Volume 64, Issue 2, 2020
Journal of Scientific Research
Institute of Science,
Banaras Hindu University, Varanasi, India.

Structural, Lithological and Mineralogical Characteristics of Aravallis and Neighboring Areas: North-Western Part of Chittorgarh, Rajasthan

Ganga Biswa*[1], K. K. Sharma[2], Ritesh Purohit[1] and Jamuna Biswa[1]

[1]Faculty of Earth Science, Mohan Lal Sukhadia University, Rajasthan, India. biswaganga03@gmail.com*
[2]Government College, Sirohi, Rajasthan India.

Abstract: **The North-western part of the Chittorgarh region constitutes one of the oldest Precambrian terrain of Indian peninsula. The rock outcrops in the study region are part of Aravalli Supergroup and overlies Banded gneissic complex (BGC). Petrological studies of the rock samples are done to know the mineralogical variations occurring in the nearby areas and interpreted that recrystallization takes place in quartzite rocks and also the area has undergone deformation and shearing. This paper illustrates the lithological, structural, and mineralogical characteristics of the basement-cover rocks existing in the area around the Aravalli region which will help us to understand the different geological records of these terrains and their relationships.**

Index Terms: **Aravalli Mountain Range, Precambrian, basement-cover rocks, Hindoli.**

I. INTRODUCTION

The paper represents the details of the structure and lithology of the area around the northwestern part of the Chittorgarh region, Rajasthan. Precambrian rocks of the State comprise of the older high-grade gneissic basement, the BGC (Banded Gneissic Complex), two Proterozoic mobile belts-the Delhi and the Aravalli Supergroups respectively. The Aravalli Supergroup of rocks which consists of the Early Proterozoic constitutes an important component of the Precambrian crust of the NW part of the Indian Shield. This Supergroup of rocks unconformably overlies the Archaean basement and comprises a major part of the metasedimentary sequences with some metavolcanics too. The Aravalli Supergroup in northwest India hosts several important carbonate–siliciclastic succession of Palaeo Proterozoic age (Roy, A.B. and Jakhar, S.R., 2002.).

Crustal Evolutionary history of Precambrian rocks of Rajasthan and their correlation with other similar studies have been taken on a global scale. The study area lies in the western part of the Chittorgarh region which includes mainly the Archaean basement (BGC) and the Aravalli Supergroup (Fig.1).

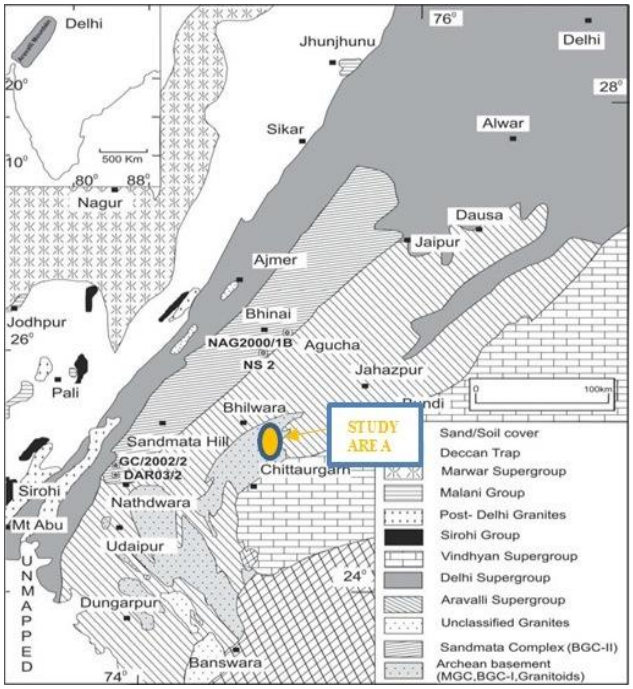

Fig.1. Generalized geological map of the Aravalli Mountains and environs, showing the location of samples for zircon dating (Roy, A.B. & Jakhar, S.R., 2002.)

* Corresponding Author

The area consists of metasedimentary lithoassemblages viz., quartzites, phyllites with clay pockets which has also been mentioned as paleosols extending about 200-300 meters in the study regions. The stratigraphic succession of the Precambrian rocks of Aravalli Mountains consists of the Mewar Gneiss & granites as basement rocks (Table I). These basement rocks consist of the Untala gneiss, quartzites, marbles, calc-silicates, amphibolites, etc. which is overlain by the rocks of the Aravalli Supergroup consisting of the Upper Aravalli granites, Middle and lower Aravalli Groups (A.B. Roy, 1990).

Table I. 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

II. LITHOLOGICAL CHARACTERISTICS OF BASEMENT- COVER ROCKS

The Banded Gneissic Complex has more wide occurrences in the region and is regarded as the oldest succession of supracrustal representing primary sediment. Lithological field characteristics have been studied on a wide scale and also are under constant comparison between the lithologies that exist in the Udaipur sector which bears few variations. The main problem for understanding the basement-cover relationship can be highlighted through field studies. The quartzite outcrops in the region comprise as the marker horizon and siliceous veins are the main features in them indicating that the area has rock formations that are highly deformed (Fig.2a). This also includes clay formations marking the contact between Aravalli rocks and the basement rocks (Fig.2b). Detailed studies regarding the recognition of unconformity of Archaean–Proterozoic (AP) through various pioneering authors and their tectonic stratigraphic studies enable to recognize the unconformity at Jhamarkotra, SE of Udaipur, Rajasthan. The formation which bears little deformed stromatolitic phosphorite rest on peneplained granite-gneiss surface (Roy, A.B *et al.* 1988; Choudhari, R. and Roy, A.B., 1986.)

The nature of unconformity which is observed in the area relates to the description which explains the erosional unconformity and suggested continuous erosion of the basement rocks forming peneplain before the deposition of the Aravalli succession. Quartz are the dominantly occurring minerals in the region followed by the feldspars, clay minerals, and red ochre in few parts of the region. Their appearance in the field is not constant as it depends on the deformation which the area has undergone and to the weathering processes and presence of Fe content in them as well. Recognization of pockets of white mica which is a metamorphosed paleosol and occurring invariably with the granite-metasediments providing excellent criteria in the field for tracing unconformity between the basement and the cover rocks (Hacket, C.A. 1881; Roy, A.B. and Paliwal, BS., 1981). The contact between the Aravallis and the basement has been marked in the field by the presence of erosional unconformity indicated by paleosols (Fig.3). These paleosols have wide extensions of about 100-200 m or even more in some parts. This includes starting in chronological order with basement rocks Banded

Gneissic Complex (BGC) with the intrusion of Berach granite. These are followed by clay pockets (paleosols) overlain by the cover rocks i.e., quartzites followed by shales and phyllites. (Table II) & Fig 4. Dyke is observed as an intrusion in the area.

Fig.2. Field photographs showing- (A) Quartzite rock with Quartz vein indicating deformation (Gangrar, Chittorgarh, Raj.) (B) Clayey formation- contact between basement (BGC) and quartzite (Aravallis), Ajolion ka Khera, Chittorgarh, Raj.

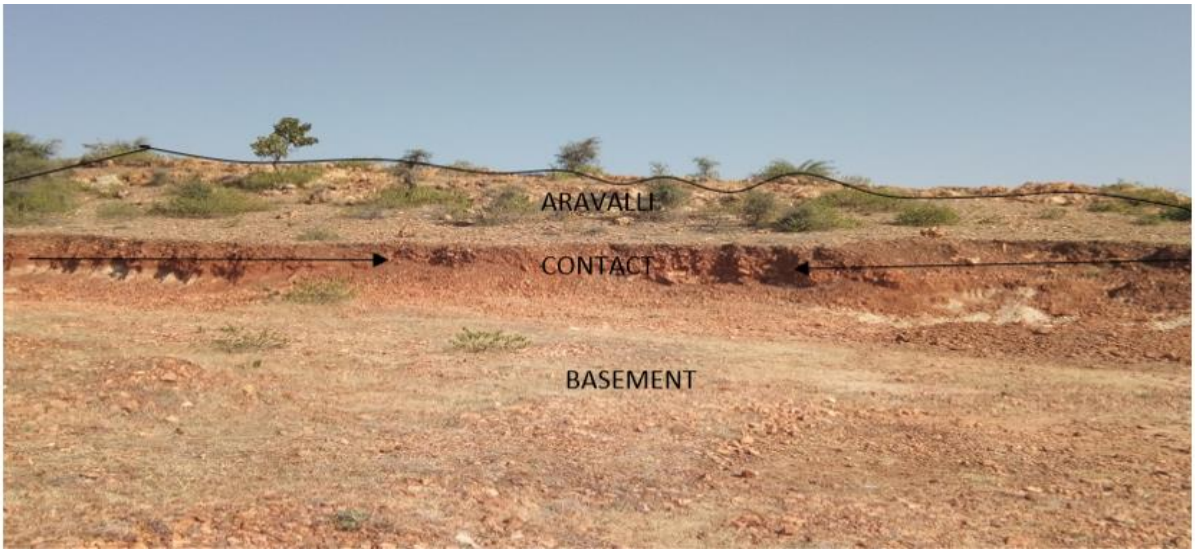

Fig.3. Field photograph showing contact between Basement and Aravalli (Gangrar, Chittorgarh, Raj.)

TABLE II: Stratigraphical column of the lithologies occurring in the study area (Gangrar area).

AGE	GROUP	SUPERGROUP	LITHOLOGY
Archaean	Hindoli	Lower Aravalli supergroup	Intrusive dyke
			Shales/Phyllites
			Cover rocks (Quartzite)
			Clay beds (paleosols)
			BGC & intrusive granites.

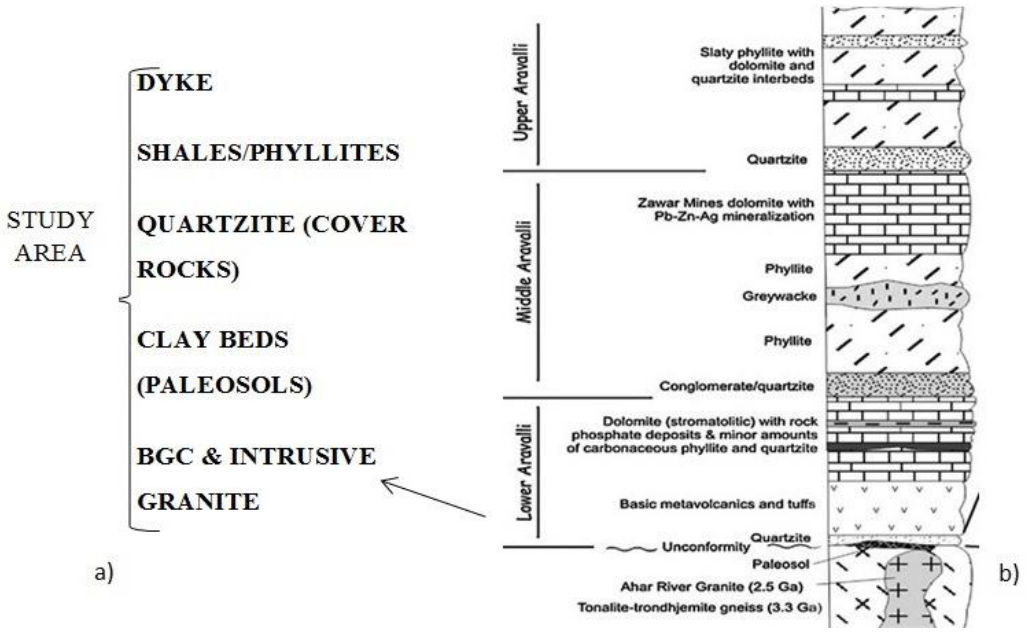

Fig 4.a) The column indicating the lithologies of the study area (Chittorgarh-Gangrar area); b) Column showing schematic compilation of lithostratigraphy of Aravalli Supergroup overlying the Banded Gneiss Complex (after Golani et al., 2002).

III. STRUCTURAL CHARACTERISTICS OF THE BASEMENT-COVER ROCKS

Regionally, when we talk of the Aravalli regions different structural characteristics of this domain have been observed by various geologists. The rocks belonging to the Aravalli Supergroup (~2500 ma) cover a huge region in the Eastern belt and South Eastern belt of the Aravalli Mountains. 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. Due to the successive deformation orogenic cycles taking place in this region, the Precambrian rocks exhibit plastic deformation. In the study area, NW Chittorgarh, Jojron ka Khera (25.0791° N, 74.6195° E), and in the Southern part of the Bhilwara region, the basement rocks has intrusives of Berach granite. These granitic rocks are medium to coarse-grained rocks with pinkish appearance (Fig.5) and few are greyish also. Few deformed structures are also mention together with folds, schistosity, and lineations (Roy, A.B., 1985).

Fig 5. Granite rock (near Gangrar region, NW Chittorgarh)

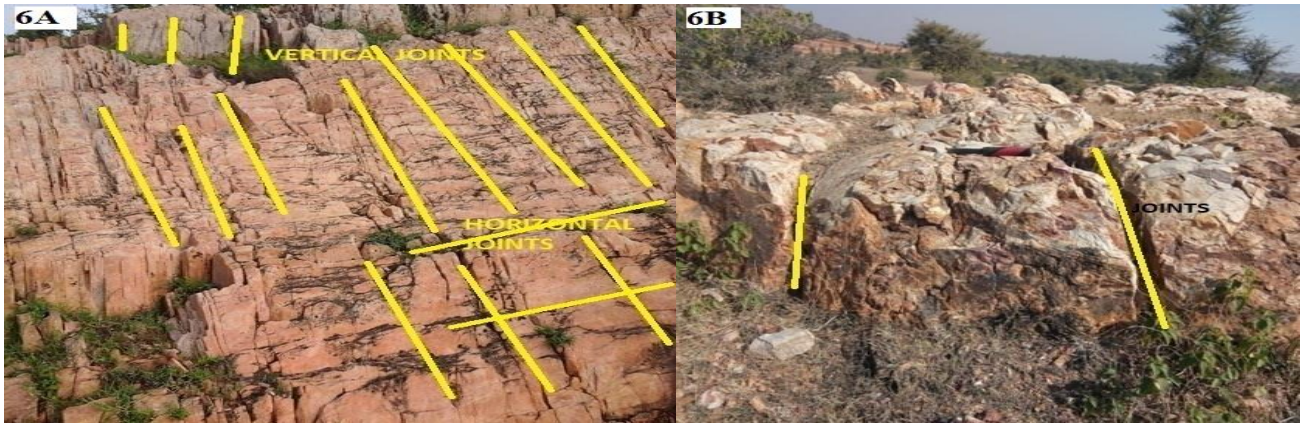

Fig 6. Two sets of joints observed in Quartzite body (Ajolion ka Khera, Chittorgarh, Raj.) (A) mostly vertical joints (B) two sets of joints (vertical and horizontal joints)

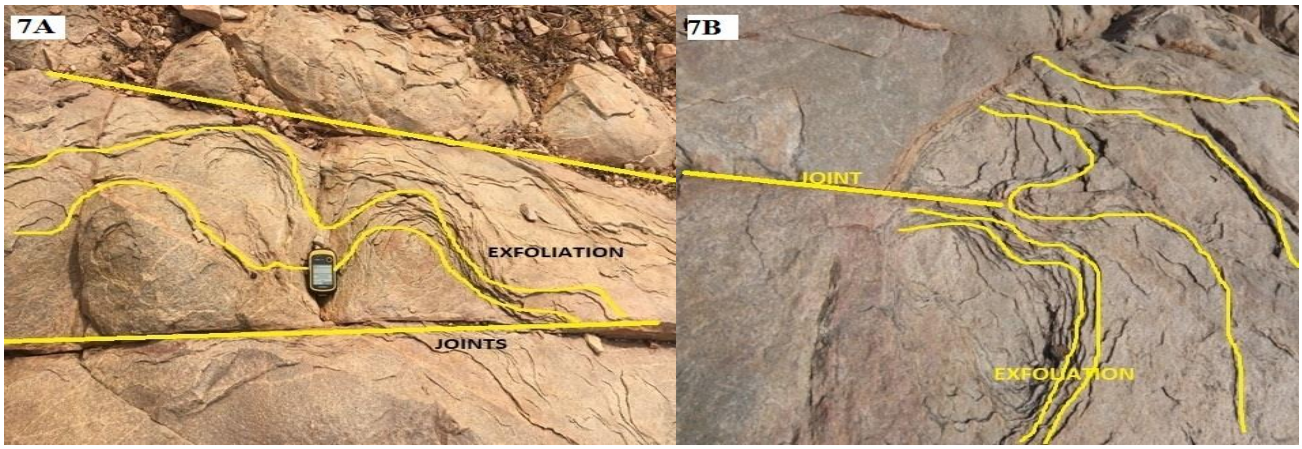

Fig 7. (a) & (b). Exfoliation with horizontal joints in Quartzite rock (Gangrar region)

Granitic rocks which occur as the basement in the region is generally non-foliated. Sets of joints are observed in the study outcrops which also indicate to be fractures of natural origin and lack lateral movement as observed in the field which can be differentiated with the fault structures. The joint planes are marked in the field as these have very less or no displacement at all. Structures are showing high deformation in the region where the quartzite rocks have formed various joint planes in them (Fig.6a & b). Few surficial features include exfoliations take place due to physical weathering in the region (Fig. 7 a&b). This feature is mostly observed in almost all the quartzites of the study area. As the area has been compared with the Hindoli Group, where the primary structures are generally defined by bands of color, graded bedding, etc. The basal quartzite and younger ferruginous quartzite are cross-bedded at many places. These features of the basal quartzite suggest a palaeocurrent direction away from the basement rocks of the Berach granite, an intrusive basement. The extension of the cover rocks (quartzites)in the region is more towards the eastern flank as compared to the western flank of the study region. On the western flank of the basement Archaean rocks are the Palaeoproterozoic rocks of the Hindoli Group equivalent to Aravalli Supergroup whereas on the eastern flank are the Mesoproterozoic rocks of the Vindhyan Supergroup. This indicates, that the western flank has undergone much more deformation as compared to the eastern flank of the study region which has a continuous extension. This comprises of the Aravallis i.e., the cover rocks and the basement being the BGC.

IV. MINERALOGICAL OVERVIEW OF BASEMENT-COVER ROCKS

The contact between the basement BGC and Aravalli Supergroup has an unconformable relationship and is characterized by the presence of alumina-rich and iron-poor paleosol which indicate a large interval before the sedimentation of Aravallis based on unconformity bounded litho-assemblages. The Lower Aravalli Group consists of the rocks of Delwara formation, Jhamarkotra formation, and the Babarmal formation (Roy & Purohit, 2012). The basement of the Delwara Formation is made up of an intercalated sequence of metabasaltic rocks and well-sorted quartzites whereas the latter Formation comprises of dolomites, carbonaceous phyllites with intercalated quartzites and the pink marble with pebbly conglomerates consist of the Babarmal formation. Mineralogically, the study area is well furnished with minerals which include quartz, feldspar, clay, and majority of these clays are silica rich. Soil horizons are observed along with the white clays (fig.8) which are quarried by the local villagers with the help of bulldozers. High alumina clay deposits are extracted manually in areas around Jojron Ka Khera, Gangrar region (Fig.9& 10). The basement of the Aravalli Mountains i.e, the Archaean basement started with an older crust which is Si-rich and that evolve into extensive granitic bodies like the batholiths during the period ca. 3.0 to 2.5 Ga. The Archaean basement serves as a rigid margin which controls the overall geology of the area. To the Northern part of the study area, large deposits of base metals viz., Pb, Zn, Cu, sulfide ores formed extensively along several, long, linear zones in the Bhilwara region. These deposits of Pb-Zn rocks are formed around 1.8 Ga years ago during the Paleoproterozoic phase.

Fig 8. Soil horizon with white clay deposits

Fig 9. Quarry of high alumina-rich clay deposit (Gangrar region, Rajasthan.)

Fig 10. Clay deposits in the study area

V. PETROGRAPHY

The petrographic study is important not only for the geological classification but also to study the texture, constituents and feature influencing the chemical, physical and mechanical behavior of the rocks and minerals.

The outcrop of quartzites occur as a sharp-crested medium to high rising ridges on the north-western and south-western part of the city of Chittorgarh. This topographic feature is in contrast to the neighboring Vindhyan ranges which are characterized by flat-top hills. The ridges of Quartzite strike NE-SW. On a regional scale, the important characteristic of these folded ridges is that the eastern limb is basically more stretched while the western limbs are visualized to be crumbled folding. In a few study areas, the outcrops show secondary reddish coloration on the surficial part of the quartzite which indicates secondary iron leaching.

Petrographically, these quartzites are non-foliated and quartz are the essential constituent followed by feldspar and micaceous minerals. Microcline is absent. Grains are medium to coarse-grained and are not elongated, having undulating boundaries. Quartzite also shows dark brown color, due to iron-rich which shows dominance in secondary iron leaching (Fig. 11). Cherty quartzite is observed at a regional scale as greyish to off white in colour. It has fine-grained textures and is found associated with other quartzites existing in the region. In the thin section, minerals which are observed are quartz, feldspar, biotite and, few ferrous contents. Quartz are greyish in cross-polar and are nonfoliated. Siliceous veins are observed in it. Quartz shows no twinning effect and extinction is absent in it. Among the varieties of feldspar, plagioclase feldspar is dominant. Both fresh and altered varieties of feldspars are observed in these rocks, but the altered varieties are mostly observed as sericite. Biotite shows less twinning and no extinction as observed in the granite rocks. On a regional scale, it can be briefly described as the outcrop of the basement rocks which occur to the west of the Hindoli formation and Bhadesar formation from Hammirgarh in the North to Putholi in the South. They occur as low lying peneplained outcrops with low topographic features and in few areas, these rocks are affected by metamorphism. This has a similar appearance on a regional scale as observed in Raipuriya, Gangrar region. Granites in the region is greyish and few are pinkish color and can be also seen in few areas. The variation in color is mainly due to the leaching process which has been taken place due to iron content in the area. In a few outcrops of granites, quartz veins are also observed on a smaller scale.

In thin section, they occur as a medium to coarse-grained, inequigranular rock essentially composed of plagioclase, microcline, quartz, feldspar. Microcline laths are subhedral in shape and variable in size and show both types of contacts i.e., straight and sutured contact. It shows well-marked cross-hatched twinning. Quartz is anhedral in shape. Quartz shows wavy extinction and due to the shearing effect, cracks are developed in quartz grains. Plagioclase feldspar is present as highly weathered accessory minerals.

Fe_2O_3 is also present as an accessory one. Biotite and hornblende are absent (Fig. 12). Foliated Phyllites in the outcrop appears to be high rising ridges which dips NNE-SSW. They are greyish to greenish. This metamorphic rock is fine-grained and shows the proper alignment of crystals in it with the effect of heat and stresses involved. They are generally composed of carbonaceous matter and silica. In some outcrops, they show yellowish color as a result of secondary leaching of iron. Phyllite shows rich bands of silica and carbonaceous content in it.

On regional scale, they are fine-grained and well foliated. In thin section, these shows alternate banding (Fig. 13) of quartz and micaceous minerals. Here, quartz shows elongation along the foliation plane whereas micaceous mineral is found to be along the cleavage plane. We can also see siliceous matter in it. Feldspar seems to be altered into sericite which is known as sericitization.

Phyllites in Hammirgarh region are generally folded and have large outcrops. The petrography of massive phyllites is almost the same as that of the foliated one. In thin section, it is observed to have second-order cleavage plane. Micaceous minerals are in major concentration and are aligned parallel to the cleavage plane. Twinning is absent and extinction is also absent.

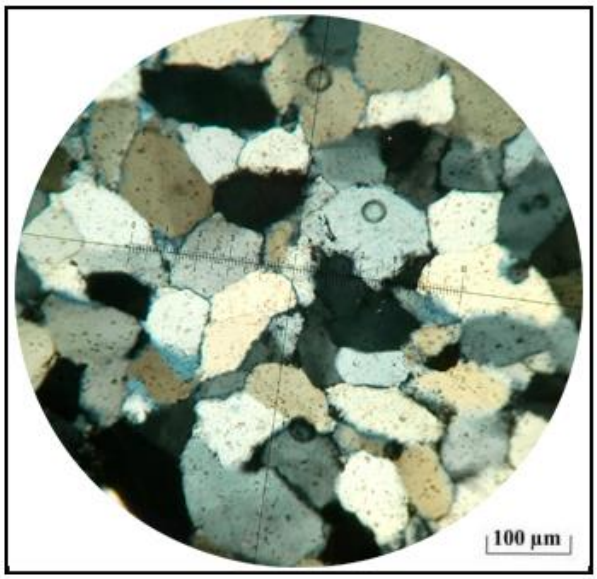

Fig 11. Photomicrograph of Quartzite (Loc. Jojron ka Khera, Gangrar, Raj)

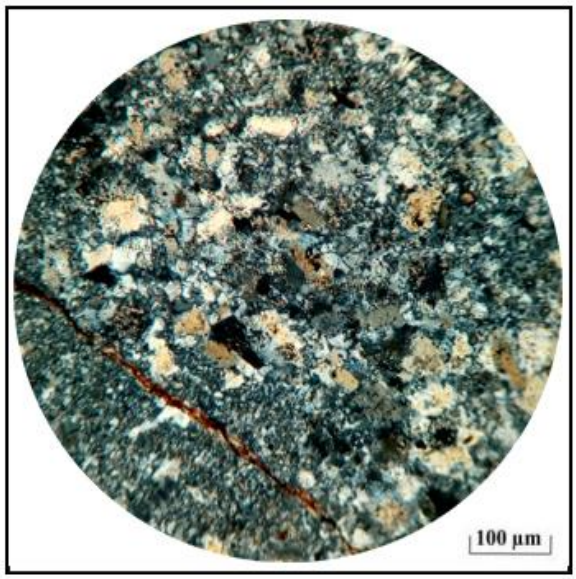

Fig 12. Photomicrograph of Cherty quartzite (Loc. Jojron ka Khera, Gangrar, Raj)

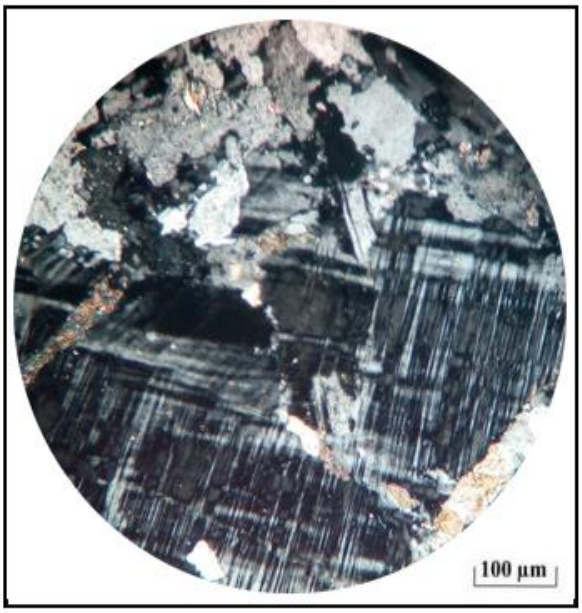

Fig 13. Photomicrograph of Granite showing major concentration of feldspar and muscovite, (Loc. Raipuriya, Gangrar, Raj.)

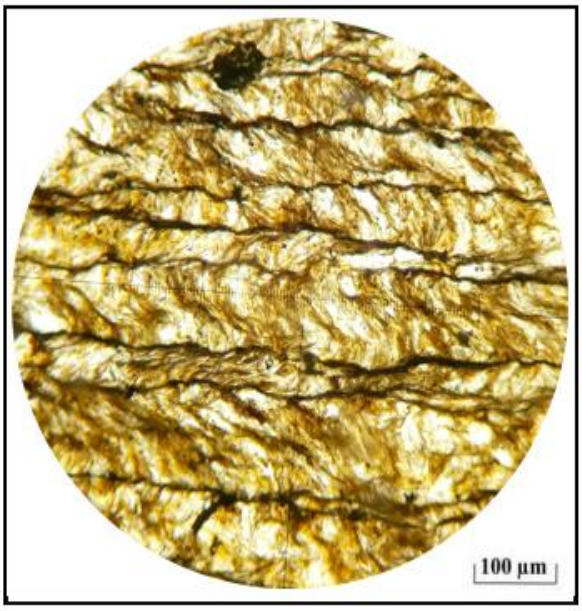

Fig.14.Photomicrograph of Phyllite (Loc. Hammirgarh area, Bhilwara, Raj.)

Table III- Description of the petrographic studies in tabular form

S. No.	ROCK TYPE	AREA OF LOCATION	MINERAL CONTENTS	REMARKS/INTERPRETATION
1	Quartzite	Jojron Ka Khera, Gangrar	Quartz- essential minerals FELDSPAR & BIOTITE- accessory minerals	Quartz grains here are interlocking and are medium to coarse grained and exhibits undulose extinction. Feldspar shows Carlsbad twinning.
2.	Cherty Quartzite	Ajolion Ka Khera, Gangrar	Quartz, Feldspar- essential minerals, Biotite, ferrous minerals- accessory minerals	The quartz grains are surrounded by ferrous minerals with high relief. This ferrous quartzite are mainly found
3.	Phyllite	Mangrop, about 16km from Bhilwara	Mainly composed of quartz, mica and chlorite.	Parallel arrangement of platy minerals. Secondary cleavages are observed vividly in thin section.
4.	Basement granite	Jojron Ka Khera, 5 kms from Gangrar	Essentially composed of quartz minerals. Other minerals feldspar, mica observed as accessory minerals.	Major content of cross hatch twinning in microcline are observed in it. In some part of the study area, pink colored variety of granites are also observed.

VI. DISCUSSION & CONCLUSION

Lithology & Petrography: - The quartzite rocks consist of the main litho-assemblage in the region. These quartzites are structurally characterized by the presence of primary foliations developed along the rock outcrops. They belong to the Proterozoic metasediments which overlie the Archaean rocks or the BGC. The dip of the primary foliations is roughly parallel to the trend of the area. The petrographic studies infer that they are mainly composed of quartz grains and are mainly differentiated from the cherty quartzite by the grain size. The grain size of the latter is much finer as compared to the former which shows medium to coarse-grained rock and these quartzites are found to be identical to the one found in the Udaipur Formation. 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 clay deposit has a smaller number of finer particles (0 to 10.5 μm) and it indicates that clay is highly siliceous in composition and has poor plasticity, as a result, they are not suitable for making in the ceramic industry (Dashora, et.al., 2020).

Basement-cover relationship: -The Archaean-Proterozoic contact (APC) is marked by a large-scale weathered surface. It has been observed that the area comprises of the Lower Aravalli Group. The APC or the Archean basement – Aravalli metasediments have erosional unconformity which is marked by clay pockets that are comparable with the Udaipur Formation. This clay section is developed on top of the granitic basement and the preservation of this section along the Archaean-Proterozoic contact in the craton is strongly controlled by the structural formation. The clay pockets of the APC are observed to be complete in the eastern side as compared to the western side. The extension of these clay pockets is generally 300-400 meters and is mostly aluminous in nature.

The structural elements recorded from the Aravalli Region have been identified into three major groups corresponding to the Bhilwara, the Aravalli, and the Delhi Supergroups. Field studies reveal the structural continuity and also the mineralogical variations existing in the study area. This is elaborated when we compare the outcrop patterns on both the side of the area, i.e., the eastern side which includes Jojron ka Khera (N25˚05.704 &E074˚36.378) via Laxmipura village(N25˚01.339 & E074˚36.993) to Ajolion ka Khera (N24˚58.919 & E074˚38.456) which has continuity of outcrops of Aravalli metasediments with the western flank which include Tagatpura village (N25˚10.172 & E074˚36.508) via Kanti (N25˚01.720 & E074˚35.350) to Borda village(N25˚05.860 & E074˚35.094), where the outcrops are mostly crumbled and less continuation is observed in the outcrop patterns. The Aravalli metasediments show deformation which is formed in the Archaean terrain denoted by the gneisses and granites. Quartz veins are the typical features in the Aravalli metasediments which indicate that the deformation occurs in the area. These siliceous veins indicate the orientation plane which occurs as an intrusion in the quartzite rocks. The trend of these veins is the same as the quartzite rocks and the presence of these veins indicate that the area is structurally controlled by minerals.

Lithological characteristics: - Lithological variations comprise of the basement rocks with the Berach Granite and dolerite dyke. The dyke shows an intrusive relationship with the basement rocks rather than with the Aravalli metasediments. This is further overlain by the clay beds of wide extension which are inferred to be as APC, followed by the metasedimentary rocks of quartzites and shales. These metasediments are formed in the Archaean terrain and the basement rocks equivalent to the BGC are denoted by the gneisses and the granites. The tectonized basement rocks

which are overlain by the quartzites, shales and, phyllites resemble the shallow water sequences of the Lower Aravalli group.

Many studies are yet to be done regarding the evolutionary history of the Aravalli craton, though articles have been published and yet the gap still exists related to the metasediments that exist in the area. On the basis of field studies, the following inferences are drawn-

There exists an erosional unconformity between the cover rocks (quartzites) and the basement rocks or the BGC and this unconformity is marked by a section of clay pockets or clay beds. Quartzites are medium to coarse-grained rocks and in some areas, these quartzites show recrystallized minerals indicating shearing which is also evident from the cracks observed in the quartz grains. 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 and shows distinctive features of saprolite which are developed on granitic terrain and these are further overlain by the metasediments of the area with intrusive dyke. The field study shows that about 70% of the clay produced from the area is white in colour and siliceous in composition. Foliations are well developed in the phyllite rocks which show cleavage planes indicating deformation in the area. The formation of siliceous veins or quartz veins whose source is local dissolution in the host rock which are transported towards the voids by the process of diffusion where this quartz precipitates. This characteristic feature can be useful for mineralization in our further studies.

ACKNOWLEDGEMENT

The authors thank Department of Geology, Faculty of earth science, Mohan Lal Sukhadia University, Udaipur for providing lab facility to conduct this work. The authors thank Prof. N. K. Chauhan (Retd. Prof., Geology Dept.) MLSU, Udaipur for useful discussions. We are also thankful to reviewer Dr. Esar for his constructive comments during the review of the manuscript.

REFERENCES

Banerjee, A.K and Sinha, P.N.1981. Structure and tectonics of Vindhyan in eastern Rajasthan. Misc. Pub. *Geol. Surv. India*, 50, 41-47.

Bhatt, A.K., Sundar, G., Singh, P.P., Rahman, M., Rengarajan, M and Sharma, D.K. 1995. A note on Uranium mineralisation in the basal Aravalli quartzite near Putholi, Chittorgarh district, Rajasthan, *India. Journal of Atomic Mineral Sci*., 3, pp.17-22

Choudhary. A. K., Gopalan, K. and Sastry, C. A. 1984. Present status of the geochronology of the Precambrian rocks of Rajasthan. *Tectonophysics*, 10, pp. 131-140.

Choudhuri, A. R., Guha, D.B. 2004. Evolution of the Great Boundary fault: a re-evaluation. *Journal Geological Society of India*,64, 21-31.

Condie K.C.1997. Plate Tectonics and crustal Evolution. *Fourth Edition, An imprint of Elsevier Science Linacre House, Jordan Hill*, Oxford 0X2 8DP.

Coulson, A.L. 1927. Geology of Bundi state, Rec. *Geol. Surv. India*, 602p.

Crookshank, H. 1948. Minerals of the Rajputana pegmatites. *Trans. Mining Geol. Met. Inst. India*, 42, 105-189.

Dashora Vijay and Shekhawat, M.S. 2020. Particle Size Distribution Study Of China Clay Of Bhilwara Area, Rajasthan Using Laser Diffraction Technique. *International Journal of Scientific & Technology Research*, 9, 4173-4177.

Datta, L. N.1967. Systematic geological mapping in parts of Chittorgarh, Bhilwara and Udaipur districts, Rajasthan, Toposheet No. 45K/8 and 45Li5. *G.S.I.* Unpublished report.

Deb, M., Banerjee, D.M. and Bhattacharya, A.K. 1978. Precambrian stromatolite and other structures in the Rajpura-Dariba polymetallic ore deposit, Rajasthan, India. *Mineral Deposita*, 13, 1-9.

Geology and Mineral Resources of Rajasthan. 2011. *Geological Survey of India*, Published by order of the Government of India.

Geological Survey of India. 1997. The Precambrain geology of the Aravalli region, Southern Rajasthan and Northeastern Gujrat. *Memoirs of the GSI*, 123 ,pp. 16-86.

Gopal Ram and Agarwal, R.N. 1993. Geophysical Methods for Subsurface Geological Mapping in Bethumni-Dariba-Bhopalsagar Belt of Rajasthan-A Case Study, Geophysical Division. *Geological Survey of India, Jaipur* 302 004,41, pp. 371-377.

Guha D B and Garkhal R. S. 1993. Early Proterozoic Aravalli metasediments and their relation with the Ahar River Granite around Udaipur, Rajasthan; *J. Geol. Soc. India*, 42, 327-335.

Gupta, S.N., Arora, Y.K., Mathur, R.K., Iqbaluddin, Balmiki Prasad, Sahai, T.N. and Sharma, S.B. 1980. Lithostratigraphic map of Aravalli region, southern Rajasthan and northeastern Gujarat, *Geol. Surv. India Publication, Hyderabad*.

Hacket, C.A. 1881. On the geology of the Aravalli region, Central and Eastern. Rec. *Geol. Surv India*, 14 (4), 279-303.

Heilbronner Renée.2010. Mapping Texture Domains in Quartzite Microstructures. *Journal Geological Society of India*,75, pp.160-170.

Heron, A. M.1917 Synopsis of pre-Vindhyan Geo]ogy of Rajputana. *Trans. Nat. Inst. Sci. India*,2, pp. 17-33.

Heron, A.M. 1917a. Geology of Northeastern Rajputana and adjacent districts. *Mem. Geol. Surv. India*, 45(1), 128p.

Heron, A.M.1936. Geology of Southeastern Rajputana. Mem. *Geol. Surv. India*, 68(1), 120p

Heron, A.M. 1953. The Geology of Central Rajputana, *Mem. Geol. Surv. India*, 79 (1), 389 pp.

Kataria, P., Chaudhari, M.W. and Althaus, E.1988. Petrochemistry of amphibolites from the Banded Gneissic Complex of Amet, Rajasthan, northwestern India,,*N. Jb. Miner. Abh*.

Mathur, R, K. 1963. Systematic geological mapping in parts of the Udaipur and Bhilwara district, Rajasthan, Toposheet No. 45K/4, *G.S.I.* Unpublished report.

Prasad, B. 1973. Geology of the pre-Aravalli rocks in parts of Chittaurgarh and Udaipur districts. *Sem.Recent advances in the geology of Rajasthan and Gujrat, Jaipur* Abstract, p.4.

Prasad, B. 1976. Revised stratigraphic Position of Banded Gneissic Complex and Berach Granite and their relationship, Chittaurgarh area, Rajasthan. *Sem.on Archaeans of Central India*. 30th Nov.-1st Dec., Nagpur. Abstract.

Purohit, Ritesh, Bhu, Harsh, Sarkar, Arindam and Ram, Joga.2015. Evolution of the Ultramafic Rocks of the Rakhabdev and Jharol Belts in Southeastern Rajasthan, India: New Evidences from Imagery Mapping, Petro-mineralogical and O-H Stable Isotope Studies; *Journal Geological Society of India* ,85, pp.331-338.

Purohit, R., Sanyal Prasanta, Roy, A.B. and Bhattacharya, S.K. 2010. 13C enrichment in the Palaeoproterozoic carbonate rocks of the Aravalli Supergroup, northwest India: Influence of depositional environment. *Gondwana Research*, 18, 538–546.

Roy, A.B. 1973.Nature and evolution of sub horizontal crenulation cleavage in the type Aravalli rocks around Udaipur, Rajasthan. *Proc. Nat. Sci. Acad. India*, 36(A), 119-131.

Roy, A.B., 1985. Tectonic and stratigraphic framework of the early Precambrian rocks of Rajasthan and northern Gujarat. *Bull.Geol., Min. and Metal. Soc. India*, 53, 100-114.

Roy, A.B.1991. Evolution of Early Proterozoic Aravalli Depositional Basin. *Sedimentary Basins of India: Tectonic Context*.

Roy, A.B., Jakhar, S.R. 2002. Geology of Rajasthan (northwest India) *Precambrian to Recent Scientific Publishers (India), Jodhpur*.

Roy, A.B., Kroner, A., Rathore, S., Laul, V., Purohit, P. 2012. Tectono-Metamorphic and Geochronologic Studies from Sandmata Complex, Northwest Indian Shield: Implications on Exhumation of Late- Palaeoproterozoic Granulites in an Archaean-early Palaeoproterozoic Granite-Gneiss Terrane. *Geological Society of India*, 79, pp.323-334

Roy, A.B. and Paliwal, BS. , 1981 Evolution of lower Proterozoic Epicontinental deposits: Stromatolite bearing Aravalli rocks of Udaipur, Rajasthan, India. *Precambrian Res.*,14, 49-74.

Roy, A.B., Paliwal, B.S., Shekhawat, S.S., Nagori, D.K., Golani, P.R. Bejarniya, B.R., 1988. Stratigraphy of the Aravalli Supergroup in the type area. In: A.B. Roy (ed.), Precambrian of the Aravalli Mountain, Rajasthan India. *Mem. Geol. Soc. India*,7, 3-31.

Roy, A.B., Purohit, R. 2015. Lithostratigraphic, geochronological and depositional framework of the Precambrian basins of the Aravalli Mountains and adjoining areas, Rajasthan, India. *The Geological Society of London, Memoirs*, 43, 55-65.

Singh, K. Pavanesh, Khan, M. Shamim. 2017. Geochemistry of Palaeoproterozoic Rocks of Aravalli Supergroup: Implications for Weathering History and Depositional Sequence. *International Journal of Geosciences*,8, 1278-1299.

***