Uttar Pradesh Journal of Zoology

Volume 44, Issue 20, Page 120-129, 2023; Article no.UPJOZ.2740
ISSN: 0256-971X (P)

Characterization of Planktonic Foraminifera in the Cretaceous, Phosphatic Nodules from District Tiruchirappalli, Tamil Nadu, India: Implications for the Biological Approach

Ajhar Hussain [a*], Nuzhat Fatima [a], Mohammad Hasan [a] and Mohd Faisal Khan [b]

[a] Department of Geology, Aligarh Muslim University, Aligarh, UP-202002, India.
[b] Department of Botany, Aligarh Muslim University, Aligarh, UP-202002, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.56557/UPJOZ/2023/v44i203653

Editor(s):
(1) Prof. Telat Yanik, Atatürk University, Turkey.
Reviewers:
(1) Elenga Hilaire, Marien Ngouabi University, Republic of Congo.
(2) Muhammad Syamsul Imran Zaini, University Malaysia Pahang, Malaysia.

Original Research Article

Received: 18/06/2023
Accepted: 24/08/2023
Published: 18/09/2023

ABSTRACT

The onshore Cretaceous marine sedimentary sequence of the phosphatic nodules is exposed in the Tiruchirappalli district of Tamil Nadu. The surface of the nodules is yellow to reddish ferruginous with light to dark brown phosphate content having veins. The presence of microbial mats, coated

**Corresponding author: Email: glyazhar@gmail.com;*

grains, and fossils wrap with the association of CFA, calcite, and quartz, associated with phosphatized microbial mats and planktonic foraminifera, are found. The texture/structures appear as algal mats, coated grains and crystal of carbonate fluroapatite in the groundmass. Organic matter in the form of microbial filaments, as revealed by SEM and thin sections studies, indicates the role of micro-organisms involved in the formation of phosphatic nodules from study area. This research contributes significant data on the planktonic foraminifera from Cretaceous phosphatic nodules in Tamil Nadu, India, and demonstrates the potential of a biological approach in deciphering the region's geological history. The findings are pertinent to paleontologists, geologists, and researchers studying Cretaceous marine environments and paleoclimatology, making a valuable addition to the existing body of knowledge in these fields.

Keywords: Planktonic foraminifera; phosphatic nodules; Cretaceous; Tamil Nadu; SEM.

1. INTRODUCTION

Cauvery Basin is one of the most prominent sedimentary basins on the East coast of South India. The basin's Cretaceous deposits are found in discrete outcrops along the western boundary that borders the Archaean basement. The study presents a comprehensive characterization of planktonic foraminifera preserved in Cretaceous phosphatic nodules from District Tiruchirappalli, Tamil Nadu, India. The research aims to investigate the biological implications of these microfossils to elucidate the geological history of the region. The greatest of these outcroppings has had its stratigraphy, megafauna, and microfauna contents thoroughly examined. It is located close to Tiruchirappalli. The majority of phosphorite deposits which are distributed globally were deposited in the cretaceous period through the process of phosphogenesis [1]. Several phosphorites from the Cretaceous contain peloids made of phosphorus. One can argue that peloids are either reworked or authigenic in origin [2,3]. Additionally, the primary mechanism underlying the extensive phosphogenesis that occurred during the Cretaceous has not yet been determined. The phosphatic nodules in the Nambakuruchi are part of the Cauvery basin of South India, which lies in the Uttatur group of the Karai formation and was first reported by Worth [4]. The area has been investigated by previous workers on different aspects as lithostratigraphy, biostratigraphy, palaeoceanography, phosphatic nodules, depositional environment and flora and fauna; Hussain et al. [5], Venkateshwarlu & Nagendra [6], (Rao et al. [7,8], Banerji et.al [9], Sundram and Rao [10], Rama Rao [11], Blanford [12]. Utilizing a multidisciplinary approach, the researchers analyzed a diverse assemblage of planktonic foraminifera species obtained from the phosphatic nodules. The assemblage was meticulously examined using advanced imaging techniques and morphometric analysis to identify to understand geological history to biological conditions related to the origin.

The present research paper deals with planktonic foraminifera based on thin sections and scanning electron microscope (SEM) have been carried out to investigate the size, nature, optical behaviour and texture/structures of phosphate and associated in biota with Planktic foraminifera texture/structures to delineate their organic origin of phosphatic nodules of study area.

2. GEOLOGICAL SETTING

The Nambakuruchi Varagupadi block of Tiruchirappalli district, Tamil Nadu, India, is a part of the Cauvery basin, which lies in the South part of India. The geographic location of Nambakuruchi (Lattitude 11^0 5′ 30″; Longitude 78^0 52′ 15″ and Varagupadi (Lattitude 11^0 8′ 50″, Longitude 78^0 54′ 00″), and phosphatic nodules occur in an area of about 27.52 square km (Fig.1). The Cretaceous succession of the Cauvery basin developed a Precambrian basement overlain by Uttatur, Trichinopolly, Ariyalur and Niniyur groups [13]. The size of the nodules ranges from 5 to 25 cm in length and 2 to 10 cm in width with spherical, elliptical circular, cylindrical shape. The surface of the nodules is yellow to reddish ferruginous with light to dark brown phosphate content (Figs. 2 & 3).

3. MATERIALS AND METHODS

The Phosphatic nodules were collected from the Nambakuruchi block of the Karai Formation, Uttatur Group Tiruchirappalli Tamil Nadu (Fig. 1). The sampling was carried out from different locations with different shapes and sizes. The representative samples were selected for thin sections and SEM image analysis. The first cut the nodules in two halves. One-half was used for

thin section studies to identify texture/structures and mineral constituents. The other half was SEM analysis. The new broken phosphatic nodules were observed under JEOL/EO 6510 JSM Scanning Electron Microscope (SEM) at USIF AMU Aligarh.

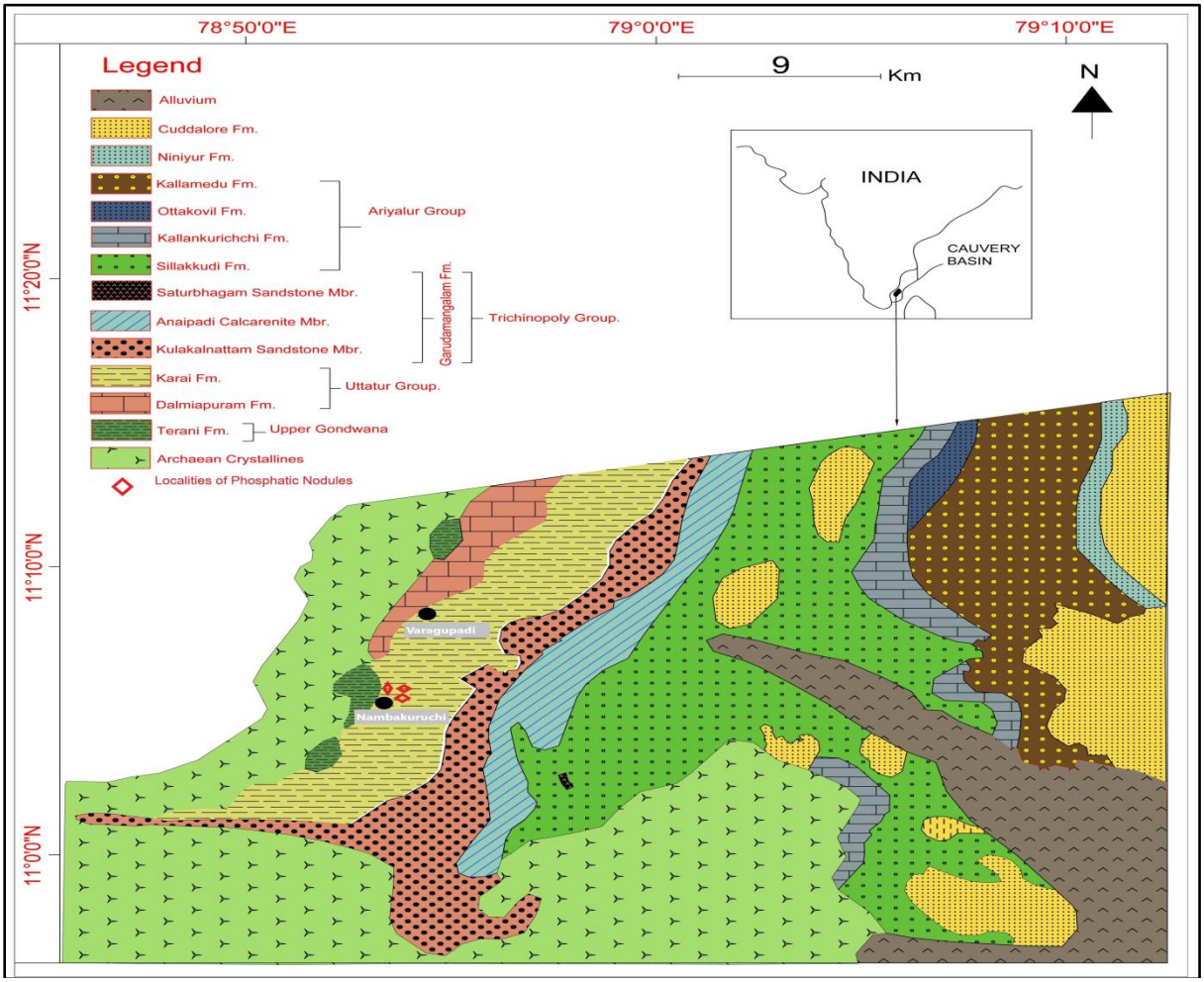

Fig. 1. Geological map of the Cretaceous of Cauvery Basin (After R. Nagendra et al, [14])

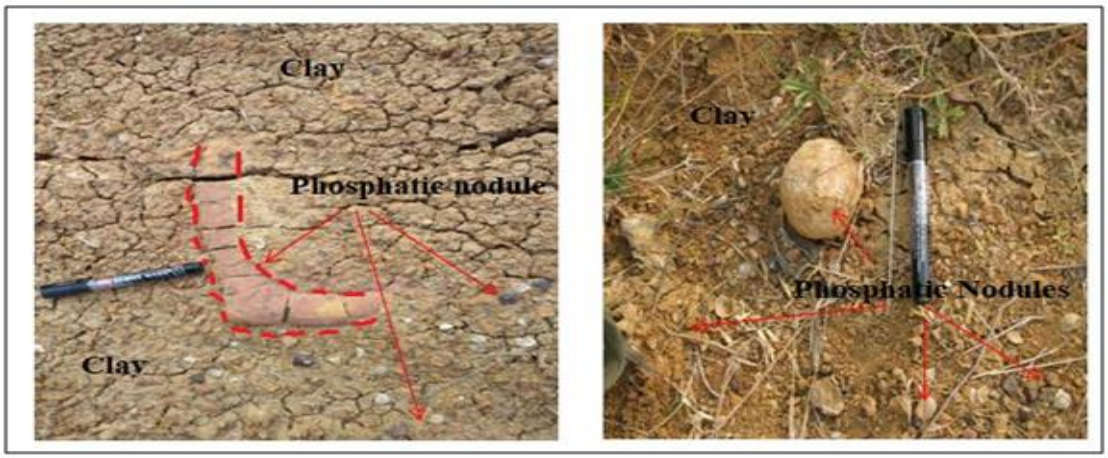

Fig. 2. Field photograph showing phosphatic nodules, Nambakuruchi block of Tiruchirappalli Tamil Nadu India

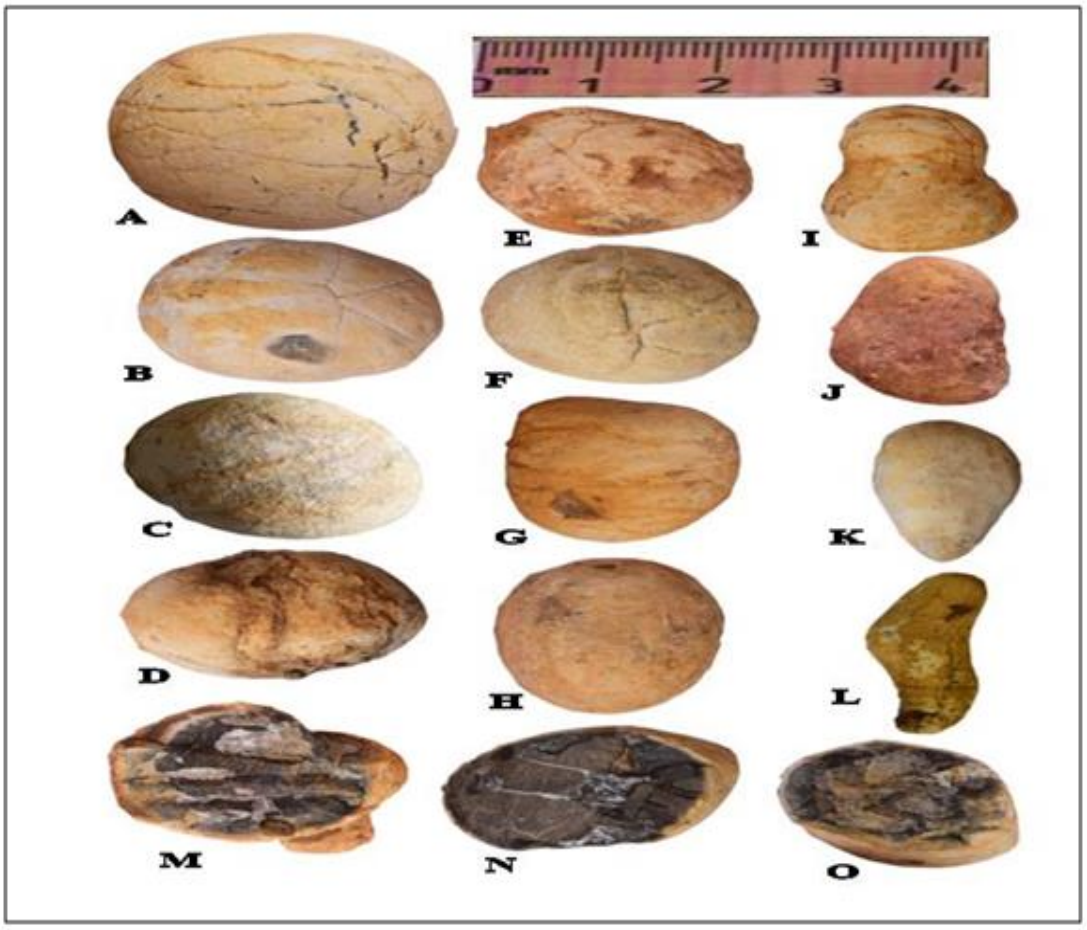

Fig. 3. Photograph of the phosphatic nodules of Nambakuruchi block of Tiruchirappalli Tamil Nadu (A - L) shape and size variation in hand specimen, (M – O) veins in the nodules

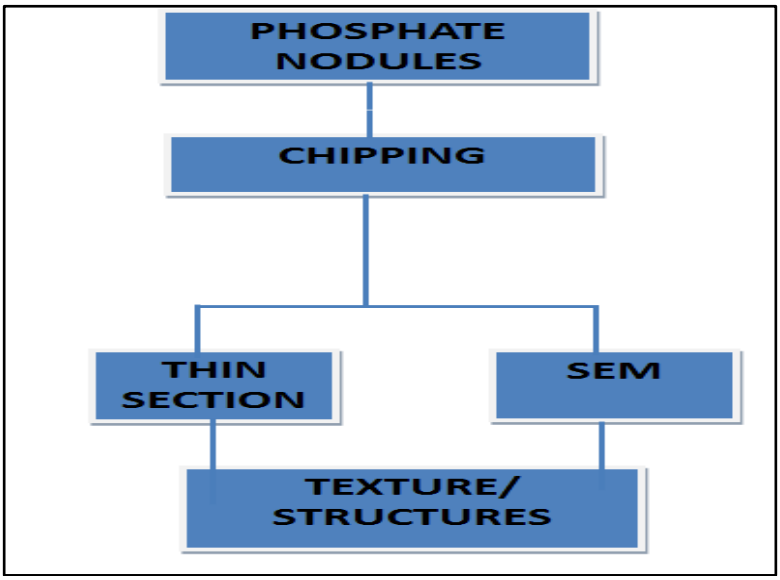

Fig. 4. Flowchart of methodology adopted for the organic origin study of phosphate nodules of the study area

4. RESULTS

The phosphatic nodules of the Nambakuruchi have different shapes and sizes. Their surface is yellow or white to reddish colour with varying veins with crystal contact (Fig. 3). The phosphate crystal is brown to grey in colour with bryozoan fragments. Thin sections of the nodules indicate that the fine phosphate grains are of silt size with a fine grain matrix. Fragments of the foraminifera and other small carbonate particles are marked with light-to-dark lamination. Photomicrographs of a thin section of phosphatic nodules with fine phosphate lamination and an inconspicuous test of planktonic foraminifera that were preserved on the groundmass may be seen in the images below (A) in plane polarised light and (B) between crossed nicols. There are planktic foraminifera, peloids, and fine detrital grains with cavities (Figs. 5 and 6). Micro cracks with microbial mats are also familiar with the algal structure. The veins/cracks cut in nodules in different directions are with silt-size detrital particles. Photomicrographs of the thin section of the phosphatic nodules showing fine silt-size phosphate matrix with planktonic foraminifera (A) in plane polarized light and (B) between crossed nicols (Fig. 6).

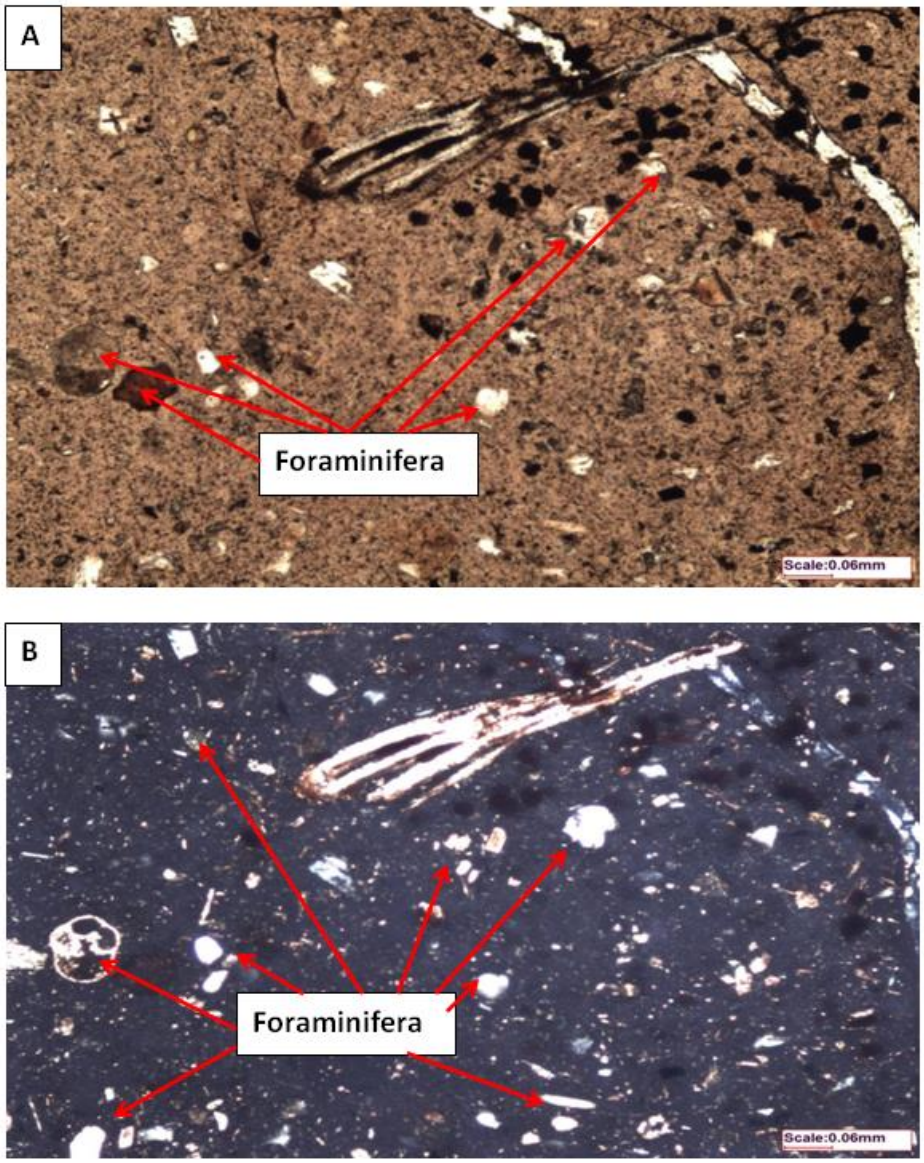

Fig. 5. Photomicrographs of the thin section of the phosphatic nodules showing fine lamination of phosphate with a small test of planktonic foraminifera and preserved on groundmass (A) in plane polarized light and (B) between crossed nicols

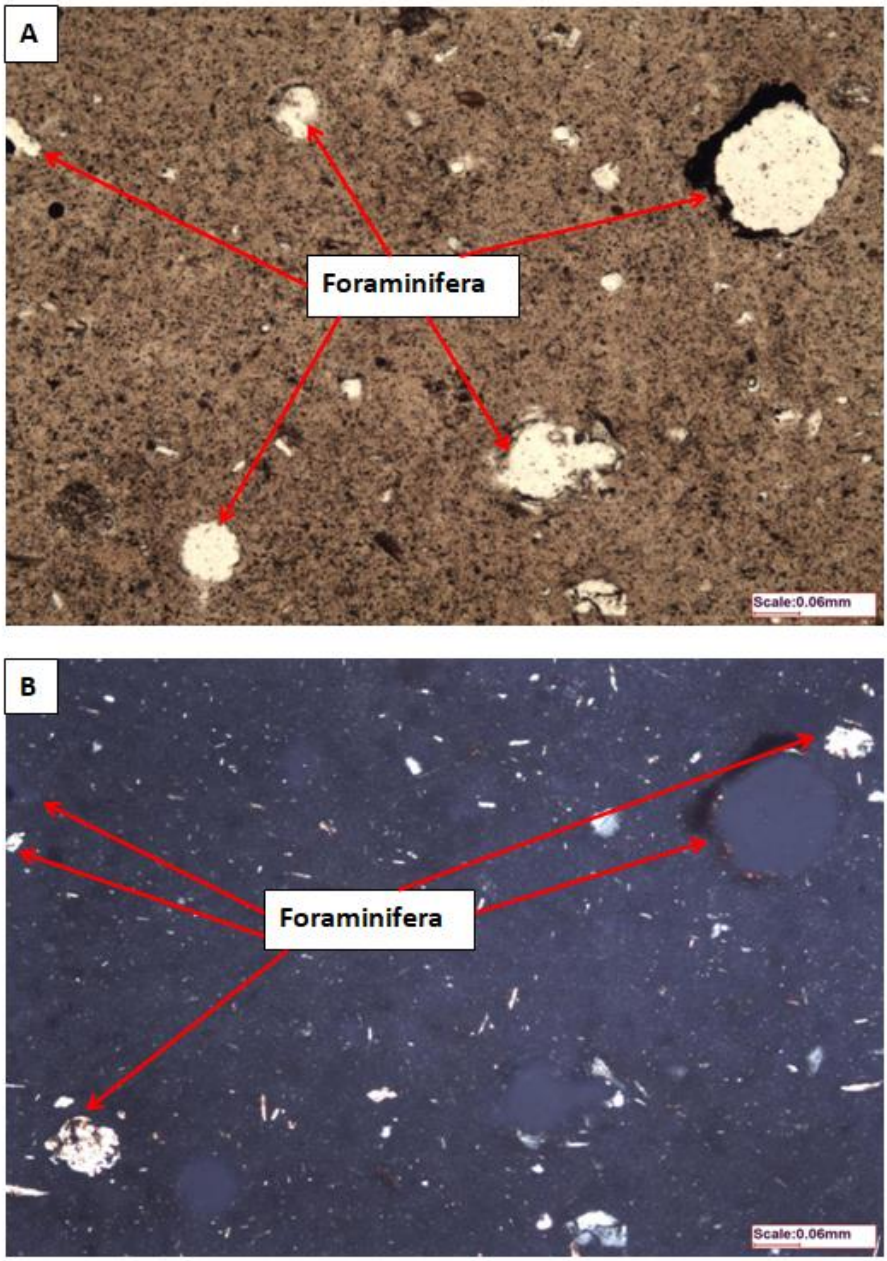

Fig. 6. Photomicrographs of the thin section of the phosphatic nodules showing fine silt size phosphate matrix with a planktonic foraminifera (A) in plane polarized light and (B) between crossed nicols

The SEM images also justify the major and minor minerals in the phosphatic nodules with the quartz and other microbial fragments of different sizes (Fig. 7). The microbial filaments are homogeneous forms with fragments of the planktic foraminifera. They are showing a uniform composition with a coated grain (Fig. 7). The laminae resemble microbial filaments, which appear hollow. Microbial filaments and phosphatized planktonic foraminifera observed in the groundmass of phosphatic nodules in shallow marine environmental conditions. These findings are also in accordance with other studies [15]. Scanning Electron Microscope (SEM) shows that the main constituents of the phosphate are carbonate fluorapatite (CFA) with a fine-grained matrix (Fig. 8). SEM micrographs of phosphatic nodules showing lamination of fossils wrap phosphatization. Globular microbial mats with cavities are found in Fig. 9. The laminated

phosphatized shows the development of the phosphate grains with the microbial filaments. Fig. 9 shows cavities formed by the dissolution of the particles with phosphate crystals. The CFA crystal consists of quartz in the central with spherical phosphatized particles. SEM studied on the surface of phosphatic nodules to observe the internal structures/texture of the nodules. These nodules include crystalline apatite, which suggests that the phosphate was initially deposited as the least crystalline or non-crystalline metastable phase. However, as shown by SEM pictures of some nodules (Fig. 9), it later underwent a transformation into crystalline apatite dependent on the saturation of phosphate minerals.

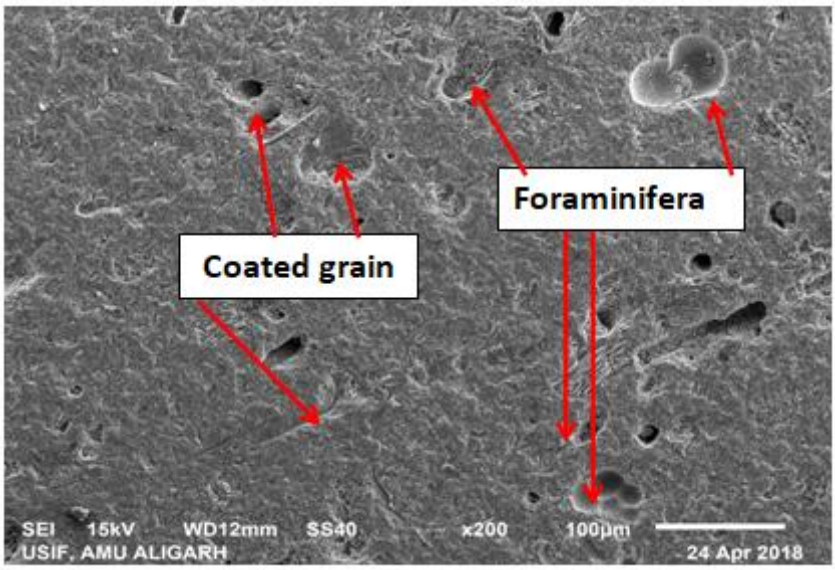

Fig. 7. SEM micrograph of phosphatic nodules showing phosphatized planktonic foraminifera in the groundmass of phosphate with coated grain

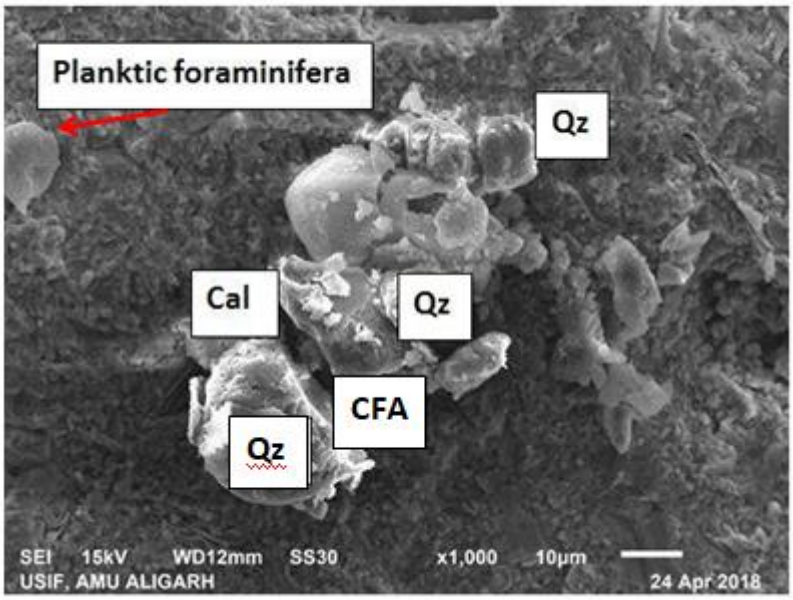

Fig. 8. SEM micrograph of phosphatic nodules showing Phosphate crystal, Quartz, Calcite and planktic foraminifera with microbial mats with of phosphatization

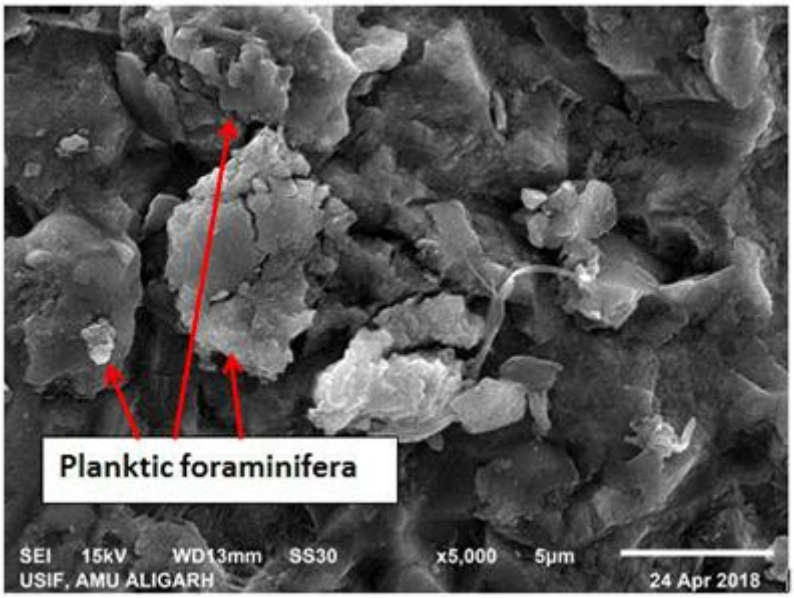

Fig. 9. SEM micrograph of phosphatic nodules showing planktic foraminifera and globular microbial filaments with fossils wrap/lamina cavities of phosphatization

5. DISCUSSION

There are different views on phosphorites, but the genesis of sedimentary phosphorites can be explained by three dominant processes [16-18]. The replacement of carbonates at the sea floor by phosphates, diagenetic precipitation from pore fluids, and precipitation by microbial activity and bacteria are these three crucial processes. Organic origin parameters studies of the phosphatic nodules show that the most dominant phosphatic constituent is CFA, with texture/ structures with planktic foraminifera micro-laminations with microbial filaments. The source of the microbial mat may be micro-organisms. According to Walter [19], the distinguishing characteristic of stromatolites is the binding and trapping of detrital particles by a microbial mat and mineral precipitation brought on by metabolic activity. Therefore the phosphate clast is of organic origin—phosphate stromatolites during the Mesozoic in a pelagic setting [20]. Micro-cracks filled with celestite, calcite, and gypsum indicate shallow environmental conditions. The presence of Celestite indicates the evaporative conditions [21]. This shows that the microbial mats are formed in evaporative conditions. Krumbein [22] described in carbonates-coated grains similar structures in Negev phosphorites [23]. The nuclei of nodules in carbonate grains related to the phosphate stromatolites formed intertidal conditions [8]. The findings revealed a rich diversity of planktonic foraminifera, providing valuable insights into the Cretaceous paleoenvironment and facilitating accurate correlations. The identification of important index species allowed for the establishment of a robust depositional framework, crucial for regional geological interpretations and correlations.

6. CONCLUSIONS

The onshore Cretaceous marine sedimentary sequence of the phosphatic nodules is exposed in the Tiruchirappalli district of Tamil Nadu. The phosphatic nodules in the Nambakuruchi are part of the Cauvery Basin of South India, which lies in the Uttatur group of the Karai formation. The colour of the surface of the nodules is yellow to reddish ferruginous with light to dark brown phosphate content. The thin section and SEM reveal that planktic foraminifera with microbial contents from organic matters present. The presence of organic matter gives the brown to brownish-black colour to the phosphatic nodules. Phosphatized microbial mats and planktonic foraminifera are found. The phosphate minerals appear as algal mats, coated grains and cryptal of carbonate fluroapatite in the groundmass. Organic matter in the form of microbial filaments, as revealed by SEM studies, indicates the role of micro-organisms involved in the formation of phosphatic nodules. The source of the organic matter may be the microbial mat. The

constituents of phosphatic nodules may have been derived from microbial bodies from the sea, and the precipitation of the phosphate during the metabolic process was the early stage of the burial of biota.

ACKNOWLEDGEMENTS

We are thankful to Coordinator USIF, Aligah Muslim University Aligarh for the SEM analysis. We thank reviewers for the improvement of the manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Notholt AJG, Sheldon RP, Davidson DF. Phosphate Deposits of the World, V. 2, Phosphate Rock Resources (Cambridge: Cambridge University Press). 1986;566.
2. Glenn CR, Arthur MA. Anatomy and origin of a Cretaceous phosphorite-Greensand giant, Egypt; Sediment. 1990;37:123–154.
3. Baioumy H, Tada R. Origin of late Cretaceous phosphorites in Egypt; Cre. Res. 2005;26:261–275.
4. Worth H. Report on the phosphate deposits of Trichinopoly. G.O No: 821, revenue dept, Govt of Madras; 1893.
5. Hussain A, Khan KF, Ahmad F. Geology, Mode of Occurrences and X-Ray Diffraction Studies of Cretaceous Phosphatic Nodules, Nambakuruchi Block of Tiruchirappalli District, Tamil Nadu, India. Bulletin of Pure and Applied Sciences- Geology. 2022;41F (1):142-148.
6. Venkateshwarlu M, Nagendra R. Drift of the Indian plate during upper Cretaceous: an appraisal from magnetic and biostratigraphic perspectives of sediment outcrop successions from Ariyalur-Cauvery Basin, Southern India. Unpublished report; 2016.
7. Rao VP, Michard A, Naqvi SWA, Bottcher ME, Krishnaswamy R, Thamban M, Natarajan R and Borole D V. Quaternary phosphorites off the southeast coast of India; Chem. Geol. 2002;182:483–502.
8. Rao VP. Dessarkar PM, Nagendra R, Babu EVSSK. Origin of Cretaceous phosphorites from the onshore of Tamil Nadu, India. Journal of Earth System Science. 2007;116(6):525-536.
9. Banerjee DM. Proterozoic and Cambrian phosphorites regional review: India subcontinent; In: Phosphate deposits of the world, Proterozoic and Cambrian phosphorites (eds) Cook P J and Shergold J H (Cambridge University Press). 1986;1:70–90.
10. Sundaram R, Rao PS. Lithostratigraphic classification of Ullatur and Trichinopoly groups of Upper Cretaceous rocks of Tiruchirapalli District, Tamil Nadu. Geological Survey of India, Miscellanceous Publication. 1979;45: 111-119.
11. Rama Rao L. Fossil Algae in India; Nature. 1958;181(4608):544–545.
12. Blanford HF. On the Cretaceous and other rocks of South Arcot and Trichinopoly districts: Mem, Geol. Surv. India. 1862 ;4.
13. Govindan A, Yadagiri K, Ravindran CN, Kalyanasundar R. A field guide on Cretaceous sequences of Tiruchirapalli Area, Cauvery Basin, India. Oil and Natural Gas Corporation Limited; 1998.
14. Nagendra R, Nallapa Reddy A. Major geologic events of the Cauvery Basin, India and their correlation with global signatures- A review, Journal of Palaeogeography. 2017;6(1):69 – 83.
15. Rao VP, Kessarkar PM, Patil SK, Ahmad SM. Rock magnetic and geochemical record in a sediment core from the eastern Arabian Sea: Diagenetic and environmental implications during the late Quaternary. Palaeogeography, Palaeoclimatology, Palaeoecology. 2008; 270(1-2):46-52.
16. Burnett WC, Riggs SR. Phosphate Deposits of the World, v. 3, Neogene to Modern phosphorites (Cambridge: Cambridge University Press). 1986;3: 464.
17. Notholt AJG, Jarvis I. Phosphorite Research and Development; Geol. Soc. Spec. Publ. 1990;52:326.
18. Follomi KB. Concepts and controversies in phosphogenesis; Eclo. Geol. Helv. 1994;87:639–788.
19. Walter MR, Bauld JTDB, Brock TD. Microbiology and morphogenesis of columnar stromatolites (Conophyton, Vacerrilla) from hot springs in Yellowstone National Park. In Developments in sedimentology. Elsevier. 1976;20:273-310.
20. Krajewski KP, Cappellen PV, Trichet JEAN, Kuhn OLIVER, Lucas J, Martin-

Algarra A, Lamboy, M. Biological processes and apatite formation in sedimentary environments. Eclogae Geologicae Helvetiae. 1994;87(3):701-746.

21. Taberner C, Marshall JD, Hendry JP, Pierre C, Thirlwall MF. Celestite formation, bacterial sulphate reduction and carbonate cementation of Eocene reefs and basinal sediments (Igualada, NE Spain). Sedimentology. 2002;49(1):171-190.
22. Krumbein WE. Biotransfer of minerals by microbes and microbial mats. In Biomineralization in lower plants and animals. 1986;55-72.
23. Soudry D, Champetier Y. Microbial processes in the Negev phosphorites (southern Israel). Sedimentology. 1983;30 (3):411-423.