Occurrence of giant nodules in the Jodhpur Sandstone, Sursagar area, Jodhpur, Rajasthan

Nodules are secondary sedimentary structures which are helpful in deciphering the diagenetic history of the rocks in which they occur, especially in calcareous rocks. These are formed by local concentration of chemical compounds in sediments and soils which are formed within the sediments or soils as a result of the rock-forming process[1]. Individual nodules are discrete bodies which differ from the enclosing sediment or soil matrix in hardness, colour, fabric and composition[1]. Nodules are spherical or ellipsoidal in shape; they are referred to as concretions if they acquire irregular shapes. These structures can occur in any sedimentary rock, but are more common in calcareous rocks. The nodules and concretions are formed by a concentration of minerals which may attain various sizes, but are commonly not more than a few tens of centimetres. Generally, they are less than a metre in diameter. Here we report the presence of giant nodules up to more than 6 m in diameter in the Jodhpur Sandstone, Marwar Supergroup, Sursagar area, Jodhpur District, Rajasthan.

The Marwar Supergroup is well exposed in western Rajasthan, which was earlier referred to as the Trans-Aravalli Vindhyans (Figure 1). It unconformably overlies the Malani Rhyolite (ca. 780–681 Ma)[2]. The beds are more or less horizontal. These are unmetamorphosed and undeformed. The Marwar Supergroup is subdivided into three groups, viz. the Jodhpur Group, the Bilara Group (=Hanseran Group) and the Nagaur Group (Table 1)[3]. The Jodhpur Group has been subdivided into the Pokaran Boulder Bed and the Jodhpur Sandstone[4]. The Jodhpur Sandstone consists of fine to coarse-grained sandstone showing abundant development of parallel bedding, large and small cross-bedding, wave and current ripple bedding, wave and current ripples, interference ripples, adhesion ripples, starved ripples, synaeresis cracks and mud cracks. Dominantly, the sandstone is brick red to maroon in the middle part with whitish to pale yellowish bands in the lower and upper parts. Well-developed microbial mats are profusely developed in the Jodhpur Sandstone[5]. The nodule-bearing horizon of the Jodhpur Sandstone has been considered as

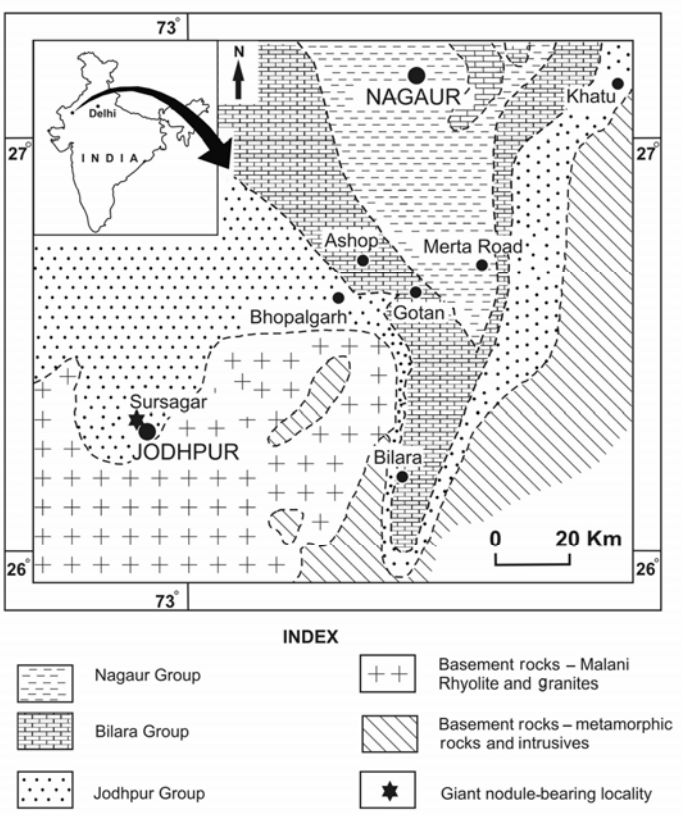

Figure 1. Geological and location map of the Jodhpur area, Rajasthan (after Pareek[3]).

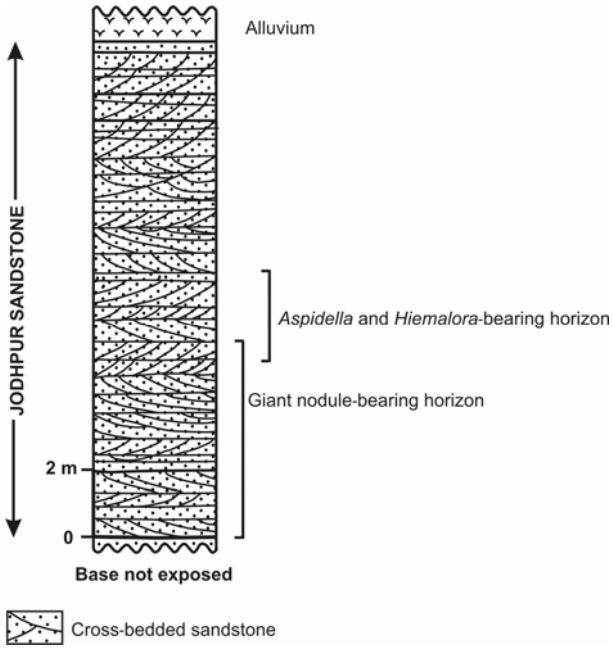

Figure 2. Litholog of giant nodule-bearing horizon, Sursagar mine area, Jodhpur, western Rajasthan. The lithology of the area is represented by fine to coarse-grained cross-bedded sandstone. (Modified after Kumar and Pandey[8].)

Table 1. Stratigraphic succession of the Marwar Supergroup (modified after Pareek[3] and Chauhan *et al*.[4])

Supergroup	Group	Formation
Late Neoproterozoic to Early Cambrian — Marwar Supergroup	Nagaur Group (75–500 m)	Tunklian Sandstone Nagaur Sandstone
	Bilara Group (100–300 m)	Pondlo Dolomite Gotan Limestone Dhanapa Dolomite
	Jodhpur Group (125–240 m)	Jodhpur Sandstone Pokaran Boulder Bed
	Unconformity	
	Basement	Malani Igneous Suite/Aravalli Rock

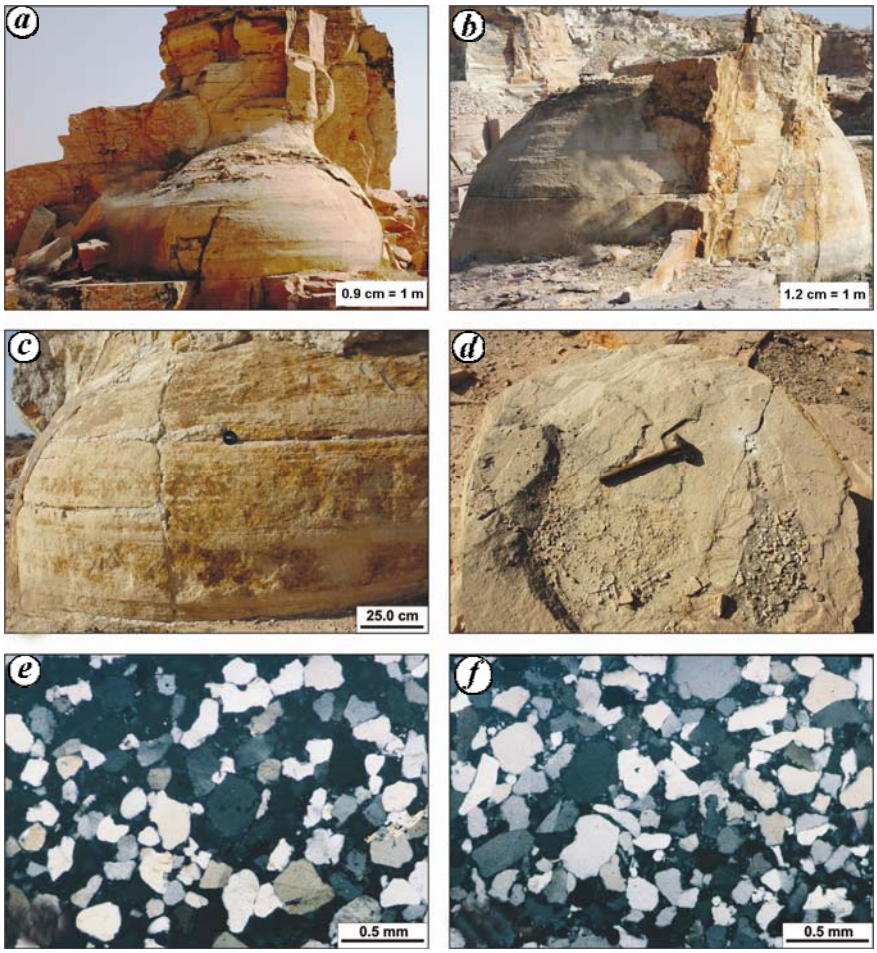

Figure 3. Giant nodules seen in the Jodhpur Sandstone. There is no lithologic difference between the host rock and the lithology of the nodule, except the hardness. ***a***, The host rock is seen both at the base as well as at the back of the nodule, in which the nodule is embedded. ***b***, The host rock is also seen associated with the nodule. ***c***, Outer margin of the giant nodule showing parallel differential markings in the sandstone. ***d***, Transverse section of the giant nodule showing clearly marked circular margin and lack of any internal structure; the entire surface looks homogenous. ***e***, ***f***, Photomicrographs of sandstone forming the nodule and host rock. The sandstones are made up of subangular to subrounded detrital quartz grains cemented together by silica (under crossed nicols). ***e***, Sandstone of the nodule; ***f***, Sandstone of the host rock.

representing the shallowing upward cycles developed under near shore-beach environment within the confines of shoreface–backshore settings.

The Nagaur Sandstone of the Nagaur Group has yielded well-preserved trace fossils, *Rusophycus*, *Cruziana* and *Dimorphichnus* and, hence, is assigned a lower Cambrian age[6,7]. The Jodhpur Sandstone has also yielded body fossils of the Ediacaran affinity and microbial mats[8]. Thus, the available data support an Ediacaran age to the Jodhpur Sandstone.

In the Sursagar area, about 6 km from Jodhpur, Rajasthan, the middle part of the Jodhpur Sandstone is exposed (Figure 2). This horizon has also been referred to as the Sonia Sandstone[3]. The sandstone shows parallel bedding, planar and trough cross-bedding, wave and current ripple marks, deformational bedding, microbial mats and bedding with low angle discordances.

In the Sursagar mines (GPS value 26°19.70′N; 73°0.12′E) a number of giant nodules of sandstone are seen within the sandstone beds (Figures 2 and 3 *a*–*d*). About 10–20 m thick succession of the middle part of the Jodhpur Sandstone is exposed in the Sursagar mines and the nodules are developed in the lower 10 m, almost at the base level of the mines. It appears that the nodules are restricted at a specific stratigraphic horizon. The nodules are spherical, with diameter ranging from 2.0 to 6.0 m. The nodules are spherical to slightly distorted. At one place two nodules are seen merging with each other. The outer surface is smooth with horizontal parallel markings (Figure 3 *c*). Any internal structure, including

concentric banding is completely lacking as the cross-section of the nodules is homogenous (Figure 3 *d*). No colour marking or mineralogical differences are noticed. In comparison to the host rock, the nodules do not show any marked colour difference and nodules are formed simply due to relative hardness. The nodules are light reddish-brown to light whitish-brown in colour, and so is the host rock. The sandstones of both nodules and the host rock have been identified as quartz arenite, with silica as the cementing material. The grain size varies from 0.10 to 0.60 mm with a mean of 0.22 mm for the nodule, and from 0.08 to 0.50 mm with a mean of 0.17 mm for host rock. There is no marked petrographic difference between the sandstone of the nodules and the host rock (Figure 3 *e* and *f*). It appears that the silica cement plays an important role in the formation of the nodules and higher concentration of silica is responsible for the formation of the nodules.

1. Yaalon, D. H., In *Encyclopedia of Sedimentogy* (eds Farbridge and Bourgois, J. D.), Hutchinson and Ross, Inc., Pennsylvania, 1978, p. 503.
2. Rathore, S. S., Venkatesan, T. R. and Srivastava, R. C., *Gondwana Res.*, 1999, **2**(2), 271–281.
3. Pareek. H. S., *Mem. Geol. Surv. India*, 1984, **115**, 1–95.
4. Chauhan, D. S., Ram, B. and Ram, N., *J. Geol. Soc. India*, 2004, **64**, 255–276.
5. Sarkar, S., Bose, P. K., Samanta, P., Sengupta, P. and Eriksson, G., *Precambrian Res.*, 2008, **162**, 248–263.
6. Kumar, S. and Pandey, S. K., *Curr. Sci.*, 2008, **94**, 1081–1085.
7. Kumar, S. and Pandey, S. K., *J. Asian Earth Sci.*, 2010, **38**, 77–85.
8. Kumar, S. and Pandey, S. K., *J. Palaeontol. Soc. India*, 2009, **54**(2), 171–178.

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