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Geology

GEOLOGY AND SEDIMENTARY STRUCTURES IN LOWER BHANDER SANDSTONES OF BIJOLIYA AREA, RAJASTHAN

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ABSTRACT Bijoliya area comes under Mandalgarh Tehsil of Bhilwara district, Rajasthan. The area mainly comprises sandstone and shale belong to Lower Bhander group (Bundi Hill Sandstone) of Vindhyan Supergroup. There are three major sandstone horizons separated by two major horizons of shale. In sandstone units of Bijoliya area many depositional, soft sediment deformation and weathering & erosional structures have been reported by the authors. These include different types of bedding and laminations, ripple marks, cross bedding, parting lineation, load casts, slump structure, rain print, flute casts, Liesegang rings, pedestal rock etc. The paper gives a description of regional and local geological setting along with the details of the various sedimentary structures present in the area.

KEYWORDS : Lower Bhander Sandstone, Sedimentary Structures, Bijoliya

INTRODUCTION:

Sandstone is one of the most common types of sedimentary rock and found in sedimentary basins throughout the world. Rajasthan has huge sandstone deposits and are mainly confined to Vindhyan Supergroup and Marwar Supergroup of rocks, exposed over an area of about 34000 sq. kms. Bijoliya area comes under Mandalgarh Tehsil of Bhilwara district, Rajasthan and falls under the Survey of India Toposheet No. 45-O/8. The area is 90 kms from Chittorgarh on Chittorgarh – Kota National Highway. Bijoliya area is the second largest sandstone producing area in the state. Figure 1 shows the location of study area.

Figure 1: Location map of the study area

GEOLOGICAL SETUP:

Geologically most of the sandstone deposits belong to the Vindhyan and the Marwar Supergroups of the Late-Proterozoic to Early Cambrian age. The sandstone of Vindhyan Supergroup are mainly exposed in eastern and south-eastern parts of the state, forming a plateau region in parts of Dholpur, Bharatpur, Karauli, Sawai Madhopur, Bundi, Kota, Jharawar, Baran, Bhilwara and Chittorgarh districts. Whereas the sandstones of Marwar Supergroup are scattered in north and western part of the state, covering the districts of Jodhpur, Nagaur, Churu and Bikaner. Minor deposits of younger sandstones are also exposed in Jaisalmer and Barmer districts (DMG, 2009).

In Rajasthan the Vindhyan sediments overlie the metamorphites of the Bhilwara Supergroup and the Berach Granite and comprise an alternating sequence of sandstone, shale and limestone having a total thickness of about 3,200 m. They are divisible into two broad subdivisions, namely, the Lower and the Upper Vindhyans. The Lower Vindhyans are predominantly calc-argillaceous while the Upper Vindhyans are mainly arenaceous. The Vindhyan Sedimentation in Rajasthan took place in two different sub-basins, the Chittorgarh-Jhalawar sub-basin in the southwest and the Sapotra-Karauli sub-basin in the northeast. The two sub-basins which later came under one cover of the sediments were separated by a median upland near Bundi. Prasad (1984) gave a comprehensive geology of Vindhyan sediments in Rajasthan (Table 1.1).

Table 1.2: Stratigraphy of Vindhyan Sediments in Rajasthan

		Chittorgarh-	Jhalawar	Sapotra-Karauli Sub-basin	
		Sub-basin			
	Bhander Group	--		Dholpur Shale	
		--		Maihar	Sandstone/Upper
				Bhandar Sanstone	
		Sirbu Shale		Sirbu Shale	
		Bundi Hill Sandstone		Upper Bhandar Sandstone	
		Samria Shale		Samria Shale	
Upper		Lakheri Lst		--	
Vindhyan		Ganurgar Shale		Ganurgar Shale	
	Rewa Group	Taragarh Fort Sandstone		Upper Rewa Shale	
		Jhiri Shale		Jhiri Shales	
		Indragarh Sandstone		Lower Rewa Shale	
		Panna Shale		Panna Shale	
	Kaimur Group	Chittorgarh Fort Sandstone		--	
	Khorip Group	Suket Shale			
		Nimbaheda Limestone			
		Bari Shale			
		Jiran Sandstone			
Lower		Malan Conglomerate			

	Lasrawan	Binota Shale			
Vindhyan	Group	Kalmia Sandstone			
	Sand Group	Palri Shale		Tirohan breccias	
		Sawa Sandstone			
	Satola Group	Bhagwan Pura Limestone		Tirohan Limestone	
		Khardeola Sandstone		Basal conglomerate and	
		Khairmali a Flows		sandstone	

------------------------------Unconformity--------------------------------

Pre-Aravalli Metamorphites.

The study area mainly comprises sandstone and shale belong to Lower Bhander group (Bundi Hill Sandstone) of Vindhyan Supergroup . According to Prasad (1981, 1984) there are different sandstone horizons which are separated by shale horizons. Figure 2 gives the regional geological setting around Bijoliya.

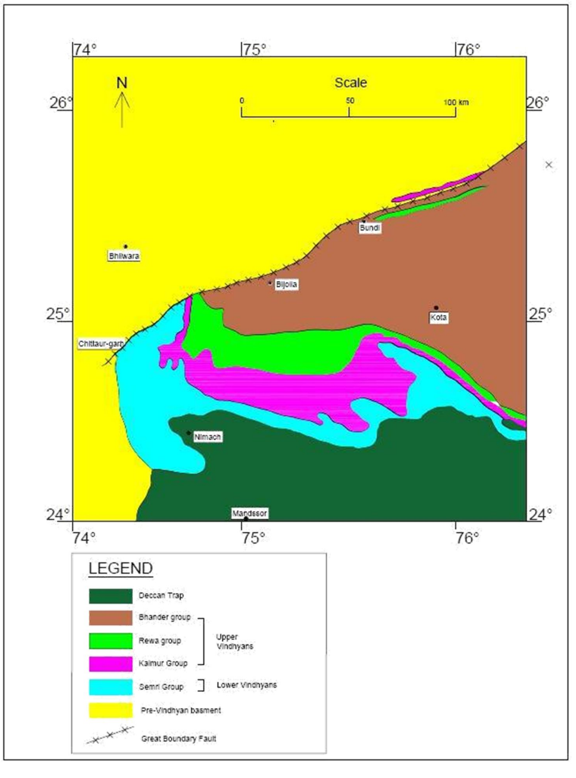


Figure 2 : Regional geological map around Bijoliya (After Prasad, 1984)

In Bijoliya area there are three major sandstone horizons separated by two major horizons of shale (Photographs 1 and 2). Lower Sandstone horizon in the southern area has fewer exposures and is of 10-20 mts in thickness. It is grey, pinkish to reddish brown in colour and fine to medium grained texturally. The Lower shale is generally thinly bedded pale greenish in colour with filthy inter beds .The middle sandstone is 30-40 mts in thickness. It is well bedded and jointed in nature. The sandstone is light green to brownish in colourand is fine to medium grained which yield splitable sandstone at places. The shale of upper region is generally bedded, grey black and brown in colour, compact, well jointed with silty interbeds. Upper sandstone is generally white, fine to medium grained, massive, well jointed, quartzitic in nature, and is exposed in the northern part of the area. The sandstone and shale horizons are more or less horizontal in nature with dip angle ranging from 0 to 6 degree (Photograph 3).

SEDIMENTARY STRUCTURES:

Sedimentary structures are large-scale features of sedimentary rocks that are best studied in the field. They are generated by a variety of sedimentary processes, including fluid flow, sediment gravity flow, soft sediment deformation, and biogenic activity. Because they reflect environmental conditions that prevailed at, or very shortly after, the time of deposition, they are of special interest to geologists as a tool for interpreting ancient depositional environments. Some sedimentary structures can also be used to identify the tops and bottoms of beds, and thus to determine if sedimentary sequences are in depositional stratigraphic order or have been over turned by tectonic forces. These structure are categorized as Depositional structures, Erosion structures, Biogenic structures and Deformation structures (Allen, 1982; Collinson and Thompson, 1989; Conybeare and Crook, 1968; Pettijohn and Potter, 1964; Potter and Pettijohn, 1977 and Reineck and Singh, 1980). In the present study area many sedimentary structures have been observed in the sandstones (Table 2).

Table 2 : Structures reported from the sandstones of Bijoliya area

Depositional Structures	Soft Sediment	Weathering & Erosional
	Deformation Structures	Structures
Bedding & Lamination	Load casts	Flute casts
Ripple Marks	Slump structure	Liesegang rings
Cross Bedding	Rain Print	Pedestal rock
Parting Lineation		Spheroidal weathering
		Exfoliation
		Panhole
		Tafoni

(a) Bedding and Laminations: Bedding is a fundamental characteristic of sedimentary rocks. Beds are sedimentation units and represent the thickness of sediment deposited under essentially constant physical conditions. In the present study area all types of bedding and laminations have been found in the sandstone formation i.e. very thick beds to thin lamina. The individual size ranges from 2.45 meters (Very Thick Bedding) to 2 mm (Thin Lamina). Photographs 4 and 5 show the types of bedding and laminations reported from the study area.

(b) Ripple Marks : Ripple marks are one of the commonest features of sedimentary rocks, both in recent and ancient sediments. Ripples are most common in shallow-water environments. They are produced as a result of the interaction of waves or currents on sediment surface. The shape and size of ripples vary considerably. Ripple marks occur in two forms, symmetric, or wave (oscillating water) formed ripples and asymmetric or current (unidirectional) ripples. In the present study area the sandstone beds often have the ripple marks which are having asymmetrical profile and of variable size and length (Photograph 6).

(c) Cross-Bedding : It is a feature that occurs at various scales, and is observed in sandstones. It reflects the transport of sand by currents that flow over the sediment surface (e.g. in a river channel). The inclination of the cross-beds indicates the transport direction and the current flow. The style and size of cross bedding can be used to estimate current velocity, and orientation of cross-beds allows determination direction of paleo-flow. In the present study area at many places the cross bedding has been observed within the sandstone beds (Photograph 7).

(d) Parting lineation : The Parting lineation (also known as current lineation or primary current lineation) is a subtle sedimentary structure in which sand grains are aligned in parallel lines or grooves on the surface of a body of sandstone. The orientation of the lineation is used as a paleocurrent indicator, although the precise flow direction. Parting lineation forms in the turbulent, viscous boundary layer immediately above the sediment-water interface. They are also the primary indicator of the lower part of the upper flow regime bedform. Parting lineation forms in very different depositional environments. The structure is most commonly found on the beach where it forms in flat, wet sediments due to swash. Parting lineation can also be created in dewatering tidal channels. (Allen, 1964, 1970; Boggs, 2006). In the present study area the parting lineation within the sandstone is a very commonly occur sedimentary structure (Photograph 8).

(e) Flute Casts : Flute casts are scoop-shaped structures on the soles (undersides) of beds. They are features representing sediments that filled depressions on the immediately subjacent bedding plane. Flute casts form by erosive scour. The most common geologic phenomena that produce flute casts are turbidity currents (underwater sediment slides). In Bijoliya area the grey sandstone at places have flute cast structure (Photograph 9).

(f) Load Casts : Load casts are bulges, lumps, and lobes that can form on the bedding planes that separate the layers of sedimentary rocks. These features form during soft-sediment deformation shortly after sediment burial, before the sediments lithify. They can be created when a denser layer of sediment is deposited on top of less-dense sediment. The structures are formed in response to gravitational instability. Load casts appear in very different depositional environments. They are most common in turbidites, but can also occur in fluvial and shallow-marine settings (Allen, 1985; Reineck & Singh, 1980; Moretti, et. al, 1999). In the present area at number of places the load cast structures have been reported. These structures range in size from 4 to 30 cm (Photograph 10)

(g) Slump structures : They are soft-sediment deformation structures. They are mainly found in sandy shales and mudstones, but may also be in limestones, sandstones, and evaporites. They are a result of the displacement and movement of unconsolidated sediments, and are found in areas with steep slopes and fast sedimentation rates. The structures are formed in sediments under the influence of gravity (Moretti, 2000). In the present study area this deformation structure occurs within the thin layers of sandstone and shale and is common in the study area (Photograph 11).

(h) Raindrop impressions : These are geological features characterized by small craterlike pits with slightly raised edges that are the result of the impact of rain on soft sediment surfaces. Raindrop impressions are only a few millimeters thick and less than 1 centimeter in diameter (Boggs, 2006). In the present study area at places raindrop impressions are visible within the layers of sandstone (Photograph 12).

(i) Liesegang rings or Liesegang bands : These are colored bands of cement observed in sedimentary rocks that typically cut-across bedding (Jackson, 1997; Stow, 2009). These are secondary (diagenetic) sedimentary structures and distinguishable from other sedimentary structures by their concentric or ring-like appearance. Liesegang rings can have the appearance of fine lamination and can be mistaken for laminae when parallel or sub-parallel to the bedding plane, and are more easily differentiated from laminae when the rings are observed cutting across beds or lamination. (Middleton et. al., 2003). Liesegang rings may form from the chemical segregation of iron oxides and other minerals during weathering (Krug et. al., 1996). In the present area near Power House in Bijoliya town the exposures of sandstones have well preserved Liesegang structures. Both ring type and band type appearances are visible within the sandstones (Photographs 13)

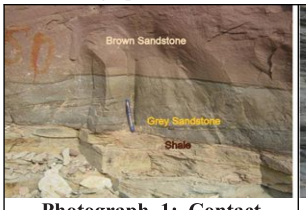
(j) Pedestal Rocks: Pedestal rock is also called as mushroom rock and is deformed in a number of different ways: by erosion and weathering, usually found in desert areas. These rocks form over thousands of years when wind erosion of an isolated rocky outcrop progresses at a different rate at its bottom to that at its top. Abrasion by wind-borne grains of sand is most prevalent within the first 3 ft of the ground, causing the bases of outcrops to erode more rapidly than their tops. Wind carrying fine sand particles act as abrasive and start cutting and polishing the isolated rock exposure. In the present area about 2 kms from Bijoliya town on Bundi Road (25 10' 26" N : 75 20' 55" E) the exposures of pedestal rocks of various shapes and size are well preserved on a small hillock(Photographs 14).

(k) Spheroidal weathering : It is the result of chemical weathering of systematically jointed, massive rocks, including granite, dolerite, basalt and sedimentary rocks such as silicified sandstone. It occurs as the result of the chemical alteration of such rocks along intersecting joints. The differences in weathering rates between the corners, edges, and faces of a bedrock block will result in the formation of spheroidal layers (Fairbridge, 1968; Ollier, 1971). In the present area near power house in Bijoliya town and also on Bijoliya – Bundi road the exposures of spheroidal sandstone of various shapes and size are well preserved (Photographs 15).

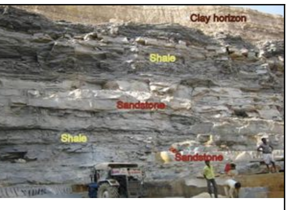
(l) Exfoliation Weathering : It is a type of physical weathering in which the outer layers of a rock surface skin off in flakes and shells. It is caused by the rapid expansion and contraction of the rock surface when subjected to extreme changes of temperature. Exfoliation occurs particularly in hot dry desert climates and on sheets of rock that are jointed parallel to the surface. In the present area 2 kms from the Bijoliya town on Bijoliya – Bundi road the exposures of sandstones showing exfoliation weathering are well preserved (Photographs 16).

(m) Panhole : A panhole is a depressed, erosional feature found on flat or gently sloping rock. Panholes are the result of long-term weathering and are generally seen on bedrock or very large blocks of rock. They are also called as weathering pits or solution pits. They are formed as a result of chemical changes in the rock by water action. In the present area 2 kms from the Bijoliya town on Bijoliya – Bundi road and also near Mandakini Temples the exposures of sandstones showing various size and shapes are exposed. The depth of pan holes are also varies from 4 cm to 24 cm (Photographs 17).

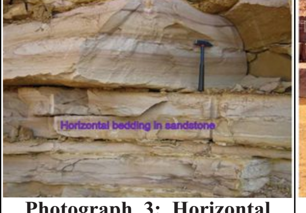
(n) Tafoni : Tafoni are small cave-like features found in granular rock such as sandstone, granite, and sandy-limestone with rounded entrances and smooth concave walls, often connected, adjacent, and/or networked. Change in climatic conditions both high temperatures and prevailing winds have had the largest impacts on the development of Tafoni caves. In Bijoliya area at many places the tafoni structure is found within the massive sandstone (Photographs 18).



Photograph 1: Contact between shale, grey sandstone and brown sandstone

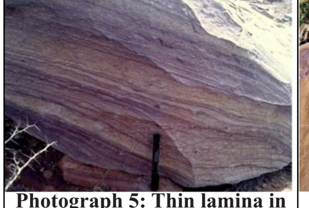


Photograph 2: Intercalated layers of sandstone and shale



Photograph 3: Horizontal nature of sandstone beds

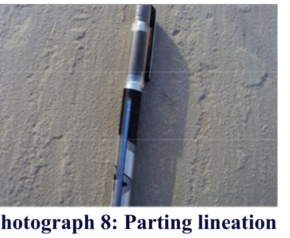
Photograph 4:Very thick bedded sandstone in Bijoliya mine



Photograph 5: Thin lamina in sandstone of Bijoliya area

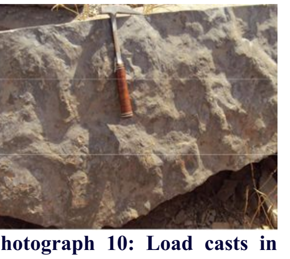
Photograph 6: Asymmetrical Ripples in Bijoliya Sandstone

Photograph 7 : Cross bedding in sandstone



Photograph 8: Parting lineation in sandstone

Photograph 9: Flute structure in grey



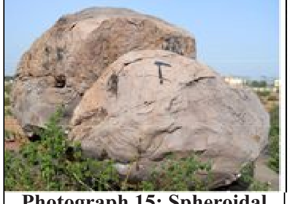
Photograph 10: Load casts in sandstone sandstone

Photograph 11: Slump structure in the area

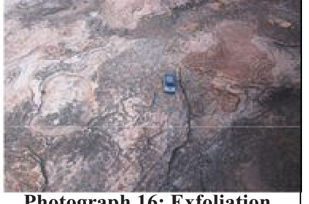
Photograph 12 : Raindrop structure in the area

Photograph 13: Liesegang rings in sandstone of Bijoliya area.

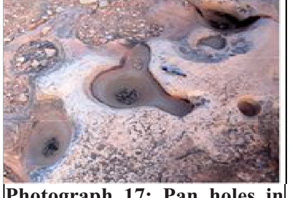
Photograph 14: Pedestal rocks in Bijoliya area



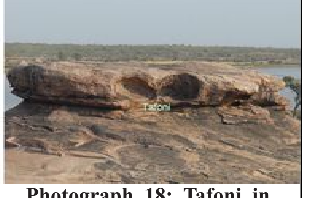
Photograph 15: Spheroidal weathering in sandstone in Bijoliya area



Photograph 16: Exfoliation weathering in the sandstones of the area



Photograph 17: Pan holes in Bijoliya sandstones



Photograph 18: Tafoni in sandstone of Bijoliya area

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