Volume 65, Issue 5, 2021

Journal of Scientific Research

of

The Banaras Hindu University

Geology and Petrological Study of Metasediments around Village Kharbar & Parsad, District Udaipur, Rajasthan

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Abstract: **In Rajasthan, the rocks of the Aravalli Supergroup overlie the basement of the Banded Gneissic Complex. There is a huge span of the stratigraphic break at Archean – Proterozoic Boundary between these two major formations which hasbeen identified as an unconformity. This major stratigraphic break was a diachronous and transitional period of around 300Ma marking the end of a period of intensive volcanic and plutonic activity and the beginning of the period of uninterrupted sedimentation on a stable crust. The Archean Granitoids, the basement gneisses and schists belonging to Mangalwar Complex as well as Sandmata Complex of the Bhilwara Supergroup or the Banded Gneissic Complex are exposed as inliers within the rocks of Aravalli Supergroup at several places. The Kharbar-Parsad area is situated on the western flank of the Sarara inlier in the southern Rajasthan. The rocks of study area is represented by biotite gneiss, granite gneiss, arkosic conglomerate, phyllitic conglomerate, quartzite, chlorite schist, dolomite, impure dolomite, carbonaceous phyllite and phyllite. These rocks are highly metamorphosed and show multiple deformations.**

Index Terms: **Aravalli Supergroup, Archean – Proterozoic Boundary, Banded Gneissic Complex, Sarara inlier, Stratigraphic Break**

I. INTRODUCTION

In southern Rajasthan, the rocks of the Aravalli Supergroup overlie the basement gneisses of the Banded Gneissic Complex. There was a huge span of the stratigraphic break at Archean – Proterozoic Boundary between these two major formations which have been identified as an unconformity (Roy, 1988). The surface of the unconformity between basement gneisses and the cover Aravalli succession has been recognized by the presence of palaeosols, patches of basal conglomerates, structural and metamorphic discordance, and an angular unconformity.

"The Archean-Proterozoic boundary (ABP) is one of the most profound and spectacular breaks in earth history in respect to the structural variation resulted due to the presence of an unconformity and the mineral deposits. It marks the end of a period of intensive volcanic and plutonic activity and the beginning of the period of uninterrupted sedimentation on a stable crust" (Radhakrishna and Ramakrishnan, 1988).

The Kharbar-Parsad area lies south of Zawar, Udaipur, Rajasthan and is located in the Survey of India Toposheet No. 45H/12 and 45H/16. The study area is situated in the western part of Sarara village (Fig.1). The study area Kharbar-Parsad belongs to the Sarara inlier in the southern Rajasthan. It is situated on the western flank of the Sarara inlier. The Sarara Inlier represents the Archean basement rocks of the Sarara Formation of the Mangalwar Complex forming an oval-shaped inlier measuring 828 km^2 (Heron, 1953), surrounded by Proterozoic metasedimentary sequence of the Aravalli Supergroup. The metasediments are quartzite, chlorite schist, dolomite, impure marble and phyllite.

The present study will unravel geological history and petrographical studies of the region. Presently a very little geological information is available on Kharbar – Parsad area. The present study is an attempt to understand the interrelationship amongst basement rocks with the cover metasediments, their metamorphism and petrological studies.

II. REGIONAL GEOLOGY

A number of gneissic bodies are exposed within the Aravalli Fold Belt (AFB), the status of which has remained controversial. These bodies are considered as 'basement inliers' by Roy et. al. (1988), partly basement and partly remobilized basement by Naha and Halyburton (1977), partly basement and partly intrusive within the AFB by Sinha Roy et. al. (1993), intrusive within the Delwara Group and basement for the Debari Group

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by Shekhawat and Joshi (1994) and intrusive within the Aravalli Fold Belt by Guha and Garkhal (1993).

According to Roy and Jakhar, 2002, the Archean Granitoids and the basement gneisses and schists belonging to Mangalwar Complex, Sandmata Complex of the Bhilwara Supergroup, or the Banded Gneissic Complex are exposed as inliers within the rocks of Aravalli Supergroup at several places (Fig.1). The inliers exposed in the southern Rajasthan are Sarara inlier, Punali inlier, Ahar River inlier, Bagdunda inlier, Jaisamand inlier, Udaisagar inlier and Kherwara inlier.

The inliers in southern Rajasthan are recognized as consisting of a different basement and cover rocks. A huge variation of lithologies has been identified as the rocks show low to high-grade metamorphism as well as vast dissimilarity in the deformation (Radhakrishnan, Ramakrishnan, 1988). The presence of polymetamorphism and multiple deformations in the region makes it significant.

The Sarara Inlier is the best-known 'inlier' of the basement ensemble, which occurs south of the Zawar, Udaipur (Heron, 1953). The Sarara area of southern Rajasthan, comprises mixed gneisses, supracrustals of metamorphosed pelites, carbonates, and cherts with mafics and ultramafics of Sarara Formation belonging to the Mangalwar Complex and it forms oval-shaped inlier measuring 46 km × 18 km (Heron, 1953), surrounded by the metasedimentary sequence comprising conglomerate, grit, quartzites, and phyllite, belonging to the Debari Group of the Lower Proterozoic Aravalli Supergroup. Extensive migmatisation /or granitisation of rocks is observed in the core part of the inlier.

The ensemble of mixed rocks of the basement is unconformably overlain by the aforesaid metasedimentary and metavolcanic sequence of the Aravalli Supergroup (Chakrabarti, 1992). The basal conglomerate, having clasts procured from these mixed rocks marks the unconformity between the two major lithostratigraphic units. The conglomerate is overlain by quartzite followed by phyllite in order of superposition, the latter being garnetiferous and carbonaceous at places (Chakrabarti, 1992). The basic rocks are sparing in the inlier and the sediments are metamorphosed upto staurolite grade. In the Sarara-ki-Pal region, quartzose mica schist with staurolite and sillimanite are quite common. The northern part of the inlier comprises basal Aravallis with conglomerate and the metabasites, while the southern one is exposed with upper Aravallis (Heron, 1953). Conglomerate outcrops as a pebbly bed to grit with fining upward tendency. It occurs as a thin unit directly overlying the basement, often showing pinching and swelling. At the northern fringe of the inlier, the conglomerate is quite thick due to folding, overlying metabasites/metavolcanics of the Delwara Formation. The inlier lacks the exposures of the metavolcanics (Delwara Formation) except at the northern fringe where it is exposed as a large outcrop.

In the Sarara area, Aravalli deformations are overprinting over the folded rocks of the Mangalwar Complex. An overturned antiform, plunging southeasterly is a major regional structure encountered, exposing Mangalwar rocks in the core (Chakrabarti, 1992).

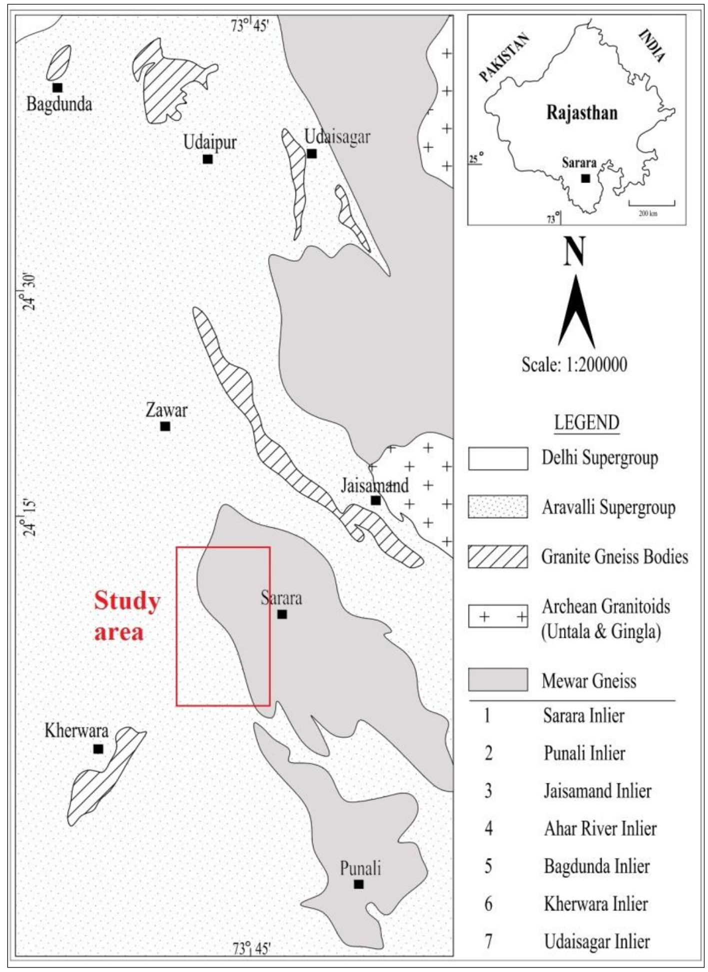

Fig. 1. Regional map shows the distribution of different Archean inliers in Aravalli Supergroup in southern Rajasthan (Gupta et al. 1980).

III. METHODOLOGY

Preparation of the lithological map of the study area is done using topo-sheet enlarged to 1:10,000 scale for higher resolution and detailed geological studies. A lithological map depicting the distribution of lithological units in Kharbar area is shown in Fig.2. Physical properties and the nature of different litho-unit samples collected from the field are identified in hand specimen and thin sections prepared to study petrological details.

IV. RESULT

Rock types of the whole area have been divided into the following major groups (Fig.2):

A. Biotite Gneiss
B. Granite Gneiss
C. Conglomerate

D. Quartzite
E. Chlorite Schist
F. Carbonate rocks
G. Phyllite

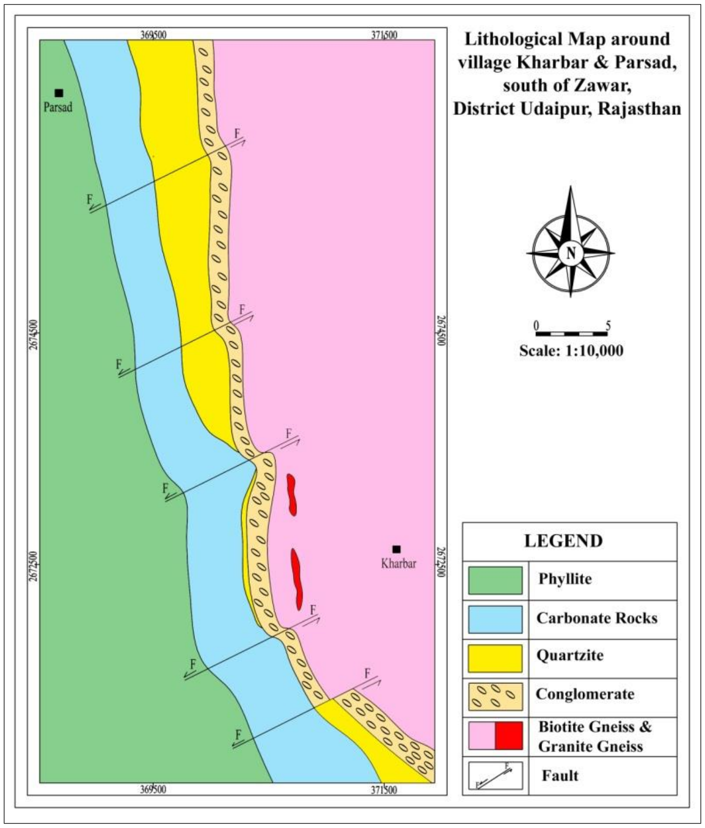

Fig. 2. Lithological map around Kharbar – Parsad area of Udaipur district, Rajasthan.

A. Biotite Gneiss

Biotite Gneiss forms the basement to the Aravalli Supergroup of rocks that belongs to Sarara Formation. In the present area of study entire flat, valley portions, cultivated land, and the slopes of the ridges are occupied by the biotite gneiss rock. It occurs associated with granite and gneiss. It is brown and dark grey in color in the hand specimen. It is mainly composed of quartz, feldspar, and biotite. The biotite gneiss of the Sarara Formation shows a gneissic structure (Fig. 3).

The thin section shows gneissic texture. The essential minerals, in order of their dominance and percentage, are quartz 30-40%, microcline 20%, plagioclase 10-15%, biotite 20% with sericite and opaques as accessory minerals. The quartz individual grains, as well as composite augens, are observed. Biotite forms discontinuous layers enveloping the quartz and feldspathic minerals. Orthoclase is medium to coarse-grained. Alteration of orthoclase has given an appearance of dusty clay minerals and sericite. Inclusion of sericite, muscovite, and quartz are found in orthoclase.

Fig. 3. Field photograph shows the gneissic structure in biotite schist near Parsad village.

B. Granite Gneiss

The granite gneiss is the country-rock associate with basement biotite gneiss. The basement granite gneiss of Kharbar – Parsad region forms isolated hillocks basement plain covered by sandsoil. Based on physical appearance and hand specimen mineralogy, two types of granitegneiss are identified in the study area. The first type of granite gneiss is coarse to medium-grained, gray-colored, and gneissic foliation present. In coarse-grained varieties, feldspar megacrysts occur as large oval or tabular-shaped grains measuring over 0.5 to 3 cm along the foliation plane (Fig. 4). These megacrysts set in a fine-grained matrix (Muscovite-biotite-quartz groundmass). The second type is fine-grained granite gneiss**,** mainly intruded within the first type of granite and biotite gneiss. Quartz veins are also present in this granite gneiss. Both types of granite are mainly exposed around Sarara village and east of the Kharbar – Parsad area.

Fig. 4. Field photograph showing megacrystsset in a fine-grained matrix of granite gneiss on-road Parsadto Sarara village.

Petrographically, these granites are generally medium to coarse-grained and show inequigranular texture. This is mainly composed of quartz and feldspar. Quartz grains are anhedral, irregular and variable in size and shape and show interlocking. Interlocking grains of quartz and feldspar form the typical intergrowth granitic texture (Fig. 5). In potash feldspar orthoclase is the prominent mineral, which is tabular in shape and generally altered to clay minerals, similarly, plagioclase feldspar grains are also highly altered. Feldspar grains show cross-hatch as well as albite type twinning (Fig. 5). Muscovite, biotite, and iron oxides are occurring as accessory constituents. The laths of muscovite are variable in size and shape showing well-defined one set of basal cleavage. Foliation is recognized in thin sections by the parallel arrangement of muscovite and biotite laths forming alternate bands. Sericitization of feldspar is frequently observed which is due to shearing and weathering. It is composed of 60 % of quartz, 20 % of feldspar, and 20 % of muscovite, biotite, and other accessory minerals.

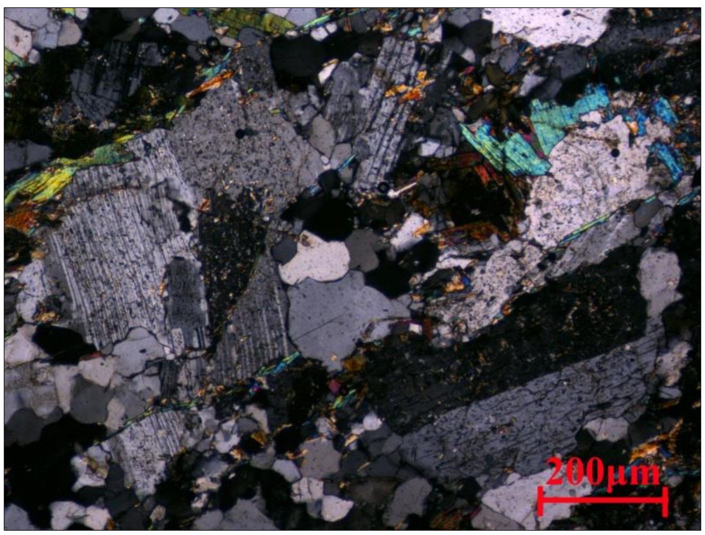

Fig. 5. Microphotograph shows interlocking grains of quartz and feldspar and albite twinning.

C. Conglomerate

It is present as moderately high rising sharp-crested ridges with a gentle slope towards southwest. The strike of conglomerate is NNW-SSE to NE-SW and dip towards SW. The conglomerate horizon forms the basal unit of the metasedimentary sequence enveloping the biotite gneiss and granite-gneiss.In the study area conglomerate exposed in two types of matrix, arkosic matrix, and phyllitic matrix. phyllitic matrix conglomerate is exposed north of Parsad village. It is yellowish and grey to buff color and polymictic in nature. The thickness of the phyllite bed varies from 10-80 meters. The framework of the conglomerate comprises subangular to elliptical pebbles of granite gneiss, quartzite (grey, black, white-colored), mafic rocks, vein quartz, and a few pebbles of quartz-tourmaline rock. The clasts are embedded in the matrix. The size of the pebbles shows extreme variation in dimension ranging from (1 X 0.5cm) to (25 X 5cm). The pebbles are aligned in preferred orientation along the bedding and foliation plane (Fig. 6). The stretching pebble lineation is noted to be plunging at a moderate angle.

Fig. 6. Field photograph shows elongated pebbles along the bedding and foliation plane in arkosic conglomerate near Govt. school of Kharbar.

Under the microscope, the rock shows a schistose to gneissic texture with well-developed augens (Fig. 7). There is a variation of the grain size from coarse to medium and fine-grained. Major mineral in this rock is quartz along with muscovite, biotite, garnet and iron oxide occurring as accessory constituents. Banding of alternating quartz-rich and mica-rich zones are very common.

Quartz occurs as individual grains as well as composite augens. They are medium to fine-grained and anhedral to subhedral in shape. Usually, the grains are of equidimentional shape but the strained grains are lenticular in shape with their long axes in the foliation plane. These lenticular grains are arranged parallel to the foliation plane (Fig. 7). The boundaries between adjacent quartz grains are generally long, but somewhat irregular contact is also observed. The large and medium quartz grains show a typical marginal granulation and mortar structures. Because of sharp contact between the medium-grained quartz domains, which are floating in the fine-grained matrix. Some of quartz grain shows crushing effects due to shearing. Contact between quartz and micaceous minerals is often irregular and hazy. Small muscovite and sericite inclusions are also observed in quartz grains, its perpendicular orientation to stretched quartz grains.

Muscovite, biotite, and its fine-grained equivalent sericite are the common micaceous minerals. They usually show definite parallelism as elongated, flaky aggregates, plaited layers, and shreds. The flakes of micaceous minerals are parallel to S_1 and S_2 planes and they are bisecting each other at an angle. Biotite is brown in color and often peleochroic with maximum absorption parallel to the schistosity plane.

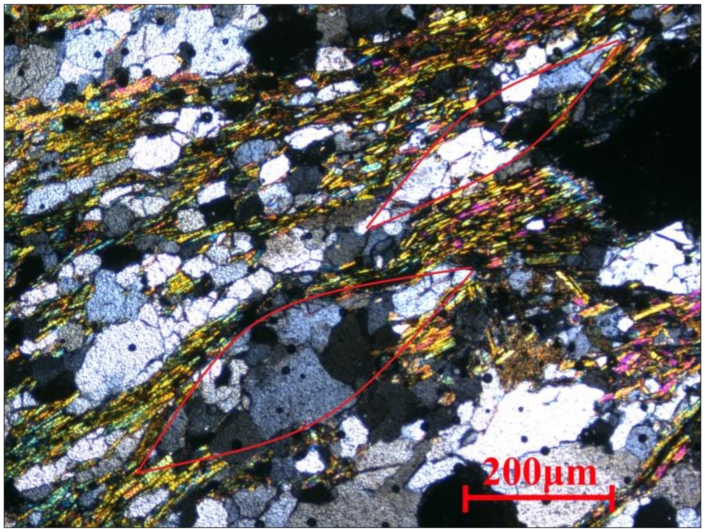

Fig. 7. Microphotograph showing the schistose structure and lenticular grains of quartz arranged parallel to the foliation plane.

D. Quartzite

Quartzite occurs as moderate to high rising sharp-crested ridges in contact with the outcrop of Conglomerate in the west direction. The dip directions suggest that the quartzite overlies the conglomerate followed by chlorite schist in the younging direction. In few outcrops where quartzite are in direct contact with impure marble in the younging direction. The quartzite outcrops are light yellow-creamish and purple-violet colored on the outcrop. The thickness of quartzite outcrop varies from 40-200 meters. Quartzite shows parallel bedding (S_0) and cleavage planes (S_1) (Fig. 8) with moderate to high amount of dip. Based on outcrop pattern and study of hand specimens quartzite shows two types of nature; massive and micaceous. Quartzite shows massive nature and violet color in the north and south direction of Kharbar village where quartzite is thick and at Kharbar village quartzite is comparatively thin and shows micaceous nature. The massive quartzite in the south of Kharbar village gives a brownish-violet appearance due to iron leaching which indicates the possible presence of gossan. The strike of quartzite is NW-SE and dip towards SW. Quartzite outcrops are frequently fractured and have two sets of joints. Quartz vein was also observed at some places.

The thin section of this rock shows medium to coarse-grained quartzite. Quartz is the dominant mineral of this rock, it is usually present as irregular grains with a straight grain boundary. The quartz grains are anhedral to subhedral in shape and show granoblastic texture. The mineral grains show the tight inter-granular zig-zag pattern of interlocking (Fig. 9), and also long surface touching contact. At places, shearing has led quartz grain with a lensoidal shape, surrounded by micaceous minerals. Accessory minerals are biotite, muscovite, iron oxides, and opaque minerals. The micaceous minerals present are fine-grained in texture. The mineral grains are elongated and stretched and oriented along the developed cleavage plane (Fig. 9). This quartzite is composed of 90 % of quartz, 10% of biotite and muscovite, and other accessory minerals like iron oxides and opaque minerals.

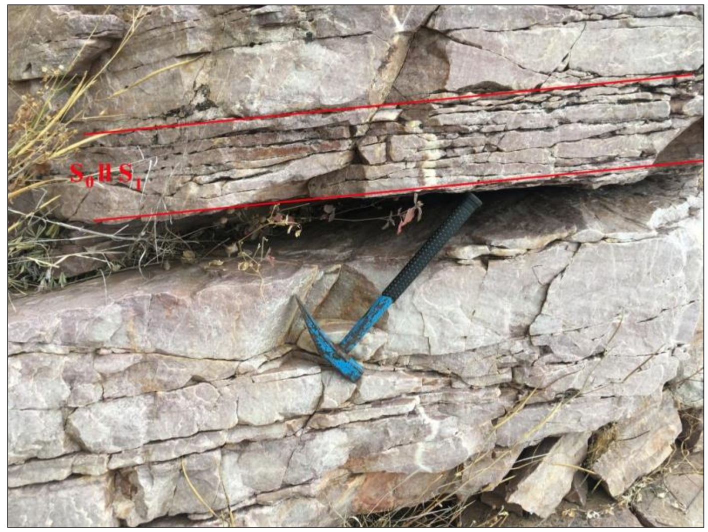

Fig. 8. Field photograph showing the parallel arrangement of bedding (S_0) and cleavage (S_1) in quartzite near Parsad village.

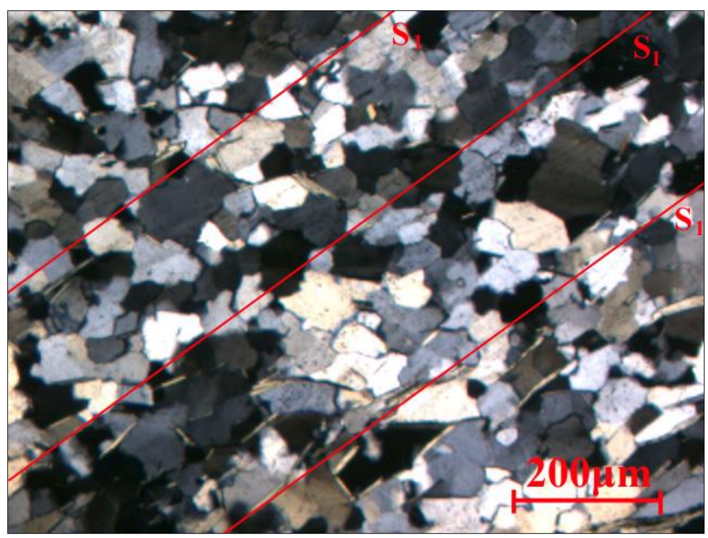

Fig. 9. Microphotograph shows interlocked and elongated quartz grains along the cleavage plane.

E. Chlorite Schist

The chlorite schist is exposed in a linear thin band and overlaps the quartzite. The rock is dominated by chlorite and is in shades of green color, fine to medium-grained, and well develop schistosity with satin or velvet luster (Fig. 10). It is fairly hard and compact but so easily pliable along the schistosity. Megascopically chlorite is the only recognizable mineral along with quartz and garnet.

The thin section of this rock shows well-developed schistosity, marked by mica, chlorite, and quartz is usually segregated along with biotite into distinct bands which alternate with quartz-rich bands (Fig. 11). This rock is strongly sheared. The grains of quartz are enhedral and fine to medium-grained. Quartz occurs as separated grains and aggregates as lenticles. Segregation of quartz into Augen structures is commonly observed. Chlorite and muscovite generally occur as an irregular shaped outlines, and perfectly parallel. Few laths of biotite are observed which are oriented parallel to schistosity. The flakes of muscovite and chlorite are parallel to S_1 and S_2 planes and they are bisecting each other at an angle (Fig. 11).

F. Carbonate rocks

Carbonate rocks in the study area occur in the form of long continuous bands. The band, which extends from north of Parsad to south of Kharbar village is in association with the quartzite and phyllite. On the basis of outcrop patterns, the carbonate outcrops are divided into dolomite and impure marble. A thin intercalatory band of carbonaceous phyllite with carbonate rock is observed in the west of Kharbar village. The thickness of the carbonate rock band is about 80-150 meters. Dolomite shows characteristic typical elephant skin weathering (Fig. 12). Impure marble exposed in the study area exhibits primary structure bedding (S_0) (Fig. 13). At places, near Kharbar village, isoclinals folds, faults are present in impure marble. Calcite and quartz veins are also noted in dolomite and impure marble.

Fig. 10. Field photograph shows green color and fine to medium-grained chlorite schist near Kharbar village.

Fig. 12. Field photograph shows typical elephant skin weathering in dolomite.

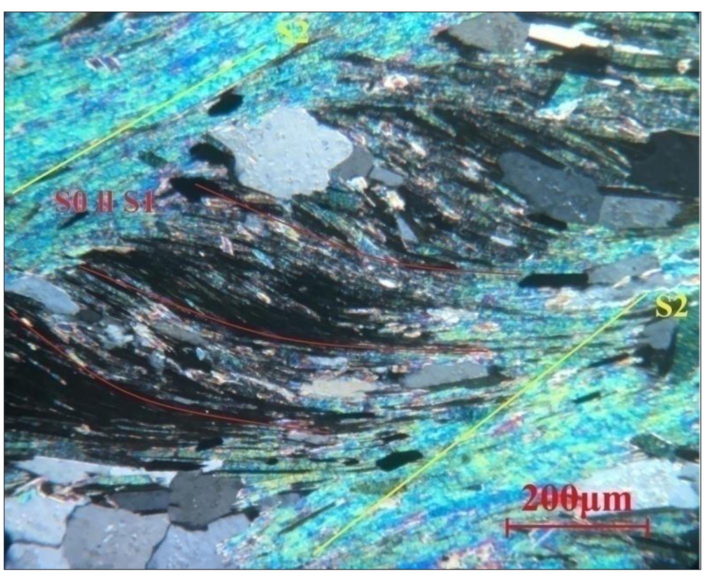

Fig. 11. Microphotograph showing well-developed schistose structure and the relationship between S_1 & S_2cleavages.

Fig. 13. Field photograph showing bedding and micro-fault in impure dolomite near the dam at Kharbar village.

Petrographically, dolomite is weakly foliated, medium to fine-grained, and essential minerals include calcite, dolomite, and quartz while accessory minerals include carbon, sericite, and iron oxide (Fig. 14). The interlocking arrangement between quartz and grains of calcite is observed. Grains of calcite and quartz are variable in size and shape. The micaceous minerals are present along the foliation plane. Muscovite veins are also present in this rock. On the basis of the geochemistry of selected samples, it can be stated that the carbonates of the study area are dominantly dolomitic.

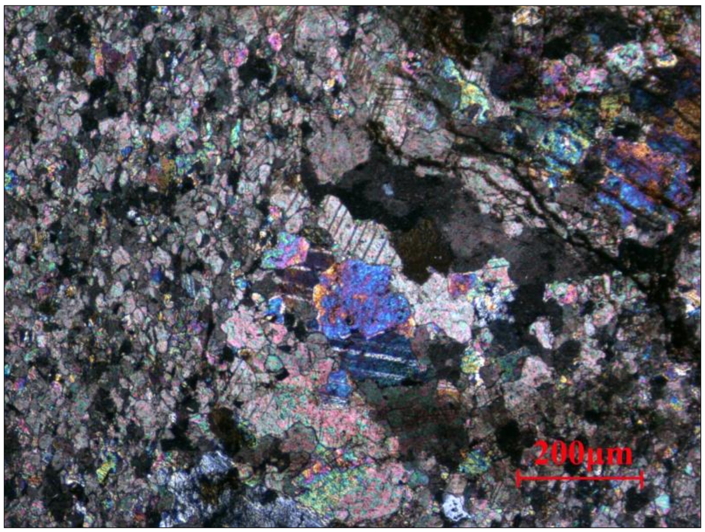

Fig. 14. Microphotograph shows fine to medium-grained dolomitic rock.

In thin sections, impure marble is fine to medium grained with carbonate minerals (calcite and dolomite) as essential minerals and quartz, biotite, and iron oxide as accessory minerals. The carbonate grains are anhedral to subhedral in shape showing more or less granoblastic texture however a slight elongation in carbonate grains is observed.

The grains are very well interlocked, although show touching contact with inter-granular spaces (Fig. 15). The carbonate grains are variable in size and shape and having well define rhombohedral twining (calcite twinning) (Fig. 15). Dolomite and calcite appear color-less with 3 sets of cleavage, low relief but cannot be differentiated in thin sections. Secreted grains of quartz are generally present.

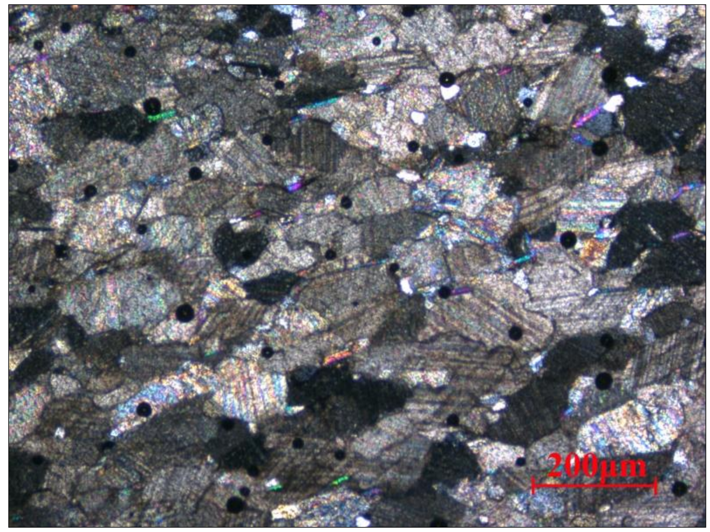

Fig. 15. Microphotograph showing well-interlocked carbonate grains and rhombohedral twinning in calcite.

G.Phyllite

In hand specimen, phyllite is fine-grained, greenish-grey to brown in color comprising of quartz, feldspar, chlorite, biotite, and muscovite. The contact between phyllite and dolomite is sharp. The rock is foliated and foliation is generally in the form of slaty cleavage (fine continuous cleavage) (Fig. 16) and occasionally occurs as schistosity (coarse continuous cleavage). The thickness of the phyllite bed varies from 50-100 meters. At places, kink band is also noticed.

Fig. 16. Field photograph shows foliated, fine-grained greenish-colored phyllite at Kharbar village.

In thin section, this phyllite has a well-developed foliation as a result of both parallelisms of flaky minerals and banding due to mineral segregation with variation in mineral composition. It is composed of quartz, feldspar, and muscovite/sericite, biotite and is fine-grained. Under cross nicols, foliation is defined by the flaky minerals aligned in a preferred orientation.

V. DISCUSSION & CONCLUSION

The biotite gneiss and granite gneisses form the basement and the cover rocks are the metasediments of the Aravalli Supergroup in the Kharbar – Parsad study area. Biotite gneisses exhibit a sharp contact with metasediments of the study area. Granite gneiss outcrops are as low-lying isolated hillocks, intrusive and plains covered by sand-soil. The Kharbar – Parsad metasediments comprise dominantly of conglomerate, quartzite, chlorite schist, carbonates, carbonaceous phyllite, and phyllite. Carbonates show two type of nature in the area (dolomite and impure marble). The rocks of the study area are characterized by shearing and folding. Post tectonic quartz, pegmatite, calcite, and iron veins in metasediments. Detailed cover – basement geological studies of these basements and metasediments along with petrology and field relation suggest that it belongs to the Banded Gneissic Complex and Aravalli Supergroup.

Summarising all, the present study reveals geological history, relationship between various litho-units and petrographical details of the rock units of the study area.

ACKNOWLEDGMENT

The research work was carried out with the financial assistance received from the Department of Science and Technology (DST), New Delhi. The authors are grateful to the DST for the same. The authors acknowledge the help and suggestions received from Dr. Ritesh Purohit (Head of the Department).

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