

**Figure 1 a-c.** Photomicrographs of infected red blood corpuscles with growing trophozoites of *P. ovale* as seen in thin smear under oil immersion lens ( $\times 1000$ ).

The study village situated at the foot of forested Naga Hills on Assam–Nagaland border is highly endemic for malaria. The patient with *P. ovale* infection was a daily wage earner, who never moved out

of district Jorhat during his life time. However, he occasionally visited the adjoining Naga hills for collection of fire wood, jhoom cultivation, log cutting, etc. Since our 1½ years of investigation we detected only one case of *P. ovale*, the chances of indigenous transmission of *P. ovale* in the study village seemed remote and the patient most likely contracted this infection in Nagaland during one of his visits to the Naga hills. The chances of *P. ovale* transmission in Myanmar bordering Nagaland state are relatively higher since wide distribution of *P. ovale* is on record from Myanmar<sup>6</sup>. However, this assumption needs confirmation.

*P. ovale*, frequently confounded with *P. vivax*, causes mild malaria and is hardly fatal<sup>7</sup>. Due to its rarity, *P. ovale* infection, at present, does not pose a public health problem in India. However, if remained undiagnosed or underdiagnosed due to it being confounded with *P. vivax*, this may spread to more foci causing malaria morbidity problem in future. The present finding of *P. ovale* and a recent case report of *P. malariae* from Kamrup district of Assam<sup>8</sup> indicate that, besides *P. falciparum* and *P. vivax*, these two species of human malaria parasite are also present, though very few in number, in the northeastern region of India. Proper population-based surveys using molecular tools, particularly in international border areas, could throw light on the magnitude of prevalence of these relatively rare parasite species in this region.

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## Fossilized elephant bones in the Quaternary gypsum deposits at Bhadawasi, Nagaur district, Rajasthan

We report here fossilized remains of an elephant discovered in a gypsum bed during its mining at Bhadawasi village in Nagaur district of western Rajasthan. The skeletal remains were embedded within the Quaternary gypsum below a sand cover of about 2.6 m. Fossil remains collected include: a part of femur, proximal head of femur, a piece of tibia, a large

fragment of scapula, one of the vertebrae – probably a lumbar and many pieces of broken ribs. These findings suggest forested conditions along a river (? Vedic Sarasvati) at the time. Presently the region is occupied by the Thar Desert.

Fossilized bones of a large mammal were discovered recently in the gypsum bed of the Quaternary age at Bhadawasi

village (27°14' : 73°40') located about 20 km from Nagaur town on the Nagaur–Bikaner road (Figure 1) during the mining of gypsum. The gypsum mine (Figure 2) in which the remains were found is about 2–3 m deep and is located in the land of Adu Ram, a local farmer. This is the first report of the presence of fossil remains of a large mammal in the

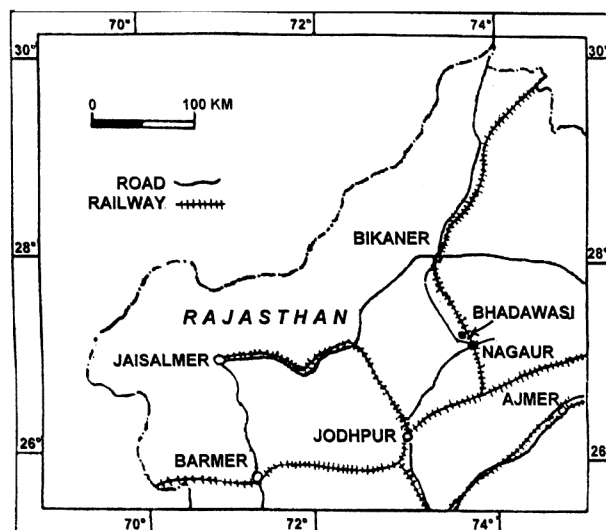


Figure 1. Location map of the study area.



Figure 2. Geological succession of the mining site at Bhadawasi. Arrow indicates the exact location of the fossils.

Table 1. Lithological succession of the site

85 cm	Fine-grained loose yellowish brown aeolian sand.
115 cm	Semi-consolidated fine grained light yellow and greyish brown sand.
60 cm	Fine grained yellowish brown sand mixed with $\text{CaCO}_3$ concretions.
165 cm	Petrogypside layer with fossils of the elephant.
??????	*Fine-grained yellowish brown silty sand.

Quaternary sediments of the great Thar Desert of western Rajasthan.

A lithological succession showing different Quaternary units has been prepared to show the precise stratigraphic position of the fossil-bearing horizon of the quarry site, from where the fossil remains have been discovered (Table 1). The gypsum layer is overlain by a 2.6 m thick cover of fine-to-medium grained sand known as very deep 'Bher'<sup>1</sup> with typical sandy texture (Figure 2). The top 85 cm thick cover of fine grained yellowish brown aeolian sand is followed by about 115 cm thick layer of semi-consolidated fine grained light yellow to light greyish brown sand. Below this is a 60 cm thick imper-sistent layer of fine grained yellowish brown sand mixed with  $\text{CaCO}_3$  concretions. Underlying about 165 cm thick layer of gypsum in which the fossil bones were embedded, is petrogypside<sup>1</sup> in nature with light grey (10 YR 7/, 7/2) colour. Below the gypsum layer there occurs fine-grained yellowish brown silty sand. There are indications of the presence of more fossil remains *in situ* in the same gypsum horizon (Figure 3) waiting to be unearthed.

The fossil bones recovered from the gypsum bed show 90% alteration and give strong effervescence on acid treatment. There was very little quantity of acid insoluble found in the fossil samples.  $\text{CaCO}_3$  content in the enclosing gypsum layer is found to be about 11.80% whereas  $\text{CaCO}_3$  in the gypsum crystals developed within the bones is about 16.46%. Average  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$  content in the enclosing gypsum layer at the site is of the order of 20–25%, whereas in the gypsum crystals within the bones it is about 50–60%.

Because of the impervious nature of the enclosing gypsum layer, the gypsified bones were protected from complete decomposition by the ground water. Gypsum has not only deposited on the bones but has also crystallized within the inner part of the bones (Figure 4 a). Beautiful crystals of gypsum appear at the place of the bone marrow.

The fossil remains embedded in the gypsum bed include: (i) a 61 cm long part of the femur (Figure 4 a), indicating that the total length of the femur may possibly be more than double of it; (ii) the proximal head of the femur (Figure 4 b) measuring about 20 cm in diameter; (iii) a 37 cm long part of the tibia; (iv) one of the bones of the vertebral column, proba-

bly a lumbar with small spines and a large body; (v) a piece of scapula; (vi) a small portion of trachea with well-defined tracheal rings, and (vii) a large number of pieces of broken ribs. Lack of awareness in the mine workers has caused some damage in the fossil remains during



**Figure 3.** Lower part of the geological section of the mining site, indicating the location of fossil remains in gypsum bed. Some more remains are peeping out.

their removal from the gypsum bed, which otherwise could have been in a better condition.

The front view of the femur (Figure 4 c) shows well-defined patellar groove and a robust shaft. Whereas, the posterior view (Figure 4 d) shows two well-developed condyles, separated by the inter-condylar groove. The upper portion of the 37 cm long piece of tibia is about 15 cm broad and the lower portion is more than 21 cm broad. Front view of the tibia is somewhat flat compared to the posterior view, which is distinctly convex in appearance. The head of the femur shows a distinct impression of articulating muscle attached on it.

The large bones embedded in the gypsum bed with the characteristic shape, discovered at Bhadawasi appear to be of a large mammal, possibly an elephant, i.e. *Elephas maximus*<sup>2</sup> (Asian elephant) or its ancestor *Stegolophodon*.

From the ecological point of view, the presence of elephant remains in the gypsum bed may appear quite intriguing. This is because the gypsum layer represents the arid climatic conditions and desiccation of lakes along the major palaeo-channels as basin fills<sup>3</sup>, possibly in the depressions associated with disorganization and segmentation of an ancient river system (? Vedic Sarasvati) during Neotectonic activity in this part that gave rise to the formation of the

saline lakes<sup>4,5</sup>. On the other hand, the preferred eco-system of the elephant is humid tropical climate with thick forested environments, which is rather different to the Thar Desert of today where the fossils were found. The pachyderm must have got trapped in a playa in search of water and died, whose remains have been discovered now.

No precise information about the age of the gypsum layer containing the fossilized elephant bones is available. Studies made in the Bikaner–Nagaur belt<sup>6–9</sup> show the presence of two thick horizons of the gypsum in the Quaternary succession<sup>10</sup>. On the basis of analysis of the fossil pollen grains, an upper Holocene age for the younger gypsum zone and the late Pleistocene age for the lower gypsum horizon have been suggested<sup>11</sup>. It cannot be stated with certainty if the gypsum-bearing horizon of Bhadawasi (Nagaur) represents the older or younger horizon. Nevertheless, on the basis of correlation of lithologs of the present area with that of the Kawas<sup>12</sup> near Barmer, it may be suggested that the Nagaur fossiliferous horizon post-dated the 22 ka LGM episode. We may thus presume a possible late Pleistocene age of the elephant fossil-bearing gypsum horizon of Nagaur. However, a middle or early Holocene age for the elephant remains cannot also be ruled out completely as there are evidences in support of arid conditions in the region



**Figure 4.** Fossilized bones of the elephant. **a**, Side view of the femur showing formation of gypsum crystals in side the bone; **b**, Proximal head of the femur; **c**, The front view of the femur showing robust shaft and a well-defined patellar groove; **d**, The back view of the femur showing well-developed condyles and the inter-condylar groove.

about 4800  $^{14}\text{C}$  yr BP<sup>9</sup> and > 10,000  $^{14}\text{C}$  yr BP<sup>11</sup>. We expect that exact date of the fossils and the enclosing sediments will be determined in the near future.

The present discovery is significant from the point of view of understanding the environmental conditions and the rapid climatic changes that the Thar Desert has witnessed and how a green fertile land along the mighty river system (? Vedic Sarasvati) got desertified. Detailed palaeontological work and dating of the lithological succession of the site are in progress in collaboration with other research organizations of the country.

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