Presence of Quartz Pebble Conglomerate (QPC) from Babarmaal Belt, Lower Aravalli Group

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The present study for the first time reports a horizon of Quartz-Pebble-Conglomerate (QPC) from the Babarmaal Formation of the Palaeoproterozoic Aravalli Supergroup of Rajasthan. The QPC horizon is located 18 km southwest of Udaipur city, in the vicinity of the famous pink marble mining belt of Babarmal. The QPC body occurs in close association with the quartzite overlying the basement BGC. It is overlain by the calcitic pink marble strikingly in contrast to the other associated dolomitic carbonates of the Jhamarkotra Formation, from the Lower Aravalli Group.

Keywords: QPC, Babarmal belt, Lower Aravalli Group Aravalli Supergroup

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1. Introduction

The rocks of Babarmal belt of Udaipur district from Rajasthan occur prominently in close vicinity of the basement rocks of Banded Gneissic Complex (Heron, 1953), which are *sensu stricto* basement renamed as Mewar Gneiss (Roy *et al* (1988) and Roy and Jakhar, 2002) (Figure 1). Babarmal belt popularly known for the pink marble deposits has been previously studied by Heron (1953), Gupta *et al* (1980; 1997) Maheshwari *et al* (2002), Roy and Jakhar (2002), and Avadich *et al* (2006) on various geological aspects.

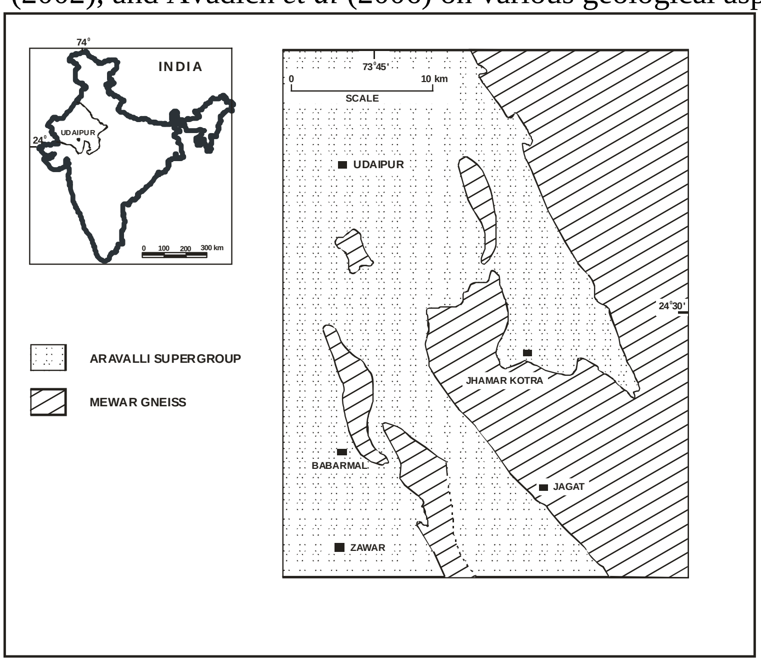

Figure 1: Map showing Location of Babarmal region from Udaipur District, Rajasthan (modified after Roy & Jakhar 2002).

Occurrence of Quartz-Pebble-Conglomerate (QPC) from the belt in close association with the pink marble has been hitherto unreported. The present study for the first time reports the occurrence of QPC from the belt which bears great significance in the entire evolutionary history of the Aravalli Supergroup. The report of this QPC, first from the Palaeoproterozoic of Rajasthan, vindicates the fact that QPC are prominent in the Precambrian (Cox *et al* 2002) and more such horizons can be traced out in the area for further significant studies and mineral deposit exploration. QPC generally remain unreported on regional geological maps because of the inverse relationship between preserved volume and age (Gilluly, 1969 and Ronov, 1983). Detailed high resolution mapping in selected transects is suggested to trace similar litho-units in the area.

The pink marble in itself is a carbonate antiquity in the entire Palaeoproterozoic Aravalli Supergroup because of its various distinguishing features *viz.* mainly higher grade of metamorphism, lack of primary sedimentary features, dominance of calcitic instead of dolomitic carbonate and absence of stromatolitic rock-phosphate. The QPC and pink marble association in the Babarmal belt point towards a unique geological history previously unknown in the Paleoproterozoic Aravalli Supergroup.

2. Geology

The rocks of Babarmal belt have been described by Heron (1953) as a part of “Raialo Series” of the Archaean “Aravalli System” denoting an unconformity between the basement and the younger rocks. On the basis of lithostratigraphy he had correlated the calcitic pink marble of Babarmal with the white-grey dolomitic/calcitic marble of Raialo. The pink marble according to him is represented by two narrow isoclinal synclines separated from each other by a distance of a mile. Further studies by Gupta *et al* (1980 & 1997) led to revision in the status of the pink marble and classified the marble into Palaeoproterozoic formations with host of nomenclatures. They also revised the structural features of the pink marble by Heron (1953), describing it as two antiforms generated by the second deformation, instead of the regional isoclinal features. Considering Babarmal as part of the type area of the Palaeoproterozoic Aravalli Supergroup Roy and Jakhar (2002) designated the rocks of the area as part of the Jhamarkotra Formation of the Lower Aravalli Group. The rocks of the Jhamarkotra Formation in the area directly overlie the Archaean basement outcrops which have been named as constituent of “Sarara Inlier” of Mewar Gneissic complex, with the significant absence of the lower metavolcanic Delwara Formation of the lower Aravalli Group in the belt (Roy & Jakhar, 2002; Roy and Purohit, 2018). However, Avadich *et al* (2006) reported occurrences of the barite derived in the Babarmal belt from the epigenetic hydrothermal solutions generated by the off-shoots of the Delwara volcanic activity. The disseminated discordant pockets of meta-amphibolites rich in Barite, within the flanks of the basement gneiss in the Babarmal belts have been presumed to be evidences of equivalents of Delwara Formation in the Babarmal belt (Mehta *et al* 2007).

3. Lithology and Petrography

One of the prominent features in the belt is peneplained basement characterized by low topographic features, while the supracrustals occur as high crested hills. Many peneplained outcrop features have also been masked by the alluvial cover and mine dump of the pink marble quarries. The outcrops are lithologically characterized mainly by the basement banded gneisses, amphibolites veins and dykes, pink marble, quartzite and a prominent QPC litho-unit band encircling the pink marble. The basement in the Babarmal belt has been named as ‘Sarara Inlier’, which has the regional strike of NW-SE. It is traversed by large number of amphibolitic plugs along the flanks mainly. Basement rocks are overlained by quartzite intermingled with QPC, which in turn is conformably overlained by the pink marble with sharp contacts and rare sheared contacts of schists. The pink colour of the marble is presumably due to the Mn and Co enrichment, which has been contributed mainly from the late mafic magmatic activities observed in the area (unpublished DMG report). The western limb of the pink marble is overlained by phyllite, which is in direct contact with the dolomitic carbonate of typical characters of Jhamarkotra Formation of Lower Aravalli (Roy and Jakhar, 2002). The eastern pink marble body (the eastern limb of Heron, 1953) overlying the QPC shows regional isoclinal fold features. Pink marble and QPC both have strike of N30^{0}W dipping moderately (45^0 towards SW). The QPC encircles the pink marble as pinch and swells along a semi-arcuate margin. The fining upward grain size of the pebbles of the QPC is towards the pink marble in the core indicating towards a regional isoclinal antiform. The region also shows low strain deformation patterns indicated by the moderate dips in the entire terrain.

The QPC immediately overlies the basement BGC represented by granite and gneiss. It is intermingled with the quartzite which is primarily arkosic. On the crest of the quartzite ridges, occurrence of quartz veins gives massive character to the quartzite. Coarse to fine grain size gradational variation noticed in QPC from flanks to core indicates younging direction towards the pink marble in the core. QPC associated with quartzite primarily consists of quartz and oligoclase which has underwent serecitization in thin sections. The other accessory minerals identified are biotite, pyrite, calcite and other ferruginous oxides. The grains of QPC are rounded to sub-rounded relatively of assorted fragments of quartz which are homogenously pebbly and/or cobbly (Fig. 2). Pebbles and cobbles vary in size between and to a little extent angularity is also observed in few grains of the studied QPC (Figure 3 and 4). QPC litho-unit subsequently underwent regional scale shearing as evidenced by the development of fibrous grains (Fig. 5). Such secondary activities on QPC lead to porosity loss, diagenetic mass transfer or intrastratal solution, broadly denoted the reworking phenomenon. Pressure solution activity is very common in QPC and is evident on microscopic and macroscopic levels (Mosher, 1981). In the present studied QPC evidences of pressure solutions are distinct with the presence of relatively high proportion of interpenetrating and nested grain contacts (Fig. 5). Considerable pressure solution activity recorded in the Babarmal QPC also suggests dissolution and mass transfer and consequent volume loss. This fact gives the snapshot of the operational processes which led to the development of pockets of QPC in the belt confined to the arkosic quartzite.

The QPC is also embedded with rip-up-clasts derived mainly from the basement schists and gneiss which are also taken-up as evidences of reworking of the QPC. It has more than 90% of the clasts consisting of vein quartz, chert or quartzite. Pockets of QPC accumulations also occur locally along the drainages, directly overlying quartzite bedrocks. Thick or laterally extensive units are not observed in the belt. Such nature of QPC strongly vindicates the above-mentioned mass flow hypothesis of unsorted

Figure 2

Figure 3

Figure 4

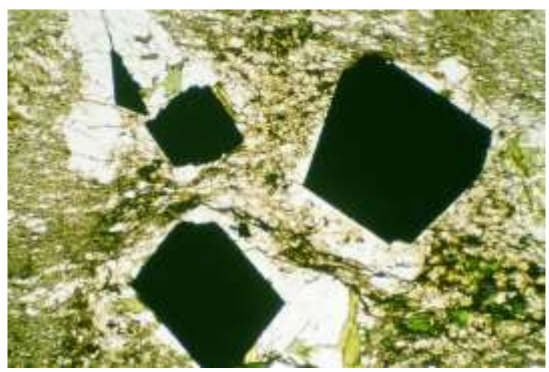

Figure 5

Figure 2: Outcrop of QPC showing sub-rounded grains of quartz pebble conglomerate; Figure 3: Elongated stretched grains along c-axis of quartz in QPC. The direction of c-axis is shown along the direction of the pen in the photograph
Figure 4: Sub-rounded clasts of quartz of QPC embedded in the arkosic quartzite matrix
Figure 5: Thin section photomicrograph of QPC under cross nicol showing detrital pyrite cubes overlying the medium grained quartz and feldspar

sediments along the river bed flanks or alluvial fan, which subsequently got reworked during later tectonic activities. Like many QPC, the present studied QPC shows lithological evidences of unbroken labile clasts (Fig. 4) which indicate the fact that little time was there for the break down of clasts. The QPC deposit at Babarmal can be inferred as a primary reworked deposit developed due to intense weathering under protracted transporting conditions.

4. Discussion

The occurrence of QPC horizon in the Babarmal belt bears high significance, as it is one and only of its kind, in the entire Aravalli Supergroup of rocks. QPC, in general are representative of explicit palaeoenvironmental conditions suggestive of tectonically dormant conditions with high rate of mechanical and chemical weathering (Boggs, 2001; Selley, 2000). Processes invoked to explain QPC origin explain prolonged mechanical abrasion (Kingsley, 1984) intense chemical weathering (Reimer and Mossman, 1990) or recycling of older conglomerates (Youngson and Craw, 1996). In geologic record, however, substantial QPC accumulations are found in sequences derived from lithologically diverse source rocks, but in the present case there seems to be a single source for the QPC, presumably Sarara Inlier, the basement.

Presence of rip-up clasts of schist and gneiss composition bears resemblance with the Sarara Inlier BGC. These relatively unsorted clasts in QPC signify that the provenance was in considerable vicinity. The QPC also shows presence of distinct detrital pyrite cubes (Fig. 5) in the intermingled arkosic matrix of the quartzite. Intermingling of detrital pyrite cubes with QPC matrix however suggest that the chemical weathering did not play major role in sediment sorting as played by the mechanical abrasion. The rounded to sub-rounded, ovate shaped clasts of QPC (Fig. 2,3 and 4) are snapshots of the intense and prolonged mechanical abrasion to which the QPC horizon at Babarmal had underwent. This prolonged period of sorting and abrasion for QPC origin in present case connotes its lithostratigraphic position.

QPC immediately overlies the Sarara Inlier BGC and virtually encircles the pink marble. Further the gradational variation in grain size of the QPC litho-unit is towards the isoclinally folded pink marble lying in the core. The stratigraphic position of the QPC and the pink marble litho-units is in between the BGC and the overlying barite bearing schist equivalent to the Delwara metavolcanic (Mehta *et al* 2007). On correlation with the other litho-units regionally it seems that QPC horizon underlies the litho-units of Delwara and Jhamarkotra Formations of the Lower Aravalli Group of the Aravalli Supergroup in the Babarmal belt. Moreover conditions of deposition of QPC in general denote a long hiatus as QPC originated under protracted palaeoenvironmental conditions. This ensures that the hiatus represented by the QPC horizon at Babarmal is certainly between the Lower Aravalli Group and the BGC. This presumption in that case is interpretative of the fact that the QPC at Babarmal is representative of the hiatus between the Aravalli Supergroup and the BGC. BGC in the Rajasthan starts from ~3300 Ma and culminates at 2500 Ma (Wiedenbeck *et al* 1996) and Aravalli orogeny spans from 2150 to 1850 Ma (Deb and Thorpe, 2004; Roy and Jakhar 2002). The hiatus which BGC and pink marble together represent is between 2500-2200 Ma. The present study on the basis of field data needs to be verified by precise geochronological dating of the marble and the QPC, which has also been undertaken by the authors.

Occurrence of QPC is also significant in relation to mineralization of U and Ag. Such processes of prolonged sorting through mechanical weathering, also lead to ideal conditions of uranium and gold concentration. QPC host many gold and uranium ore bodies, and there is active debate about connections between the mineralization and origin of QPC. QPC type uranium deposits make-up 13% of the world uranium resources and the main deposits are the Elliot Lake in Canada and the Witwatersrand gold-uranium deposits in South-Africa. In India, the gold-uranium bearing QPC represent oldest syn-sedimentary deposits located at the base of the Bababudan and Chitradurga Groups in Karnataka, the Dhanjori Group in Singhbhum, the Iron-ore Group of Jharkhand and Orissa. The QPC litho-unit at Babarmal needs to be thoroughly investigated for Uranium and Gold deposits in future.

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