

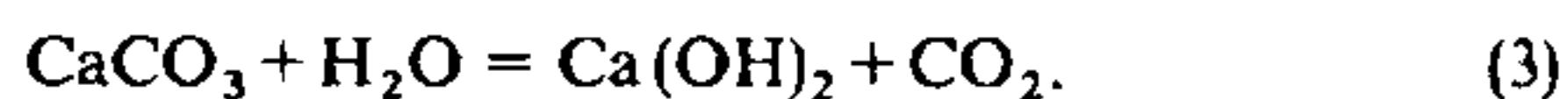
relatively large amounts of humic acid and consumes much or all of the available dissolved oxygen in water that infiltrates.



The area around Vidavaluru–Mudavarthi has all necessary required elements both for generation of  $\text{CO}_2$  and its possible migration downward into the desaturated unconfined aquifer with empty pore space, as a result of sequential droughts in the area. As and when the system is subjected to quick changes in the saturation levels (rise in water levels) as a result of flash rains, the recharged water displaces the gas filled in pore space (without giving much scope for interaction/dilution) and consequently the displaced 'gas' moves into open well structures available in the area.  $\text{CO}_2$  being a heavier gas than  $\text{O}_2$  gets stacked in the lower part of the well and escapes into atmosphere during relatively warmer time periods.

The second possibility is generation of carbon dioxide from calcium-rich shell zone which occurs abundantly in the near-surface aquifer zone around this area. This zone is subjected to aeration and saturation during the periods of droughts and wet periods respectively.

During the periods of drought and high temperatures, this zone could act like a heat chamber underground and when quick recharge takes place due to 'flash rains',  $\text{CO}_2$  could be released as expressed below:



The  $\text{CO}_2$  generated through the above process could be of limited magnitude. More studies however are required to establish the applicability of the process in this area.

The above two processes could work either independently or jointly for production of 'carbon dioxide'. The first process could take place in alluvial sedimentary tracks where intensive cultivation and irrigation practices are in vogue, and where the near-surface aquifer system is subjected to overdraft situations followed by 'flash rains' and 'quick recharge'. In other words, whenever flash rains occur, after long dry spells in an intensely cultivated area, the chances of accumulation of ' $\text{CO}_2$ ' in well structures will be more.

Agriculturists should be advised not to go into the wells particularly in such situations as described above till such time the groundwater system reaches full saturation levels and the generated  $\text{CO}_2$  either escapes into atmosphere or gets dissolved in water. The release of  $\text{CO}_2$  cannot persist for a long time in a season, but can recur again in subsequent years if the conditions laid down above necessary for generation of  $\text{CO}_2$  repeat. The presence of  $\text{CO}_2$  could be tested by lowering a 'candle' or 'lantern' into the well, and in the event of presence of  $\text{CO}_2$  in wells, rigorous pumping

should be carried out so that accumulated gas is flushed and escapes into atmosphere.

1. Reddy, M. K. and Vithal Rao, M., A report on gases and water samples at Vidavalur, Nellore District, AP Tech. Report, NEERI, 1988.
2. Jakucs, The Karstic corrosion of naturally occurring limestones in the geomorphology of our age, Symp. Karst-Morphogenesis Int. Geophys. Union, 1973, pp 52.
3. Trainer, F. O. and Heath, R. C., *J. Hydrol.*, 1976, 31, 37.
4. Zonn, S. V. and Li, Chin Kuei, *Sov Soil. Sci.*, 1960, 12, 1265.
5. Gupta, S. K. and Mehta, K. K., *Blujal News*, Quart. Journal, Central Ground Water Board, 1988, vol. 3.

ACKNOWLEDGEMENTS. I thank Prof. D. Guptasarma, Director, National Geophysical Research Institute, Hyderabad, for his keen interest and support; and Dr Prasanta Mahapatra, District Collector, Nellore, for providing all necessary logistics support in the field.

Received 22 July 1989; revised accepted 4 October 1990

## Fossil cyanobacteria from the stromatolitic phosphorites of Udaipur, Rajasthan, West India

M. S. Sisodia

Department of Geology, University of Jodhpur, Jodhpur 342 001, India

Small spherical bodies identified as fossil cyanobacteria have been found within or in the vicinity of stromatolites in the Precambrian Aravalli phosphorites of Udaipur. These extremely rare fossils are elliptical to circular in section, 20 to 100  $\mu\text{m}$  in diameter, and occur both singly and in massed colonies. They have a nucleus of carbonaceous material surrounded by a zone of very fine radiating needles of francolite or calcite. This outer zone is interpreted as francolite formed by transformation of assimilated phosphorus during early diagenetic alteration of the cells. These cyanobacteria could thus have been instrumental in accumulation of phosphorus in the Aravalli phosphorites.

THE Udaipur phosphorites are strictly confined to stromatolites which have been interpreted as accreting in subtidal, intertidal and supratidal environments<sup>1-4</sup>. They are hosted by the dolomitic limestone unit of the Aravalli Supergroup. This supergroup has been assigned an age of 2000 million years (myr) (Aravalli orogeny)<sup>5</sup>. The petrography and geochemistry of the phosphate-bearing stromatolites of Udaipur have been described by several workers<sup>1-3,6,7</sup>, who are also described some filamentous, cellular microfossils. In the present note we report the presence of cyanobacterial fossils and envisage a vital role for them in phosphogenesis.

Examination of stromatolites under high magnifica-

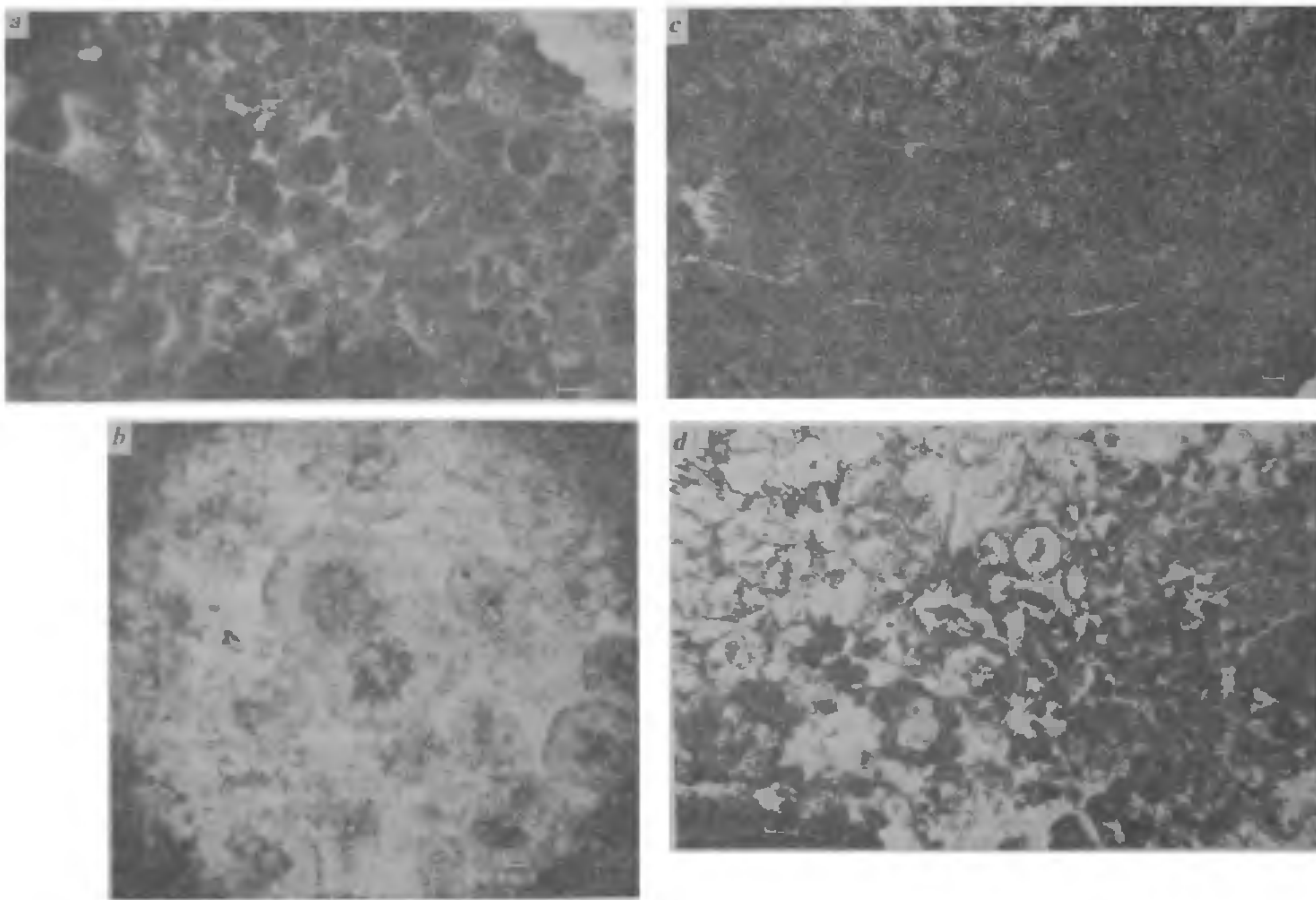


tion shows apatite located in micro-sized rounded bodies that morphologically resemble bacteria. These cellular structures are 20 to 100  $\mu\text{m}$  in diameter, elliptical to circular in section, and occur both singly and in massed colonies (Figure 1, *a, b*). They occur within the stromatolites or in the very close vicinity of the latter. On close observation the entire lamina of the well-preserved, undeformed stromatolites can be seen as constituted of these cells (Figure 1, *c*). They have a nucleus of carbonaceous material surrounded by a zone of very fine radiating needles of francolite or calcite. Most of them are composed entirely of francolite while some show a distinct core of francolite surrounded by a rim of calcite.

The similarity in the shape and size or complete morphology of these cells suggests that they are cyanobacteria of a single species or a morphologically indistinguishable group of species. The preservation of the complete cells suggests that they were free from grazers or competition.

In some cases these cyanobacteria occur as isolated grains in the sparry calcite matrix. The nuclei of some of these cells are seen replaced by sparry calcite while some show their margins highly corroded by sparry calcite such that often only their traces can be observed (Figure 1, *d*). It is very likely that most of these cyanobacteria have been obliterated and replaced by sparry calcite during diagenesis, and probably that is why their preservation is so very rare.

To explain the origin of marine phosphorites, one needs answers to some basic questions: What was the source of phosphorus? Is the phosphate of organic or inorganic origin? It is very well documented now that all the major phosphate deposits of the world are intimately associated with organic-rich sediments and that living organisms play a vital role in phosphogenic processes<sup>8-13</sup>. The origin of the stromatolitic phosphorites of Udaipur has been discussed by several workers<sup>1,2,6,7,14,15</sup>. However, there is ambiguity regarding the precise role played by algal structures in the



**Figure 1.** Cyanobacterial fossil cells showing nucleus of carbonaceous material surrounded by a zone of radiating needles of francolite or calcite: *a*, nicols crossed (scale bar 20  $\mu\text{m}$ ) and *b*, nicols uncrossed (scale bar 10  $\mu\text{m}$ ). *c*, Blurred outlines of cyanobacteria in the lamina of a stromatolite (scale bar 10  $\mu\text{m}$ ). *d*, Ghost fossil cells in a sparry calcite matrix, some cells show corroded nucleus or corroded margins (scale bar 20  $\mu\text{m}$ )



phosphogenesis. Valdiya<sup>16</sup> explained the origin of stromatolitic phosphorite of Pithoragarh and emphasized that the death and degradation of algae supplied phosphorus and caused diagenetic transformation of stromatolite into phosphate.

O'Brien *et al.*<sup>8</sup> ascertained that the nodular phosphorite of the East Australian continental margin shows phosphorus located in bacteria and that the phosphorite was formed by the accumulation of carbonate fluorapatite during post-mortem alteration of phosphorus-rich bacterial cells. Riggs<sup>9</sup> has a similar opinion for the origin of phosphorite of Atlantic coastal plains. On this ground it can be suggested that the stromatolites at Udaipur accreting in subtidal to supratidal settings originally consisted of cyanobacteria. These cyanobacteria enjoyed luxurious growth because of the absence of competitors, predators or grazers, and accumulated normal or perhaps elevated concentration of phosphorus metabolically. The assimilated phosphorus in these cyanobacteria transformed into apatite after active metabolism ceased in the cells, eventually forming a large deposit.

3. Sisodia, M. S., Ph D thesis (unpublished), 1986, p. 124.
4. Sisodia, M. S. and Chauhan, D. S., *Sedimentology*, (submitted).
5. Roy, A. B. (ed.) in *Geol. Soc. India, Mem* 7, 1988, p. 3.
6. Banerjee, D. M., *Geol. Soc. Am. Bull.*, 1971, 82, 2319.
7. Banerjee, D. M., Basu, P. C. and Srivastava, N., *Eco. Géol.*, 1985, 75, 1181.
8. O'Brien, G. W., Harris, J. R., Milnes, A. R. and Reeh, H. H., *Nature*, 1981, 294, 442.
9. Riggs, S. R., *Geol. Soc. Am. Abs. with Progr.*, 1982, 14, 77.
10. Soudry, D. and Champetier, Y., *Sedimentology*, 1983, 30, 411.
11. Lucas, J. and Prevot, L., *Chem. Geol.*, 1984, 42, 101.
12. Prevot, L. and Lucas, J., *J. Sediment Petrol.*, 1986, 56, 153.
13. Cook, P. J. and Shergold, J. H., in *Phosphate Deposits of the World*, (eds. Cook, P. J. and Shergold, J. H.), Cambridge University Press, Cambridge, 1986, vol. 1, p. 369.
14. Southgate, P. N., in *Phosphate Deposits of the World*, (eds. Cook, P. J. and Shergold, J. H.), Cambridge University Press, Cambridge 1986, vol. 1, p. 327.
15. Sisodia, M. S. and Chauhan, D. S., *J. Geol. Soc. London, Spl. Publn.*, 1990, 52, 313.
16. Valdiya, K. S., *Sedimentology*, 1972, 19, 115.

**ACKNOWLEDGEMENTS.** I thank Prof. J. Lucas for his attempts to photograph these cyanobacteria under SEM. He unfortunately could not do so with the supplied samples, probably because of their extremely rare preservation. I also thank Prof. D. S. Chauhan for fruitful discussion and help, and Prof. M. J. Frost for comments and improvements in the initial draft of the paper.

Received 1 September 1990; revised accepted 27 December 1990

1. Chauhan, D. S., *Precambrian Res.*, 1979, 8, 95.
2. Chauhan, D. S. and Sisodia, M. S., *Geol. Sur. India Spl. Publn.*, 1984, 17, 79.

## MEETINGS/SYMPOSIA/SEMINARS

### International Symposium on the Evolution of Deserts

Date: 11-19 February 1991

Place: Ahmedabad, India

Focal themes include:

**Origin and evolution of deserts.** Palaeoenvironment, including palaeometeorology and palaeoanthropology; geology, including role of neotectonics and sea level changes in the evolution of deserts; geomorphology and remote sensing in deserts, hydrology and palaeohydrology, including palaeolakes, palaeodrainage and palaeofloods, soils, evaporites. Intercomparison of palaeoclimatic sequences from various deserts and with marine and continental records.

**Geochronology of deserts.** Luminescence geochronology, radio-carbon dating and accelerator mass spectrometry

**Physics of desertification.** Desert dust and aerosols, aeolian processes in deserts (models and wind tunnel studies) and factors in dune processes

**Man and desertification.** Albedo changes, climatological studies related to sand destabilization, land-use planning, ecological and environmental impacts of large-scale open irrigation systems.

**Aeolian processes** in Earth-like planets, viz. Mars and Venus observations, comparisons, modelling.

Contact: Dr A. K. Singhvi

Convener, Symposium on Deserts

Physical Research Laboratory

Navrangpura

Ahmedabad 380 009, India

Phone: (91) 272-490116 (Res.) 462129 (Off)

Telex: (91) 121-6397 PRL IN

Fax: (91) 272-445292.

### National Symposium on Current Trends in Pteridology

Place: St. Xavier's College, Palayamkottai

Date: 4-6 October 1991.

Topics include morphology, anatomy, palynology and phytochemistry; taxonomy, biosystematics, species relationship and phylogeny, cytogenetics, reproductive biology, experimental studies and biosystematics; flora conservation, relationship of different floras and environmental changes in relation to pteridophytic flora.

Contact: Dr V. S. Manickam

Convener, Symposium on Current Trends in Pteridology

Department of Botany

St Xavier's College, Palayamkottai

Tirunelveli 627 002