

## Dinosaurian geo-heritage site at Balasinor, Gujarat, India: recognition, sustainability and mass awareness

Subrata Das Sharma

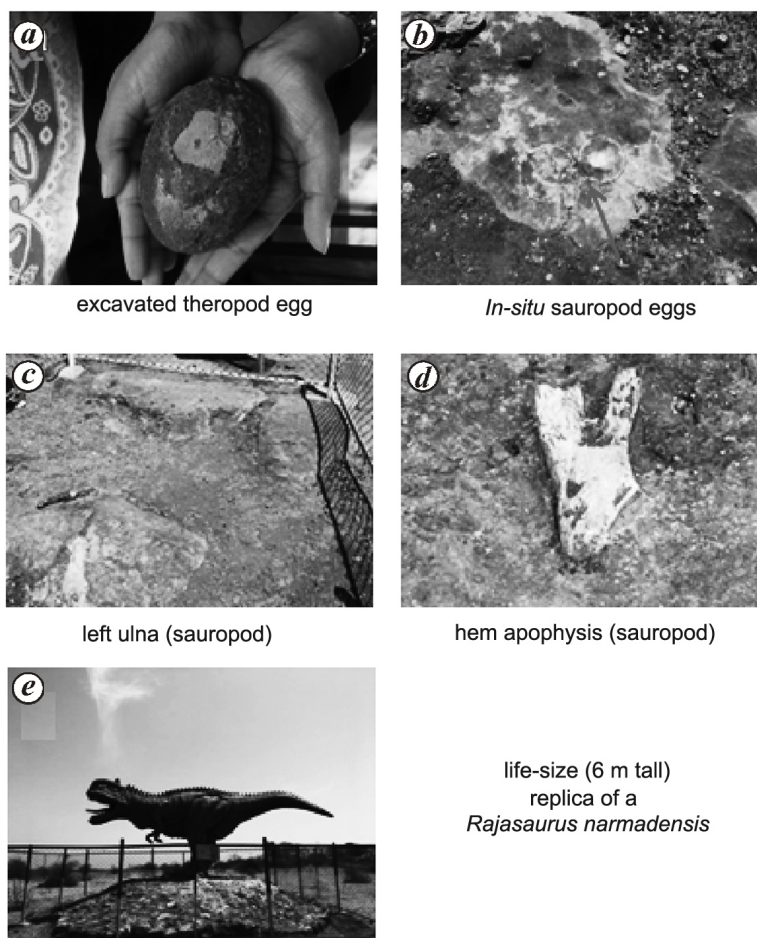
Balasinor (22.95°N, 73.33°E), Gujarat, India was a princely state belonging to the Babi dynasty. Since 1980s, the place has been attracting a large number of geoscientists for its rich record of dinosaurian fossil eggs, nesting grounds, teeth and bone fossils within the Late Cretaceous (Maastrichtian) Lameta Formation. Although the area is fenced and maintained by the State Forest Department of Gujarat as a Dinosaur Fossil Park, the best preservation, protection and maintenance practices are grossly lacking.

In a recent trip to Balasinor, Gujarat, India, I had an opportunity to visit the Dinosaur Fossil Park situated about 12 km north near Raiyoli village (also referred as Rahioli<sup>1,2</sup>). As a geophysicist having little knowledge on the subject, it was an eye-opener for me. The vast fossil resources that can help reconstruct and understand the evolution, birth and demise of dinosaurs are a real treat to the eyes. The unique feature of this site is that it represents both hatchery and graveyard. The global importance of this site is underscored by several key discoveries<sup>2-5</sup>, which dictate that proper recognition, preservation and protection are vital. Recommendations are made here towards that direction.

Dinosaur fossils near Raiyoli village were noticed in 1981–82 during geological field mapping<sup>6,7</sup>. Two geologists from the Geological Survey of India (GSI), Ahmedabad discovered rounded, ball-like structures (Figure 1 *a* and *b*) on the quarry face of limestone bed. They suspected that these structures might be dinosaur eggs. To test this they made thin sections and compared them with known dinosaur egg shells from North America and Europe, revealing that the ball-like structures were indeed fossilized dinosaur eggs<sup>7</sup>. Interestingly, further studies<sup>8</sup> confirmed that the fossil egg-bearing horizon is underlain by calcareous sandstone containing sauropod<sup>9</sup> and theropod<sup>9</sup> teeth, and a conglomerate horizon yielding an abundance of dinosaur bone fossils (Figure 1 *c* and *d*). Such a rich trove of fossilized bones and eggs occurring within a distance of a few kilometres is extremely rare. Some significant contributions that came to light from this site are: (i) discovery of a new species of dinosaur, *Rajasaurus narmadensis*, having a braincase with unusual protrusion in the form of a head-crest (Figure 1 *e*), which is first of its kind re-

ported only from India<sup>2</sup>; (ii) a fossilized 3.5 m long prehistoric snake (*Sanajeh indicus*) that got fossilized in an exceptional setting wrapped inside a sauropod dinosaur nest, indicating that snakes used to prey on dinosaur hatchlings<sup>3</sup>. Although many more surprises might be forthcoming from this fossil-rich site and a recommendation from the Indian geologists to declare the site as a UNESCO

Geopark is under way<sup>10</sup>, it is surprising that a monograph on National Geological Monuments published by GSI<sup>11</sup> does not include Balasinor. After visiting the site, I realized that a rare national treasure like the Raiyoli Fossil Park needs detailed and rigorous studies. Simultaneously, the site also demands recognition and more protection than just fencing. As dinosaurs used to move freely



**Figure 1.** Exhibits from Dinosaur Fossil Park near Raiyoli village, Balasinor, Gujarat, India (23.0573°N, 73.3419°E).

in the region, there is high probability that the vast unprotected areas surrounding the 72 acres of protected fenced land may bear their precious fossil remains. Unchecked access to these lands poses problems of theft and damage, which has already occurred in Balasinor (Jeffrey A. Wilson, pers. commun.). To meet the criteria of a UNESCO Geopark and to protect the site, some recommendations are proposed below for urgent action.

(i) The monograph National Geological Monuments<sup>11</sup> should be revised to include Balasinor. Besides this, recognition at the international level such as UNESCO demands certain well-defined academic and other criteria to be fulfilled<sup>12</sup>, which should be followed.

(ii) Introduce basic geology at school level so that all children can value the precious resources of the earth.

(iii) Impart general education to the local villagers about scientific and cultural significance of geo-heritage sites.

(iv) As an incentive, a selected few villagers can be hand-picked and imparted advanced training to take up the profession of a guide in order to explain about the exhibits to visitors at the Raiyoli Fossil Park. Such steps ensure job opportunities to villagers, besides making them watch-dogs for the heritage site.

(v) To teach and inspire the visitors, the museum should be stocked with fossils and information (see (ix) below).

(vi) Step (i) should be taken up by GSI with additional support from a few university departments. Steps (ii)–(v) can also be taken up by GSI, as it is the best evaluator to assess the significance of each site. Moreover, GSI is well-equipped with all the necessary infrastructure

facilities and its offices are spread throughout the country.

(vii) Introduce entry fee so that access to the Fossil Park is limited only to genuinely interested visitors.

(viii) The revenue generated from step (vii) can be used judiciously towards improvement, protection and preservation of the site.

(ix) It is satisfying to note that a new Dinosaur Informatics Centre and Museum has been inaugurated at Raiyoli on 8 June 2019, which is the first of its kind in India<sup>13,14</sup>. It is equipped with contemporary facilities like 3D projection, virtual reality presentations, stereoscopic interactive kiosks, besides life-sized dinosaur replicas. To promote the site internationally, the Gujarat government has announced allocation of funds to the tune of Rs 10 crores.

In conclusion, it is stressed that geo-heritage sites in India, their sustainability and need for mass awareness programmes are vital issues that need urgent attention. Concerted efforts are required from relevant departments and institutions so that Indian geo-heritage sites appear in the UNESCO Geopark list, which is yet to happen.

1. Mathur, U. B. and Pant, S. C., *J. Palaeontol. Soc. India*, 1986, **31**, 22–25.
2. Wilson, J. A. *et al.*, *Contrib. Mus. Paleontol. Univ. Mich.*, 2003, **31**, 1–42.
3. Wilson, J. A. *et al.*, *PLoS Biol.*, 2010, **8**(3), e1000322; doi:10.1371/journal.pbio.1000322
4. Chatterjee, S. and Rudra, D. K., *Mem. Queensl. Mus.*, 1996, **39**, 489–532.
5. Novas, F. E. *et al.*, In *New Aspects of Mesozoic Biodiversity* (ed. Bandyopadhyay, S.), Springer-Verlag, Berlin, 2010, pp. 45–62.

6. Dwivedi, G. N. *et al.*, *Curr. Trends Geol.*, 1982, **7**, 79–87.
7. Mohabey, D. M., *Curr. Sci.*, 1983, **52**(24), 1194.
8. Mathur, U. B. and Srivastava, S., *J. Geol. Soc. India*, 1987, **29**, 554–566.
9. The sauropods (lizard feet, predominantly herbivore) had a slender head, long neck, elephant-like body and a long tapering tail. They walked on four sturdy legs. The theropods (beast feet, carnivore) had a large head with strong jaws and sharp teeth. Their small front legs were sharp with curved claws for grabbing prey. They walked on large, strong rear legs.
10. <http://archive.indianexpress.com/news/gujarat-was-home-to-snake-that-ate-dinos/586064/>
11. Anantharamu, T. R. *et al.*, National Geological Monuments, GSI Special Publication No. 61(6), 2001, p. 98.
12. [http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP\\_UGG\\_Statutes\\_Guidelines\\_EN.pdf](http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IGGP_UGG_Statutes_Guidelines_EN.pdf)
13. <https://timesofindia.indiatimes.com/entertainment/events/ahmedabad/gujarat-gets-a-new-dinosaur-informatics-centre-and-museum-in-balasinor/articleshow/69738478.cms>
14. <https://www.asianage.com/india/all-india/090619/indias-first-dinosaur-museum-inaugurated-in-gujarat.html>

ACKNOWLEDGEMENTS. I thank Jeffrey A. Wilson (University of Michigan, USA) for his meticulous review of an earlier version of this manuscript and Rajeev Patnaik (editor) and an anonymous reviewer for an in-depth review.

*Subrata Das Sharma lives at Flat No. 307, Prajay Ashray Apartment, Hyderabad 500 039, India.*  
e-mail: [dassharma@rediffmail.com](mailto:dassharma@rediffmail.com)