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Lithology and Structure of Aravalli Supergroup and Associated Rocks of Southwestern Part of Chittorgarh District, Rajasthan

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Abstract: **The Aravalli Supergroup constitutes an important component of the Precambrian crust of the NW part of the Indian Shield. These exhibit well-preserved records of a protracted history of development of Precambrian terrain, which spans about 2500 myr of the Earth's history. The south-western parts of the Chittorgarh region represent one of the oldest terrain of Indian peninsula. These are named as Banded Gneissic Complex (BGC) and overlying Aravalli Supergroup rocks. The Bhadesar area lies in the south western part of Chittorgarh district, Rajasthan. Regional scale mapping on 1:75,000 reveals that the outcrops of the region are elongated and mostly stretched along N-S direction. The rocks outcrop in a linear belt comprising gneisses and granites of Archaean age. The rocks of the Bhadesar Formation in the area have patchy exposures. The basement rocks outcrop in a linear belt comprising gneisses and granites of Archaean age. Quartzites are the basal lithounits of the supracrustals that show elongated stretched quartz grains along the contacts which are razor sharp on outcrop scale. These are white to grayish in colour and some weathered surface is brown in colour, in some part ferruginous quartzite with numerous quartz veins is observed. Petrographic analysis of quartzite revealed mineralogical variation and at places ductile shearing. The Precambrian rocks of the Aravalli region exhibit a plastic deformation which took place during stage of cratonisation. The general trend of the bedding in quartzite is N-S with dip direction NW- SE. The quartzites in the area are structurally characterized by foliations along the rock outcrops.**

Index terms: **Aravalli Supergroup, Proterozoic, Banded Gneissic Complex, Archaean, Quartzites.**

I. INTRODUCTION

The BGC forms the basement for all the younger metasedimentary rocks of the Aravalli and Delhi Supergroups (K. Naha & S.Mohanty, 1990). The Aravalli Supergroup developed during early Proterozoic and constitutes an important component of the Precambrian crust in the northwestern part of the Indian Shield. The Aravalli Supergroup unconformably overlies the Archaean basement and comprises a major part of the metasedimentary sequences with some metavolcanics in Mewar region of Rajasthan. The study area lies in the southwestern part of the Chittorgarh region, which includes mainly the Archaean basement (BGC) and the Aravalli Supergroup. The Aravalli Supergroup is underlain by Banded Gneissic Complex with a contact of conglomerate horizon. Gupta (1934) and Heron (1936) considered Banded Gneissic Complex and Bundelkhand Gneiss as basement for overlying metasediments. The metasediments of the region appeared bounding the granitic body or occurred as enclaves in the later comprises dolomitic limestones, quartzites, sericite chlorite, sericite albite schists and quartz pyrophyllite chlorite schist. Quartzites are the basal lithounits of the supracrustals that show elongated stretched quartz grains along the contacts indicating tectonised contact with basement rocks. The main objective is to understand the nature and relationship of ductile and shear deformed contacts between lithoassemblages in the area and also the mineralization pattern through petrographic studies.

II. GEOLOGY OF THE STUDY AREA

Gupta (1934) and Heron (1953) described BGC as an intimate admixture of igneous and sedimentary rocks and their

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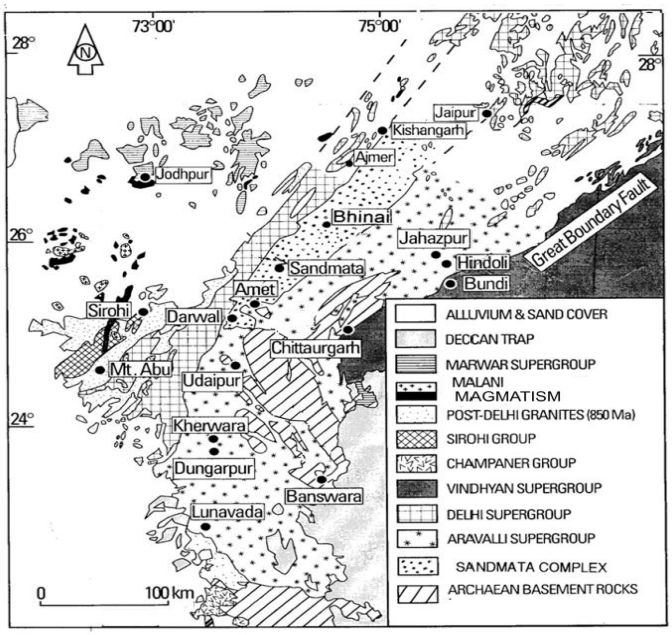
derivatives. A number of intrusive ranging from felsic to mafic constitutes a significant part of the BGC. Prasad et.al (1997) noted a compositional variation across the granite body, in which pink coloured, non-foliated, medium-grained granite in the eastern part grades into gneissic granite towards the west. The Banded Gneissic Complex (BGC) having more extensive occurrences in the region is regarded as the oldest supracrustals succession representing some of the primitive sediments composed of unweathered igneous debris overlying the Bundelkhand gneiss. Crookshank (1948) was the first to challenge the antiquity of the Archaean basement rocks conceived by Heron (1953) and his colleagues stating that the BGC is nothing but the migmatised metasediments of the Raialo- Aravalli rocks. The Berach Granite (Bundelkhand Gneiss of Gupta 1934; Gupta & Mukherjee 1938; Heron 1935) of Chittorgarh area was thought to be the basement for younger sediments. Prasad (1982) presented the geology of Chittorgarh in Table-1.

Table 1: Geology of Chittorgarh region (Prasad 1982).

	Acid Intrusive	
	Basic Intrusive	
	Berach Granite and Gneiss	
	Dungla Migmatites and Para amphibolites	
	Bari Sadri and Hera Quartzite	
	Unconformity	
Chittorgarh Group	Bhadesar shale	Shale , quartzite, limestone and dolomite
	Putholi Shale	Shale, siltstone and quartzite

Topographically, the Chittorgarh area is characterized by undulating feature with scattered linear hills in the area. The district has a regional slope from north to south. The Chittorgarh district comprises rocks of Bhilwara Supergroup, Aravalli Supergroup, Vindhyan Supergroup, Deccan Traps and recent alluvium. The undeformed Middle Proterozoic sediments forming the Vindhyan Supergroup occur in a large arcuate basin in the northern region of the Indian shield. Basement rocks (Pre-Aravalli) i.e. the Bhadesar formation and Berach Granite are overlain by Vindhyan rocks with unconformity in it. The Bhadesar formation consists of quartzite, dolomitic limestone, shale, slate. Lower Vindhyan rests unconformably on Bhilwara Supergroup and at certain places this Group is overlain by Khairmalia Andesite, Khardeola Conglomerate or Bhagwanpura Conglomerate. The Vindhyan Supergroup sediments are found further east of Chittorgarh which is separated by Great Boundary fault and it mainly comprises conglomerate, shales, sandstones, limestones and porcellanite. Deccan Traps are mainly exposed in southern part and are basaltic in nature; some intrusive bodies of dolerite have been identified in Gangrar and Bari Sadri. While moving eastwards, the Hindoli Group is found which trends north east – south west in north, and more northwest – southeast in south. The Vindhyan basin of Rajasthan forms dome and basin like structure (Ramsay 1985) and characterized by peribasinal deformation where the central part exhibits little or no deformation.

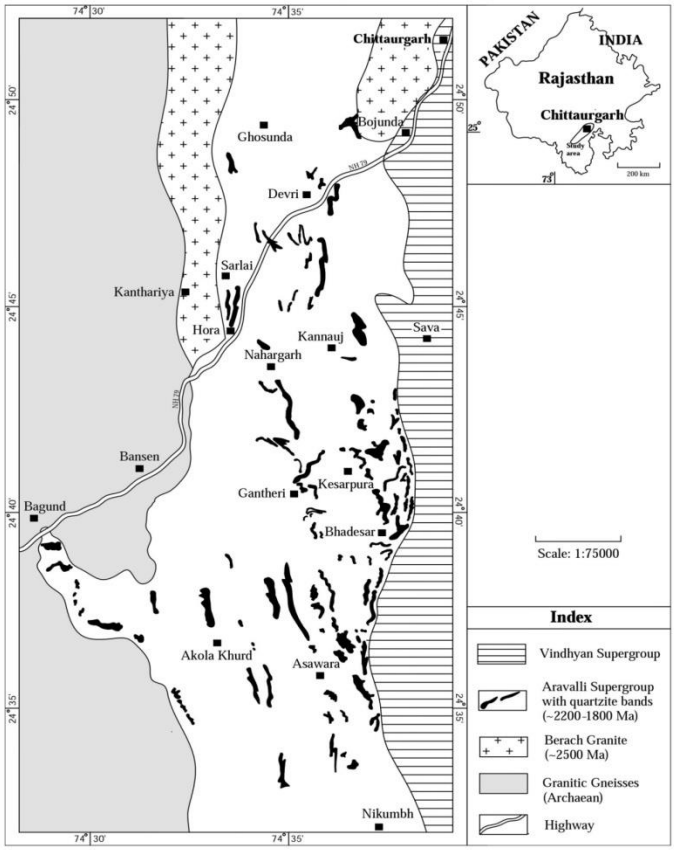


Map 1: Generalized geological map of Aravalli Mountain belt (After Heron, 1935, Gupta et al., 1980, Roy, 1988, Sharma, 2004).

III. FIELD RELATIONSHIP

To know the outcrop pattern of the area regional map is prepared on 1:75000 scale (Figure 2). The structural map of the region exhibits north-south stretched elongated geometry of the rocks. The basement-cover relationship between the rocks of the Mangalwar Gneisses and Aravalli metasediments is tectonized and represented by ductile shear zone. The contact of the basement rocks on the eastern flanks are with the Vindhyan Supergroup rocks which comprise a number of lithounits including shale, sandstone, siltstone, carbonate etc. and the basement rocks (Berach Granite) with the cover rocks of the Vindhyan Supergroup rocks is not sheared. This contact has been popularly described as Great Boundary Fault (GBF). The cover sequences of the Mesoproterozoic Vindhyan Supergroup are almost undeformed in contrast to the basement rocks of the Archaean basement rocks of Mangalwar Gneisses & Berach Granites and cover rocks of the Palaeoproterozoic Aravallli Supegroup Group which are complexly deformed. At some

places the deposition of flat undeformed Vindhyan sedimentary lithoassemblages is seen on the deformed and folded basements which show an apparent folded appearance of the Vindhyans. The rocks of the study area can be broadly categorized into basement rocks, cover rocks and intrusive rocks. One of the prominent features in the belt is peneplain basement as a low topographic feature and the supracrustals occurring as high crested hills. Lithological field characteristics have been studied on a wide scale, and in thin section, we have described rocks on the basis of their optical properties and it is useful for classification and its correlation with the whole rock chemical data. In the present petrographic studies, an attempt has been made to give only the general petrological characters of the rock types.



Map 2: Regional geological map of the study area on 1:75,000 scale (southwestern part of Chittorgarh area), Rajasthan .

IV. PETROGRAPHICAL CHARACTERISTICS

Basement Rocks

The basement in Bhadesar area is Berach granite which outcrops as isolated hillocks and peneplain surfaces covered by soil. Most of the terrain is covered with the recent sandy alluvium (Fig 1a). These rocks are difficult to identify at most places, as their nature has been considerably modified on account of surface erosion. Both coarse grained and medium grained granite is observed in the area with pinkish appearance and few are greyish also. The mineral assemblage of coarse grained granite is same as medium grained granite with minor differences as the former is composed of biotite (Fig 1b).

Table 2: Stratigraphic Succession of the Precambrian Rocks of the Aravalli Mountains (A.B. Roy, 1990).

		Age in Ga
Delhi Supergroup	Vindhyan Supergroup Malani rhyolite suite	0.75
	Erinpura granite and Godra granite	0.75-0.90
	Champaner Group (Sirohi Group) Post-Delhi granites Ajabgarh Group	1.45
	Alwar Group Ryanhalla Group	
	Post-Aravalli granites Darwal and Amet granites)	1.9
Aravalli Supergroup	Upper Aravalli granites Middle Aravalli Group Lower Aravalli Group Berach granite	(~2.6)
Mewar Gneiss & Granite	Untala and Gingla Granite	3.0
	Politic gneiss, quartzite, marble, Calc-silicates Tonalitic biotite Gneiss, amphibolite	3.5

Fig 1: (a) Field photograph showing: Granite rock in low lying region in western part of the study area.

Under thin section, granite is medium to coarse grained, inequigranular rock, essentially composed of microcline, quartz and some grains of plagioclase feldspar (Fig 2a). Microcline laths are subhedral in shape and exhibit well marked cross hatched twinning (Fig 2b). Plagioclase feldspar grains are subhedral and show lamellar twinning. It is present as highly weathered accessory minerals.

Fig 1: (b) Pink Granite due to high abundance of K-feldspar megacrysts.

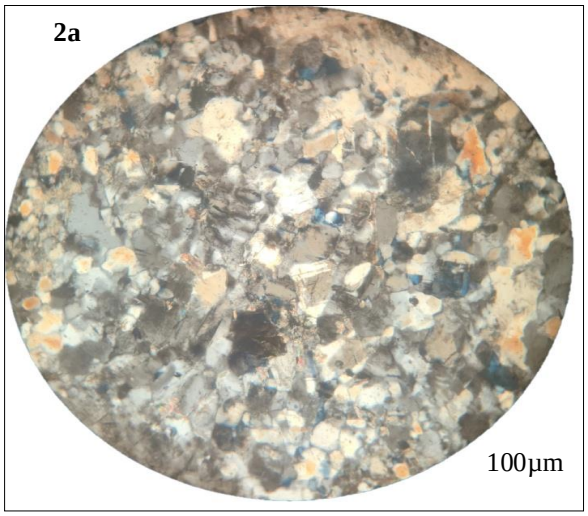
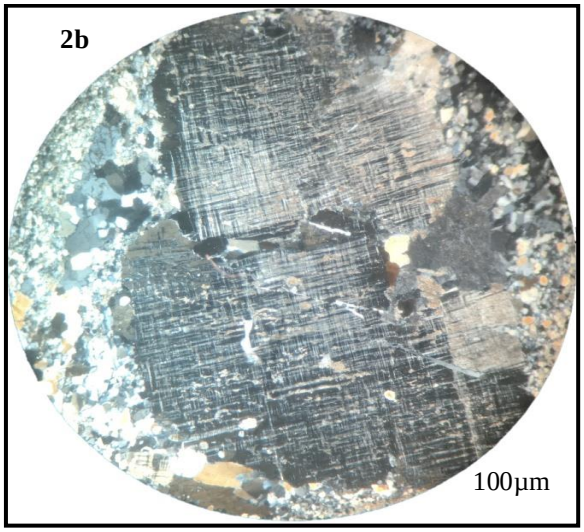


Fig 2: Photomicrograph showing: (a) Intergrowth texture between quartz and feldspar in granite with accessory minerals like biotite laths.



(b) High resolution cross hatch twinning characterizing presence of microcline in granites.

Cover rocks: These include quartzites, phyllites, clay beds and red ochre.

Quartzite

Quartzite in the study area form sharp crested high rising ridges and resistant hill tops (Fig 3a). Clean and washed nature of quartzite is observed which strike NE-SW, these are greyish and pinkish in colour, few buff- coloured quartzites are also observed. A clear contact is observed between the quartzite and the low lying area (Fig 3b). In some part quartzite exhibits shearing in the low lying area. At places the quartzite outcrop appears reddish brown due to weathering which caused leaching in form of limonitic stains and two sets of joints is also observed. Quartzites in the area are structurally characterized by the presence of primary foliations developed along the rock outcrops. On the basis of mineral composition and texture, two varieties of quartzites have been recognized: Foliated quartzite and Massive quartzite. In the NW part of Bhadesar area, mainly foliated variety of quartzite is observed while in the SE part of Bhadesar, massive variety of quartzite is observed.

Fig 3: Field photographs showing: (a) high rising ridges of quartzite rock, near Achalpura, Chittorgarh.

Quartzite shows medium to coarse-grained minerals, and is sub- rounded in nature, having undulating boundaries (Fig 4a). The main mineral constituents are quartz, some feldspar grain is also observed. In few, quartz grains are recrystallized. Plagioclase feldspar is also colorless in thin section and appears grayish in colour under cross nicol. The feldspar grains appear anhedral in shape and the relief of low to medium with an extinction of about 10 to 15^0. Feldspar are medium grained and appear anhedral in shape and the relief is low to medium and shows Carlsbad twinning. Fig 4b shows the medium to fine grained quartz grains of cherty quartzite.

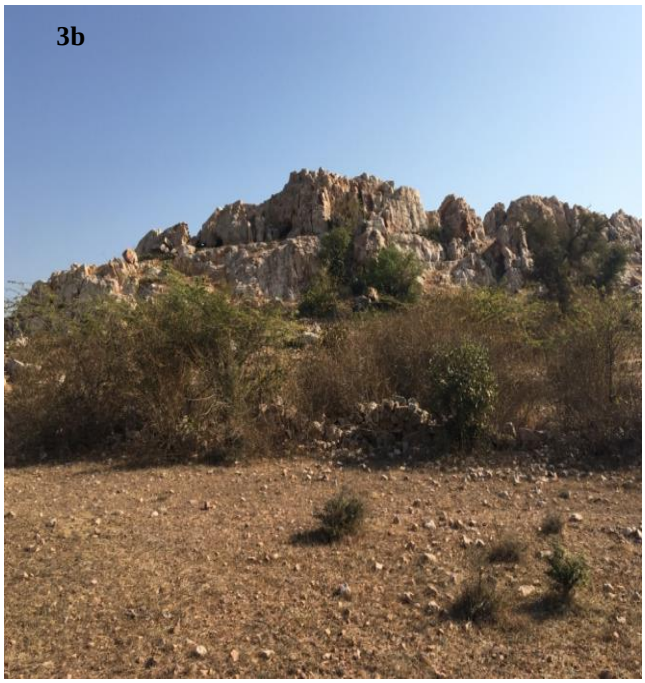


Fig 3: (b) Contact between basement (BGC) and Aravalli metasediment (quartzite) in NW part of Bhadesar region.

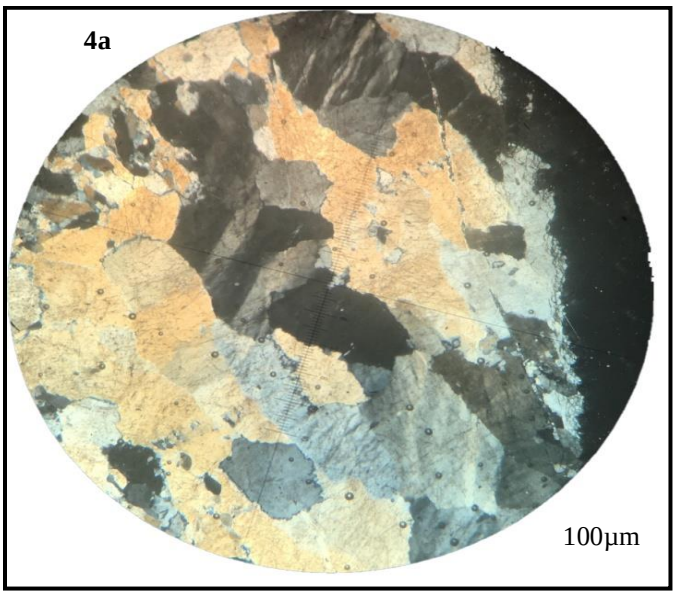


Fig 4: Photomicrograph showing: (a) Quartzite rock with quartz vein and laminar laths of feldspar grains.

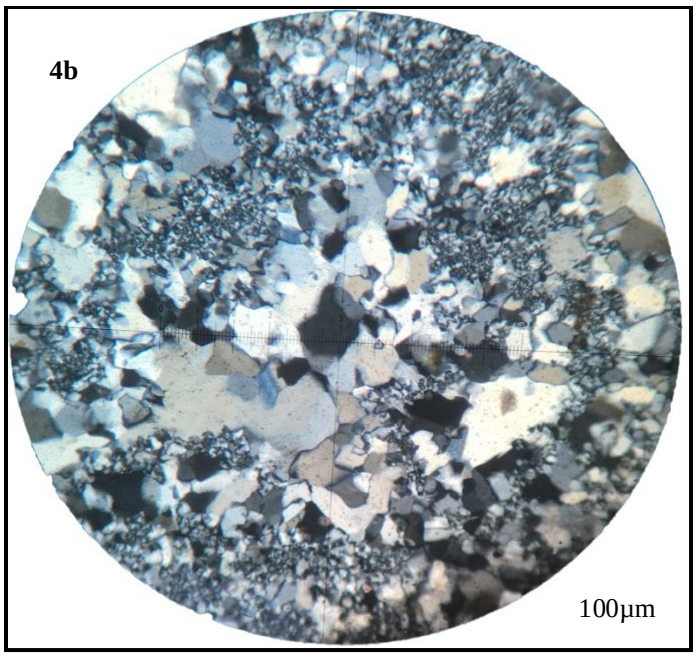


Fig 4: (b) Cherty quartzite with fine grained and the dominant mineral present is quartz with some minor minerals like feldspar, biotite and some ferrous minerals.

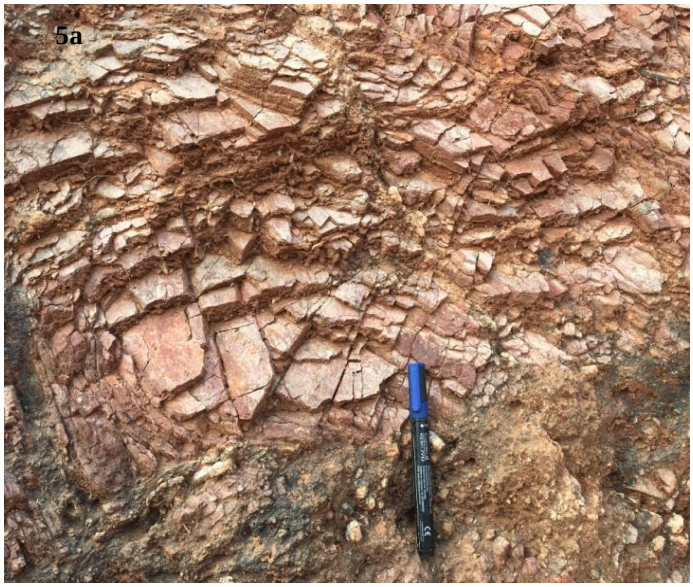


Fig 5: (a) Field photograph of phyllite rock displaying well developed foliation plane near Achalpura.

Phyllite

The phyllite are thinly bedded, at places these are arenaceous and well laminated. It is characteristically purple, greenish in color. It displays fissility, which break the rock into smooth, flat sheets, observed in the western part of Achalpura village (Fig 5a).

Under thin section, muscovite, quartz, and magnetite minerals are observed. The flakes show cleavage, muscovite grains are flaky and often are tabular in habit. Crenulation cleavages are also observed (Fig 5b).

Clay bed

Clay beds are fine grained , which is exposed in plain & foothill in the northern and northwestern part of Bhadesar region. They occur as lenticular pockets of white mica deposits which are equivalent to be as metamorphosed paleosols and are marked as discontinuous bands which occur as a boundary between basement and cover rocks. They show metamorphic character where the transformation of clay bed to red ochre bed takes place (Fig 6a).

Under thin section, very fine grained siliceous rock composed of cryptocrystalline quartz, and red to brownish iron oxide. Quartz occurs as detrital grain and sericite mainly occur as matrix material.

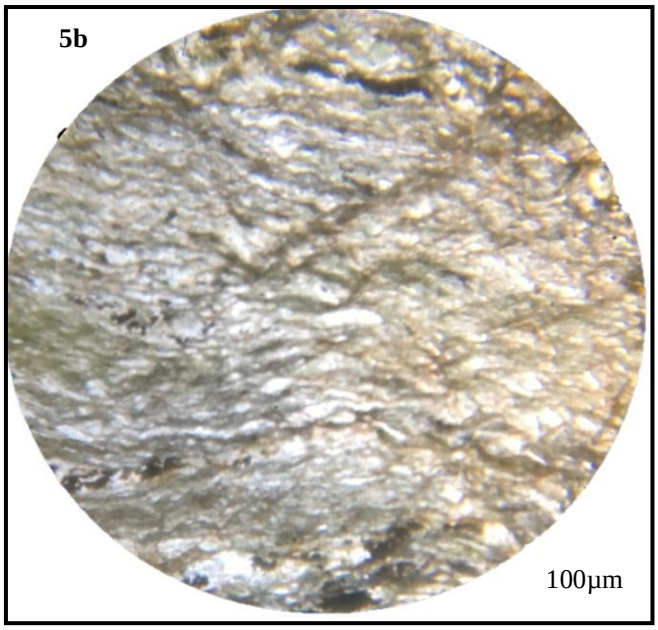


Fig 5: (b) Photomicrograph of phyllite displaying parallel cleavage where muscovite grains are flaky in nature with crenulation cleavage.

Fig 6: Field photograph showing: (a) Clayey formation- contact between basement (BGC) and quartzite (Aravallis).

Intrusive rock

The intrusive rock includes the quartz veins, found in association with all rock types: massive rocks, banded rocks and it also forms a part of basement as well as cover rocks. Quartz veins are the typical features in the Aravalli metasediments which indicate that the deformation occurs in the area and these siliceous veins indicate the orientation plane as an intrusive in the quartzite rock. In some part it is seen cross cutting each other in a rock (6b).

Fig 6: (b) Ferruginous quartzite rock showing continuous veins of quartz mineral.

V. STRUCTURAL CHARACTERISTICS

A number of structural features have been associated with the rocks of the study area. The structural elements which were recorded from the Aravalli region have been distinguished into three major groups- the Bhilwara, the Aravalli, and the Delhi Supergroups. In the study area, SW Chittorgarh, near Achalpura (24 ^{0} 44.21 N, 74°29.78 E) granitic rocks which occur as the basement in the region is generally non-foliated. These granitic rocks are medium to coarse- grained and have K- feldspar grains (Fig 1b). The quartzites are structurally characterized by the presence of foliations developed parallel to the rock outcrops (Fig. 7a). Foliations are well developed in the phyllite rocks which show cleavage planes indicating deformation in the area. Quartzite being the main lithology of the study area shows high deformational features. The joint planes are marked in the field as these have very less or no displacement at all. Mostly two sets of joints are observed in quartzite (Fig. 7b). Few surficial features include exfoliations which takes place due to physical weathering in the region (Fig.8a). This feature is mostly observed in almost all the quartzites of the study area. Bedding is one of the most important structural element which helps in understanding the structural geometry of the rocks of the area. Bedding is however untraceable in rocks showing lithological homogeneity, as well as in very strongly sheared rocks and in the present area, it has been observed mostly in quartzite and

some clay bed of the area. Lineation feature is also observed in the quartzite rock which is well observed in the south western part of Bhadesar area (Fig. 8b).

Fig 7a: Field photograph of foliated quartzite trending NE – SW in the northern part of the Bhadesar area.

Fig 7b: Field photograph of quartzite rock displaying two sets of joints in northwestern part of Bhadesar region.

Fig.8: (a) Field photograph showing exfoliation feature in study area.

(b) Field photograph of quartzite rock showing sub- vertical lineation in Bhadesar region.

DISCUSSION & CONCLUSION

The lithology in the study area belongs to the Proterozoic metasediments which overlie the Archaean rocks or the BGC. The study is mainly done to understand the existence of the different lithologies on various scale, their lithologic continuity, the distribution pattern and their mineralization characteristics. Quartzite is the basal lithounit in the region, having razor sharp sheared contact with the basement. The cover sequences comprise a number of lithounits including shales, sandstones, siltstone, carbonates etc. The lithological similarity is observed with the area of Udaipur formation of Lower Aravalli group, where they consist of the basement BGC, followed by the intrusion of Berach Granite. This is overlain by the clay pockets of siliceous nature**.** The clay minerals show the alteration of feldspar which indicates the common character of clay deposits observed in the northern part of the area which is likely to be kaolinite in nature.

The study area is mapped on a scale of 1: 75,000, rocks of similar composition constitute the Bhilwara Super group, Berach Granite and Bhadesar Quartzite well exposed in the north through west to southern part of the study area. The basement rocks (Pre-Aravallis or Bhilwara Supergroup) which constitute Bhadesar Formation and Berach Granite are overlain by Vindhyan rocks with unconformity in the study area. The rocks mainly comprises the Bhadesar Formation include shale, slate, phyllite, dolomitic limestone and quartzite. This formation is well exposed as long ridges from north to south in the western part of the area. The Bhadesar Quartzite is white and pink, jointed and very fine grained. They commonly show medium - to coarse-grained, equigranular textures containing varying proportions of felsic and mafic phases. Dark colour rock which shows secondary reddish coloration on the surficial part of the

quartzite indicates secondary iron leaching. The quartzite rock is structurally characterized by primary foliations developed mainly along the contacts of the basement and the supracrustals. Petrographic investigation identifies the quartzite rock mineral assemblages are rich in iron content. Granite occur as the basement rock in the study area, characterized by gray to pink coloured coarse grained porphyritic texture. Various samples of granite have been collected to know the mineralization pattern if any in the area. Some of the rocks have been analyzed through petrological studies which suggested that the area has been highly deformed and sheared.

Quartz veins are the typical features in the metasediments which indicate that the deformation occurs in the area. These siliceous veins indicate the orientation plane occurrence of quartz vein within the quartzite rock extending in to the Aravalli Group of rocks reflects the intrusive nature of the veins.

Our initial findings suggest that there is a difference in nature of deformation in cover rocks of the Aravalli Supergroup and the Vindhyan Supergroup. Since the cover rocks adjacent to Bhadesar Formation lack pervasive deformation and hence there is absence of ductility in contact. The current study suggests that various lithology and associated rock types in the study area are due to various tectonic episodes associated with the orogenic cycle.

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