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LITHOSTRATIGRAPHIC, GEOCHRONOLOGICAL AND DEPOSITIONAL FRAMEWORK OF THE MORLI – KHIWANDI PRECAMBRIAN METASEDIMENTS OF SIROHI AND PALI DISTRICT OF RAJASTHAN

Harish Kapasya	Department of Geology, M.L.S. University, Udaipur, Rajasthan-313001
Ritesh Purohit	Department of Geology, Government College of Sirohi, Rajasthan-307001
K.K. Sharma	Department of Geology, Government College of Sirohi, Rajasthan-307001

ABSTRACT The Sirohi Group is the youngest of the three Precambrian orogenic metasedimentary/metavolcanic sequences in northwestern India, which along with granitoids and granite gneisses constitute the southwestern part of the Aravalli Mountain belt. The Neoproterozoic Sirohi orogeny (850 Ma) marks closure of compressional tectonic regime in the Aravalli craton. The beginning of Neoproterozoic marks one of the most dynamic periods in the history of the earth.

The Morli-Khiwandi study area lies in north of Sirohi, Rajasthan and located in the Survey of India Toposheet No. 45C/16, 45G/4 and 45G/3. The study area is situated in eastern and northern part of Sumerpur town. These forms linear outcrop south-west of the Aravalli Mountain Belt. The Morli-Khwandi metasediments are part of Sirohi Group dominantly comprises shale sandstone-carbonate-carbon shale metasediments. Some of these metamorphic rocks were subjected to mylonitization and contact metamorphism. The metasediments form outcrops in the Erinpura granitoid terrain. The metasediments are phyllite, quartzite, calc-silicate and carbon phyllite.

Geological evidence suggests evolution of the Sirohi basin developed subsequent to cratonization of the underlying Delhi Supergroup rocks at ca 1450 Ma. (Roy and Das 1985. The Neoproterozoic age of the Sirohi Group is based on reports of younger tectono-thermal events between 1200 and 950 Ma from the region surrounding the Sirohi basins (Deb et al. 1989, 2001; Fareeduddin and Kröner, 1998;; Pandit et al., 2003; Volpe and McDougall, 1990; Purohit et al., 2012). A middle to late Neoproterozoic age for the Sirohi Group is also inferred from the field association of these rocks with ca. 850 Ma old granitoids (Choudhary et al. 1984) and from several isotopic ages in the range of ~780-680 Ma for the Malani volcanics and plutonic felsic activity. The magma resulted in thermal resetting of older granitoids and other Sirohi rocks. This hypothesis is confirmed from Lithostratigraphic & structural evidences.

The research study further indicate northwest drifting and an enechelon distribution pattern and last phase of geodynamic resetting in the region.

KEYWORDS : Precambrian, Orogeny, Neoproterozoic, Morli, Khiwandi, Cratonization, Tectono-thermal, Plutonic, Resetting.

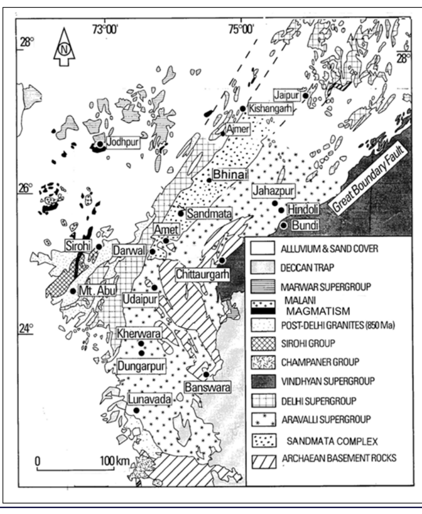
Overview:

The **Indian shield** is made up of a medley of Precambrian metamorphic terrains that show low to high-grade crystalline rocks in the age range of 3.6–2.6 Ga. These terrains forming the continental crust, attained tectonic stability for prolonged period (since Precambrian time) and are designated *cratons.* The cratons are flanked by a fold belt, with or without a discernible suture or shear zone, suggesting that the cratons, as crustal blocks or icroplates, moved against each other and collided to generate these fold belts (Sharma, 2009).

Rajasthan forms north-western part of the Indian Shield. The rock sequences of the region cover a time span of about 3500 to 0.5 Ma. The State exposes a variety of lithological and tectonic units ranging in age from Archaean to Recent times.

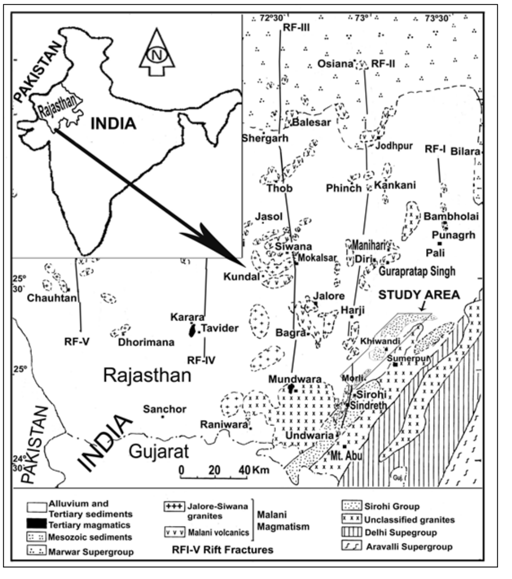
The generalized geological map of the Aravalli Mountain belt is given in Figure-1.

Figure – 1: Generalized geological map of Aravalli mountain belt *(After Heron, 1935, Gupta et al., 1980, Roy, 1988, Sharma, 2004)*



The generalized map of west of Aravalli Mountain (After Sharma, 2005) also witness variety of metasediments and other rocks are shown in Figure -2.

Figure – 2: Generalized map of west of Aravalli mountain (After Sharma, 2005)



In the figure 2, the study area have been shown in 'dash line'.

Regional Geological Set of Sirohi and Pali district:

The **Sirohi Group** of rocks is exposed around **Morli, Khiwandi** and west of Sibagoan. It is represented by grey quartzite, carbon phyllite/schist, phyllite/schist and carbonates. A linear zone around Sibagoan shows presence of banded chert, carbonate and volcanic rocks. These rocks are least metamorphosed and show simple deformation like axial planar cleavages and schistosity. Tentatively this association is put within the Sirohi Group. The Sirohi rocks are intruded by granites and show development of andalusite due to thermal effect near the contact zone. Contrary to the high-grade basement rocks with complex folding, the Sirohi rocks show green-schist facies of metamorphism and simple deformational imprints. In the western part of the area, linear ridges and isolated outcrops of agglomerate, basic and acid volcanics are exposed, which are intruded by coarse-grained homophonous granite. These volcanic rocks are included within the Malani Igneous Suite by earlier workers (Bhushan, 2000). However, the present field studies indicate physical continuation of these rocks and the volcanics of the Sindreth Group, exposed to the south of the mapped area. A paleochannel identified during the present mapping divides the two for a short distance.

The 'shale-carbonate' sequence of the Sirohi Group includes quartz rich phyllites. The virtual absence of coarser siliciclastic rocks (especially conglomerates) in the Sirohi rocks is manifestations of a highly peneplained hinterland (provenance) that supplied sediments.

The Sirohi Group is the youngest of the three Precambrian orogenic metasedimentary sequences in northwestern India, which along with granitoids and granite gneisses constitute the southwestern part of the Aravalli Mountain belt. The Neoproterozoic Sirohi orogeny (850 Ma, Sharma, 1996) marks closure of compressional tectonic regime in the Aravalli craton.

The Morli-Khandi metasediments are part of Neoproterozoic Sirohi Group (1000-850 Ma, Sharma, 1996; Sharma, 2004, 2005, 2007, 2009). These forms isolated outcrops west of Sirnava hills in Sirohi region. These comprise significant value of carbon in phyllite. Besides this, there are thick bands of carbonate sediments and quartzite. The presence of carbon rich metasediments in the study area signifies organic growth and oxygenation event during the depositional time.

The Morli-Khiwandi metasendiments indicate well developed schistosity along with linear fabric. The discontinuity in the outcrop suggests oblique movement of regional trend.

Lithological Characteristics:

Coulson (1933), Gupta et. al. (1980), Bose (1989), Sharma (1996) described various lithologies from the studied region.These may be conveniently grouped under the following heads:

A. Basement rocks (Granitoids and Veerwara Granitic Gneiss)
B. Metasediments of the Sirohi Group
C. Post Sirohi Group Granites (Sumerpur Granite, Balda Granite)
D. Malani Magmatism (Rhyolite, Basalt, Volcanic Tuffs etc.)
E. Dyke rocks (Quartz-Feldspar porphyry dykes, dolerite dykes)

Metasediments of Sirohi Group:

The rocks of the Sirohi Group are exposed in three sectors. The major part is exposed around Kavar Pahar- Khivandi – Kaliya Pahar area, northwest of Sumerpur (45G/4). Two small patches of Sirohi rocks are exposed around Morli, west of Palri (45C/16) and around Sibagoan. The Morli patch probably represents the southwestern extension of Kavar Pahar outcrop, with a gap of about 10km covered by the flood plain of the Sukri River. The lithological association of Kavar Pahar-Khivandi area and Morli area are similar, while the lithological association of Sibagoan area is different. The Sibagoan exposure is about 1-2 km wide and trends in NE-SW direction.

Towards east, the contact between the sequence and the porphyritic granite is marked by shear zone, as indicated by the presence of mylonite, while the western contact is soil covered. In Sibagoan area, banded chert, crystalline carbonate and dolomites are the representatives of the Sirohi rocks. These rocks show greenschist facies of metamorphism and two phases of deformation. The Sibagoan sequence probably represents a separatesequence, but has been included within the Sirohi Group at present due to limited database. Low-grade meta-sediments of Sirohi Group exposed around Khivandi (45G/4). The major rock units of this group are:

Quartz Mica Schist: The siliceous carbon - schist is composed of alternate bands of quartz and cabonaceous matter. These carbon schist mark black on streak plate and carbon concentration may be of 3-10%. Thin phyllitic bands are recorded within the carbon -schists unit at Kaliya Pahar and south east of Sibagoan. At places these phyllitic bands show variations in colours from light grey to brown and wherever the quartz content is appreciably less the rock becomes more foliated. The rock shows the presence of quartz, biotite, andalusite and carbonaceous matter; the carbonaceous mineral appears as dark black in colour and has an irregular lath shape. The andalusite occurs as euhedral crystals.

The Mica schist of Sirohi group is outcropping at Morli and Khiwandi region. The mica schist is silvery grey coloured, showing development of pervasive schistosity planes defined by prisms of muscovite and biotite, and flattened grains of quartz. It is composed of quartz, muscovite and biotite as major minerals. Garnet and andalusite occur as porphyroblasts. Epidote, chlorite, microcline, tourmaline and some opaque minerals occur in minor quantity. At plces mica schist grades into quatzose phyllite, phyllte and quartzites.

Micaceous quartzite: Thinly bedded, white coloured quartzite bands occupy the western portion of the area. They are present as small mound west of Kavar Pahar while northwest of Sindru they occur as low ridges running in an east west direction. Quartzite is yellowish brown, generally compact, but becomes schistose at some places, due to presence of thin micaceous layering. With increase in the proportion of the mica, quartzite grades into quartz-muscovite schist.

Carbonate Rocks: In the major part of the, rocks of the calcareous facies occur as intercalated layers within the biotite schist. These occur as linear bands along the ridges of Kavar Pahar and on the flanks of Kaliya Pahar. In the areas where calcareous rocks occurs in contact with the granite, they grade laterally into marble and calc silicate bands due to the thermal effect of granite on these rocks. The carbonate unit shows variation in texture and lthology.

Dolomite inter-bedded with numerous thin layers of dark greenish black coloured biotite schist has been recorded. The rock is fine to medium grained, greyish to brownish white in colour.

Calc-silicate rocks occur as an almost continuous exposure in the central part of the mapped area around Kaliya Pahar. The rocks occur in banded form. Alternate calc rich and silica rich bands define the banding. This banding is more prominent on the weathered surface of the rock. The silica rich bands are essentially composed of quartz grains, which show strain shadow and sutured margins. Tremolite and actinolite show typical prismatic grains. Sphene and apatite are present in minor amount. Late stage quartz and carbonate veins are seen cross cutting the calc silicate rocks.

Massive dolomite occurs as thin unit of 10-30m thick bands between Kavar Pahar and Kaliya Magra with a northeasterly trend. This unit is a fine grained, massive and hard, light bluish to grey coloured rock**.** The litho unit characteristically shows elephant skin weathering and gives slow effervescence when cold dilute hydrochloric acid is poured on it. Bedding planes is depicted by variation in colour and by the presence of thin siliceous layers. It displays characteristic deformation fabric such as flow folds and small-scale isoclinal reclined folds.

Recrystallised limestone occurs as white marble bands around the hill at Khivandi and in some places north east of Khivandi. In these places marble occurs interbanded with calc-silicates bands. Marble found in the area is grayish to white in colour, and is medium grained.

Biotite Schist: It light greyish-to-brownish coloured, fine to coarse-grained rock with welldeveloped schistosity, marked by the alignment of layered-silicates. Microscopically, the biotite schist is a fine to medium grained rock composed of biotite, and quartz as major constituents. Muscovite and sericite occur in minor amount. Garnet, epidote and opaques occur as accessories. Biotite is present in abundance. It occurs in a fine matrix containing flakes of biotite and muscovite. Quartz grains are aligned parallel to the mica flakes. Garnetiferous-biotite schist is recorded at the contact zone with porphyritic granite, in the area north east of Rojra, where the garnet porphyroblasts containing numerous fine inclusion of quartz have been noticed with in the biotite schist.). This is seen in Khivandi, Kavar Pahar and Sindru area.

Structure of the Sirohi Group and Associated Granitic Rocks:

The most significant aspect in the structural evolution of the Sirohi region (involving metasediments of the Sirohi Group) is the development of ductile shear zones which border the metasedimentary bodies. These shear zones marked by mylonites continue southward beyond the limits of the metasedimentary outcrops (Fig. 5). The nature of deformation in the western belt as will be described latter, is clearly related to ductile shearing. The rocks of the eastern Balda belt, on the other hand, bear evidence of folding following diaparic intrusion of a granite body. Before discussing in detail the large scale structures, it may be worthwhile to discuss the geometry of small-scale structural elements.

I .Small Scale Structures:
A number of small scale structures are observed in the Sirohi metasediments and associated granitic rocks. A brief description of small scale structures present in the Sirohi Group and in the associated granitic rock is given below.

A. Bedding: Bedding is one of the most important structural element which helps in understanding the structural geometry of the rocks of the area. Bedding is generally well preserved in the Sirohi metsediments. Bedding is however untraceable in rocks showing lithological homogeneity, as well as in very strongly sheared rocks. In mica-schist, bedding is identified by composition, colour and textural variations. In some rocks bedding plane is marked by profuse growth of andulasite minerals along thin layers of pelites alternating with more psammititic components. Similarly, bedding is also marked by the presence of quartzose layers within thicker pelitic zones. Primary bedding features like graded bedding and cross bedding have not been observed in the Sirohi metasediments.

B. Cleavage/Schistosity: The terms cleavage and schistosity have been used to define a set of closely spaced planar parallel secondary fabric element that imparts a mechanical anisotropy to the rocks and does not cause an apparent loss of cohesion in the rock (cf. Bayly et al., 1977).

When seen under microscope, the fabric shows domainal features like microlithon and cleavage domain (Ghosh, 1993). The former represents relatively unaltered domain with original fabric, whereas the latter are characterised by strong preferential mineral orientation along it. The cleavage with microlithon domains are described as spaced cleavage and without it as continuous cleavage. Slaty cleavage and schistosity are types of continuous cleavage, which occur in slate and schist respectively.

Hobbes et al. (1976) used the term "foliation” in broader sense, which include all type cleavage both spaced and continuous as well as metamorphic banding i.e. gneissic foliations. These may be briefly described as:

a. Slaty cleavage and schistosity: Schist splits along closely spaced planes of weakness. Sedgwick (1835) described thses secondary planes in slates as slaty cleavage. Cleavage and schistosity include all the planar structure of secondary origin which results from deformation. This plane is conventionally described as (S1).

It is the most pervasive feature in schistose rocks, and in many respect appears similar to `tectonic surface' described by Tobisch and Glover (1971). The fact that the cleavage surfaces in most of the folded terrains are approximately parallel to axial planes of folds was recognised since long (Sedgwick, 1835, Darwin, 1846). The axial planar character of S1 is indicated by its intersection with compositional layering which defines bedding plane (cf. Wilson, 1951). The trace of the bedding on the schistosity forms a subhorizontal lineation which is parallel to the fold axis. The calc silicate rocks show strongly schistose character, which arises due to parallel orientation of amphibole minerals (tremolite and actinolite) and flattened grains of carbonate minerals. Schistosity appears as a transposed feature in the zone of shearing.

b. Gneissic foliation: The granite gneisses of the Sirohi region show well developed gneissic foliation (S1A) showing alternate bands of quartz-feldspar minerals and biotite rich layers. The gneissic bands bounded by S1A planes are irregular in width, and show zig-zag pattern. This is in contrast with the mylonitic foliations, which are more uniform and planar in character. Generally, S1A planes follow the trend of the regional schistosity in metasediments. It seems possible that these foliations are transposition structures resulting from a common deformation pattern.

c. Mylonitic foliation: The lithological contacts between the granite gneisses and the metasediments are highly tectonised planes, marked by zones of ductile shearing (S2A), resulting mylonitic foliation. The grain size reduction due to shearing is maximum so in the metasediments and is less so in the granite gneiss which occurs at the contact. K-feldspar megacrysts show preferred dimensional orientation parallel to mylonitic foliation. Microscopic study, however, shows development of a few elongate megacrysts are at high angles to the foliation. Recrystallised or neoformed minerals occurring in the pressure shadow zones of K-feldspar megacrysts are quartz, biotite and muscovite. Mylonitic foliation show steep easterly dip, and are characterized by steep down dip lineations (L-S fabric).

C. Lineation: Various linear structures are present in the Sirohi Group and associated rocks. A few important of which are described below:

a. **Intersection of bedding and schistosity (FA-L1):** This lineation is formed due to intersection of axial plane schistosity and bedding. Because of this relationship the lineation is also termed as the fold axis lineation. On the schistosity planes, the lineation appears as lines or stripes of variable width. It is generally sub-horizontal grading to shallow plunging towards SSE.
b. **Mylonitic lineation (L2):** The Sirohi metasediments occurring around are bounded with ductile shear zones. All these sheared rocks show strong down-dip lineation on the schistosity and shear planes. The lineation indicates stretching of mineral grains, streaking and recrystallisation of minerals in the direction of shearing.
c. **Kink bands and Chevron folds:** Kink foliations are widely spaced and are characterized by a plane across to the schistosity or gneissic foliation which forms kinking or minor crenulations in quartz mica schist and granitic gneiss. It is non-penetrative in nature and is observed in thin sections of mica schist.
d. **Joints:** Different rock types like mica schist, calc-silicates, granite gneiss and the granite show well-development joints. No detailed study was undertaken on the attitude and nature of the joint planes. However, it has been generally observed that the joint planes show transverse and oblique relationship with the regional planar feature.

II. Large Scale Structures:
On the basis of Google view of the studied region, the following large scale structure are noticed:

Sirohi trends: Sirohi metasediments folollw NE, NNE, NNE trends. The Morli rocks follow almost north- east trend. The Khiwandi metasediments follows North-east to almost east west trend in northern portion.

The Jawai River follows Jawai lineament, this cross cutting Sirohi trends. The Google view suggests parallel Faults in the Morli-Khiwandi region.

Geochronological Interpretation:
Gupta *et al*. (1980) however, considered the 'Sirohi Group' as the youngest stratigraphic formation of the Mesoproterozoic Delhi Supergroup. Later studies by Sharma (1996), Roy and Sharma (1999), Sharma (2004) confirmed a separate stratigraphic status of the Sirohi Group, representing younger tectono-stratigraphic assemblage that evolved later to the Mesoproterozoic Delhi Supergroup, but prior to the Malani volcanic rocks. In the absence of exposed geological contacts with the Delhi Supergroup, the relative Stratigraphic position of the Sirohi Group with the former is based on the contrasting deformation and metamorphic history (Roy and Sharma, 1999; Roy and Jakhar, 2002). Thus, in contrast to the complex multiple deformation and metamorphism observed in the Delhi Supergroup (Naha *et al*., 1984; Roy and Das, 1985), the Sirohi Group characteristically shows a single-phased simple-shear related deformation (Sharma, 1996).

Occurring along a linear belt west of the Main Delhi Synclinorium with an intervening belt of granitoids of diverse types and ages, the Sirohi Group dominantly comprises shale and carbonate metasediments metamorphosed to lower greenschist facies (Sharma, 1996). Some of these metamorphic rocks were subjected to mylonitization and contact metamorphism. The degree of metamorphism in the metasediments is gradational across the shear and contact metamorphism zones.

The metapelites include both fine-grained phyllite and comparatively coarse-grained mica schist containing garnet and andalusite porphyroblasts along the contact metamorphism zones. Carbonate rocks, like metapelites, show an intensely sheared mylonitic character. The fine grained carbonates are calcitic and dolomitic in composition and include subordinate amount of mica and quartz. Mylonitized and metamorphosed zones of the carbonates show highly localized presence of parallely oriented tremolite-actinolite needles, talc alterations, wollastonite laths, and garnet porphyroblasts and in rare case diopside also. Such assemblages are seen in the carbonates along the stress-free thermal metamorphic aureole zones which are locally metamorphosed to higher grade of metamorphism in comparison to the general low grade greenschist facies metamorphism.

Anticipated Depositional Frame work:

Geological evidence suggests evolution of the Sirohi basin developed subsequent to cratonization of the underlying Delhi Supergroup rocks at ca 1450 Ma. (Roy and Das 1985). The Neoproterozoic age of the Sirohi Group is based on reports of younger tectono-thermal events between 1200 and 950 Ma from the region surrounding the Sirohi basins (Deb et al. 1989, 2001; Fareeduddin and Kröner, 1998;; Volpe and McDougall, 1990; Table 4).

A middle to late Neoproterozoic age for the Sirohi Group is also inferred from the field association of these rocks with ca. 850 Ma old granitoids (Choudhary et al. 1984) and from several isotopic ages in the range of ~780-680 Ma for the Malani volcanics and plutonic felsic activity. The magma resulted in thermal resetting of older granitoids and other Sirohi rocks (Crawford, 1975; Rathore *et al*. 1996, 1999; Roy *et al*., 2005; Torsvik *et al*., 2001, 2003; Tucker, *et al*., 2001; Van Lente, *et al*., 2009).

Purohit et al., (2012) suggested that the Sirohi basin opening occurred later than ca. 920 Ma. He also reported the single zircon age of sample collected from the Jawai Bandh region, near Sumerpur, 822.8±0.8 Ma and interpreted youngest age for the Sirohi Group on the ground that the granite body shows features indicating its synkinematic feldspar growth in relation to deformation of the Sirohi rocks. The ca. 820 Ma age appears a little younger than the earlier reported ca.835 Ma age from different granite bodies occurring within or close to the outcrops of the Sirohi Group (Choudhary et al. 1984).

Above observation are supported by following salient features which have been observed detailed mapping:

1. Reverse shear kinematics indicate a top of NW displacement.
2. The contact with the metasediments is concordant and sheared.
3. A pervasive cleavage with steep south easterly dips is also well developed in Phyllite.
4. Two sets of lineations are visible in Phyllite,
5. The orientation of foliation plane and L1 lineations are in general aggrement with the structural elements as recorded in the shear Erinpura granitic gneisses.

Concluding Observations:

The study conclude that the metasediment of the Sirohi Group strike NE-SW parallel to the Aravalli Mountains Belt and form a set-of dismembered outcrops align in a linear belt. The outcrops are separated by each other E-W disjoins (as river traces). These disjoins possibly denote the last tectonic activity in the region.

References:

1. Bose U. Correlation problems of the Proterozoic stratigraphy of Rajasthan. Indian
2. Minerals 43; 3-4; 183-193, 1989.
3. Coulson AL. The gelogy of Sirohi State, Rajputana. Mem Geol Surv, 63; 166, 1933.
4. Choudhary AK, Gopalan K, and Anjaneya Sastry C. Present status of the geochemistry of the Precambrian rocks of Rajasthan; Tectonophysics 105; 131-140, 1984.
5. Darwin C. Geological observation in South America. Smith-Edler, 1846.
6. Fareeduddin, and Kröner A. Single zircon age constraints on the evolution of Rajasthan Granulite, in Paliwal, B.S., ed., The Indian Precambrian: Jodpur, Scientific Publishers (India), 547–556, 1998.
7. Ghosh SK. Structural geology, Fundamental and Modern Developments. Pergamon Press Oxford, 591, 1993.
8. Gupta SN, Arora YK, Mathur RK, Iqbuluddin, Prasad B, Sahai TN, and Sharma SB. Lithostratigraphic map of Aravalli region, southern Rajasthan and northern Gujarat; Geol Surv Ind. 1980.
9. Gupta SN, Arora YK, Mathur RK, Iqbuluddin, Prasad B, Sahai TN, and Sharma SB. Lithostratigraphic map of Aravalli region, southern Rajasthan and northern Gujrat. Geol Surv Ind Calcutta. 1980.
10. Naha K. Mukhopadhyay DK, Mohanty R, Mitra SK, and Biswal TK. Significance of contrast in the early stages of structural of the Delhi and the pre- Delhi rock groups in the Proterozoics of Rajasthan, western India. Tectonophysics 105; 195-206, 1984.
11. Roy AB, and Das AR. A study of the relation movements, metamorpohism and granite emplacement in the middle-Proterozoic Delhi Supergroup of Rajastahn. Jour Geol Soc India, 26; 726-733, 1985.
12. Roy AB, and Sharma KK. Geology of the region around Sirohi Town, Western Rajasthan-Story of Neoproterozoic Evolution of the trans Aravalli crust.: in Prof. B.S. Paliwal (Ed),Geological Evolution of western Rajasthan, Scientific Publishers (India) Jodhpur 1999, 19-33, (1999).
13. Roy AB, and Jakhar SR. Geology of Rajasthan (Northwest India) Precambrian to recent; Scientific Publishers (India) Box 91 Jodhpur 421, 2002.
14. Sedgwick A. Remarks on the structure of large mineral masses and specially on the chemical changes produced in aggreegation of stratified rocks during different periodsafter their deposition. Geol Soc London Trans Serv, 2(3); 461-484, 1935.
15. Sharma Kamal K. Geological Setting of the Balda (Sirohi) Tungsten Deposit, Rajasthan. Journal of Applied Geochemistry, 6(2); 213-220, (2004a).
16. Sharma Kamal K. K-T magmatism and basin tectonism of western Rajasthan, India: results from extensional tectonics and not from Reunion plume activity. In Foulger, G.R., and Jurdy, D.M., eds., Plates, plumes, and planetary processes: Geological Society of America Special Paper 430, 775–784, doi: 10.1130/2007.2430(35), (2007).
17. Sharma Kamal K. Tungsten metallogeny of the Sirohi Group, Rajasthan. In: Economic Mineralisation. Ed. K.L. Shrivastva. Scientific Publishers (India) Jodhpur. 155-165, (2009).
18. Sharma Kamal K. Discussion on-"Bambolai Continental Pillow Lavas (Neoproterozoic) Trans-Aravalli Region, Pali district, Rajasthan and their Tectonic Significances." Jour Geol Soc India, 66(3); 376-379, (2005b).
19. Sharma Kamal K. Discussion on –"Petrology and Geochemistry of the Mount Abu granites, southwestern Rajasthan. Jour Geol Soc India, 69(6); 1372-1375, (2007).
20. Sharma KK. The Neoproterozoic Malani Magmatism, northwestern Indian shield: Not a plume product; www. mantleplumes.org . 2003.
21. Sharma KK. Stratigraphy, structure and tectonic evolution of the metasediments and associated rocks of the Sirohi region, southwestern Rajasthan. Unpublished Ph.D. Thesis ML Sukhadia Univ Udaipur Rajasthan, 103, 1996.
22. Sharma Kamal K. Malani magmatism: An extensional lithospheric tectonic origin, in Plates, Plumes & Paradigms, edited by G.R. Foulger, J.H. Natland, D.C. Presnall and D.L. Anderson, Geological Society of America 388; 463-476, (2005).
23. Tobish OT, and Glover L. Nappe formation in part of southern Applachian. Geol Soc Am Bull, 82; 2209-2230, 1971.