite, biotite gneiss, charnockite, mafic granulite and nepheline syenite. This rock association is distinctly different from the gneissic rocks exposed on its shoulders. Towards the central part of the NPSZ, near the village Chalania (23°27.03′N, 86°21.82′E), coexisting carbonate-rich rocks (CRR) and apatite–carbonate-rich rocks (ACRR) are identified that are enclosed by migmatitic felsic rocks and augen gneiss having a gneissic banding of amphibolite facies assemblage trending E–W to ENE–WSW defining the dominant fabric of the NPSZ[5]. The host rock is frequently traversed by bands of CRR and ACRR which are extensively brecciated and the angular fragments of CRR and ACRR are welded together by silica-rich veins. The strike of the brecciated bands is parallel with the gneissic banding of the enclosing rocks.

Here we present preliminary data on petrography, mineral chemistry, trace element and stable isotope composition of the CRR and ACRR and discuss their significance. Detailed study on the rock suites are in progress.

Original fabric and mineralogy of the studied CRR and ACRR are virtually modified by superimposed deformation, first under ductile followed by brittle regimes, and post-magmatic fluid–rock interaction. In the domains where deformation and chemical alteration are minimal, dolomite (up to 7 mol% $CaFe(CO_3)_2$ with Ca : Mg + Fe = 0.96–1.1) is the sole carbonate (CC_1) in the earliest (primary) assemblages of the CRR. Coarse and rounded dolomite grains that constitute more than 80 vol% of the CRR simulate an ortho-cumulus texture (Figure 1 *a* and *b*) with variable proportion of magnetite, apatite and monazite occurring in the interstitial space (Figure 1 *c*). In the ACRR, apatite (>70 vol%) and dolomite (15–20 vol%) are the major minerals with monazite as the accessory phase. Ductile deformation is manifested by polygonal outlines of dolomite aggregates. The large size of the polygonal dolomite grains suggests that the rock was originally very coarse-grained. Glide twin is a common feature of the recrystallized dolomite grains. In contrast to dolomite, apatite grains show brittle fractures with undulatory extinction and bending of grains around dolomite that represent impress of ductile deformation. The brittle deformation of the studied rocks is manifested by ramifying veins composed of cryptocrystalline silica (jasparoid), vug-fill silica (showing comb structure) and acicular dolomite (CC_2). Islands of angular clasts of dolomite and apatite are present in the matrix of silica and CC_2 (Figure 1 *d*). However, no marked difference between the compositions of CC_1 and CC_2 is noted, except for textural habit. Some late veins of calcite (CC_3) occasionally develop along grain margins of coarse dolomite and also produce ramifying vein networks.

Figure 2 *a* presents preliminary trace and rare earth element data of a few representative samples of the CRR, analysed in the Geochemistry Laboratory of the Department of Earth Science, Indian Institute of Technology (IIT), Kanpur using multi-collector inductively coupled mass spectrometer, after chondrite normalization[6]. The range of magmatic dolomitic carbonatites (Spitskop and Newania respectively) reported from Africa and India is also included[7,8]. The trace element composition of the studied rock follows a similar trend and overlaps with the trace element composition of the magmatic carbonatites from the two above-mentioned localities. The only marked deviation is noted for U and Th concentrations which are higher in the studied samples.

Dolomite-rich portions from four carbonatite samples that are practically devoid of secondary minerals were analysed for O and C isotope composition using a stable isotope mass spectrometer at the Isotope Geochemistry Laboratory of Department of Geology and Geophysics, IIT, Kharagpur. The measured isotopic composition of the studied rock falls within the field stipulated for mantle-derived primary carbonatites of the world. However, compared to the mantle values for C and O isotopes, the studied CRR shows slight enrichment in $\delta^{18}O$ (9.8 to 10.7 per mil) but have similar $\delta^{13}C$ (–6.6 to –6.7 per mil) value possibly owing to late fluid–rock interaction (Figure 2 *b*)[9].

Combined field relations, mineralogy, texture, geochemistry and isotopic compositions of C and O suggest that the protolith of the CRR (and the associated ACRR) was dolomitic carbonatite (beforsite[10]), which was deformed and mineralogically reconstituted during the subsequent deformation and metamorphism/fluid-induced alteration. The studied area, therefore, joins the few dolomitic carbonatites in the world and third from the Precambrian Shield of India (after Sevattur[11] and Newania[12]). Primary carbonatite is a rare rock of mantle origin and is commonly associated with riftogenic extensional setting within continents[13]. The enclosing rocks of the CRR and ACRR include a suite of felsic orthogneisses which develop a strong planar fabric (ENE–WSW) due to intense crystalloplastic deformation. The studied rocks also show the same fabric albeit less intensely relative to the enclosing rocks. Published age data show that the felsic orthogneisses of this region underwent crystalloplastic deformation and amphibolite-grade metamorphism during 928–921 Ma (ref. 14). Judging from the deformation patterns of the studied rocks (CRR and ACRR) and the enclosing orthogneisses, it seems likely that the magmatic protolith of the studied rocks was emplaced during the terminal part of the regional tectonism. Nevertheless, the petrological information of this study records a new DARC (Deformed Alkaline Rocks and Carbonatite, only deformed carbonatite here) in the Indian Shield, first time from the CGGC. According to a recent postulation[15], DARCs represent a switch of tectonic regime from extensional (during which the alkaline rock and/or carbonatite was emplaced) to compressional (during which ARCs (Alkaline Rock and/or Carbonatites) were deformed and

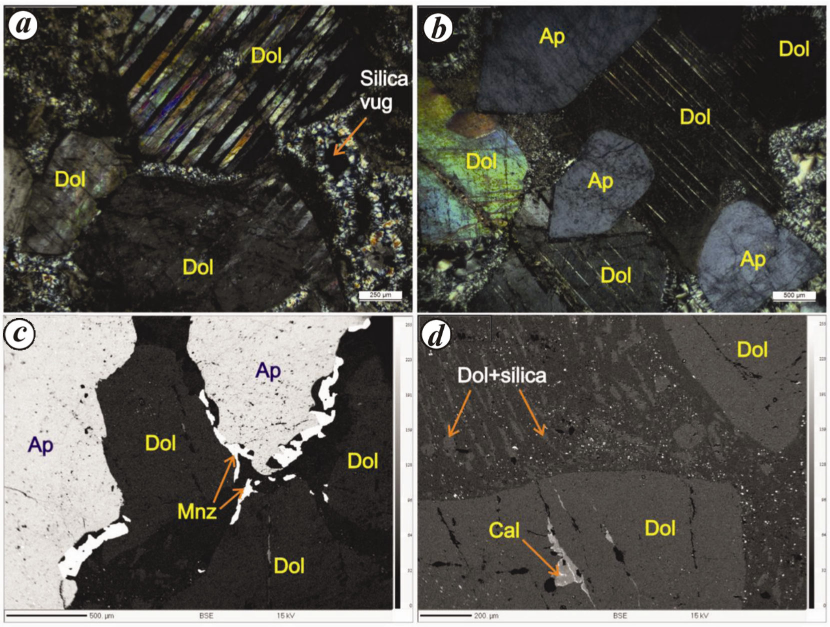

Figure 1. ***a***, ***b***, Typical ortho-cumulus texture in pure carbonate-rich rocks (CRR; 250 µm) and apatite-bearing CRR (500 µm) respectively. ***c***, Anhedral monazite in the interstitial spaces of coarse dolomite and apatite (500 µm). ***d***, Islands of big dolomite clasts (CC_1) floating in the rib-like dolomite grains (CC_2) and silica matrix. Veins of calcite (CC_3) replace along the fracture of CC_1 (200 µm). Mineral abbreviation used is according to Kretz[17].

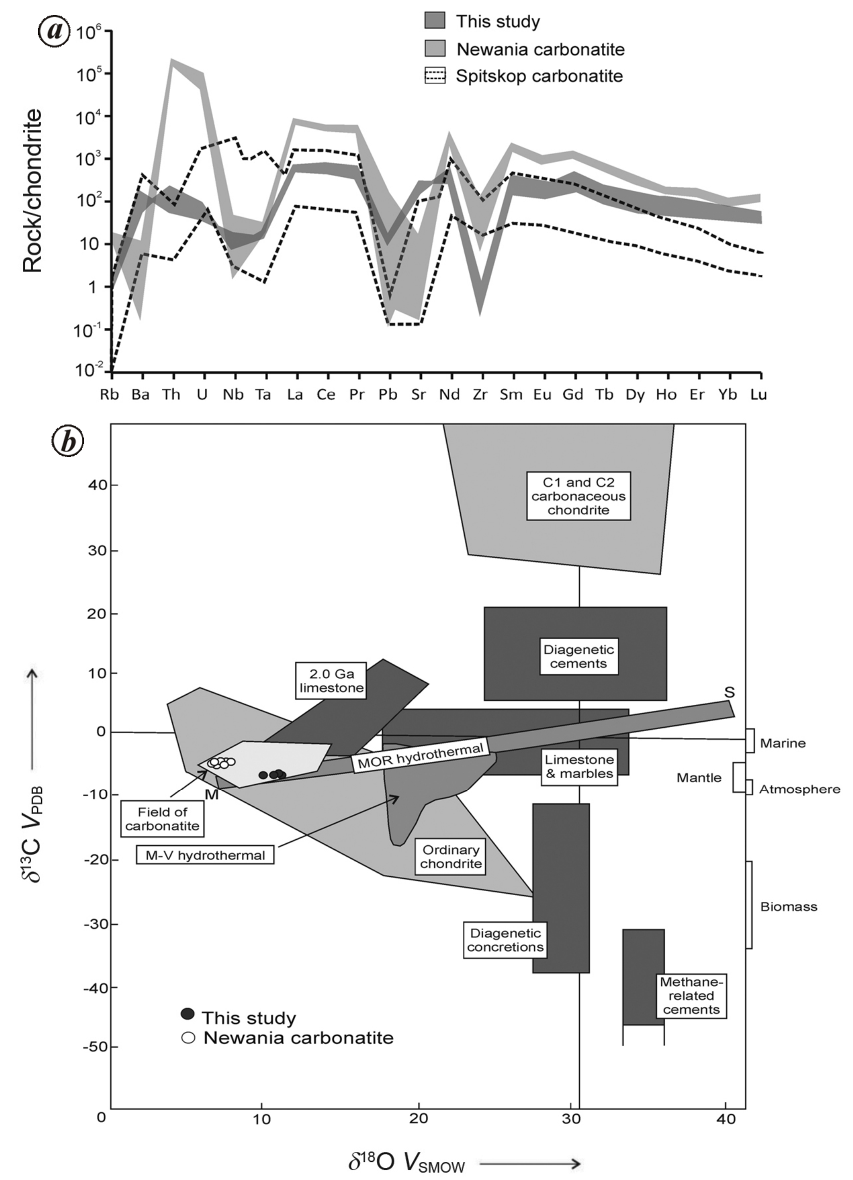

Figure 2. ***a***, Comparison of chondrite normalized spider diagram of trace and rare earth element concentrations of the present study with Newania, Rajasthan and Spitskop, Africa. ***b***, Comparison of the stable isotope signature of the present study with Newania, Rajasthan in δ^{18}O V_{SMOW} versus δ^{13}C V_{PDB} plot, which falls well within the carbonatite field.

metamorphosed) settings. Taking clue from the African occurrences of DARCs, the logic is proposed that the DARCs should coincide with the palaeo suture zones where two separate continental blocks were fused during destruction of the intervening oceanic crust. The proposal has also been applied to and proven correct for DARC localities of the Indian Precambrians of peninsular India[16]. If the contention also holds good for the studied rocks, then CGGC should be treated as a collage to at least two continental blocks that got amalgamated along the NPSZ.

Studies are in progress to validate or discard the postulation.

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ACKNOWLEDGEMENTS. S.D. and N.D. thank the University Grants Commission and Department of Science and Technology respectively, for financial support. The field work of S.S. and P.S. is supported by CAS(VI), Department of Geological Sciences, Jadhavpur University (JU) and PURSE awarded to JU. We thank Prof. Anindya Sarkar (IIT Kharagpur), Dr Upama Dutta (IIT Dhanbad) and Dr Indra Sekhar Sen (IIT Kanpur) for help in generating analytical data.

Received 16 March 2017; accepted 5 July 2017

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