Callovian-Oxfordian boundary in Kutch Mainland, India – A foraminiferal approach

Abu TALIB¹, Kaushalya Nandan GAUR² & Satyendra Nath BHALLA³

Abstract
Sections of Jurassic rocks belonging to the Chari Formation in Jumara and Jhurio domes, Kutch Mainland, are investigated for their foraminiferal microfauna. The foraminiferal assemblage composed of small benthonic species including Nodosariids, Epistominids and Trocholinids favours a Callovian-Oxfordian age for these sections. Certain species representing either the Callovian or the Oxfordian have been identified in the present assemblage. On the basis of these species, the Callovian-Oxfordian boundary has been delineated in the area.

Key words
Jurassic, Foraminifera, Kutch, Callovian-Oxfordian, Boundary.

I. INTRODUCTION
Jurassic rocks outcrop at a number of places in Kutch, Western India, but are well exposed only in the Kutch Mainland, i.e., the Central Kutch. The Kutch region is widely acclaimed in the world as one of the classic localities of marine Jurassic rocks and voluminous literature exists on various aspects of the geology of these rocks. However, little effort has been made by micropalaeontologists, including foraminiferologists, to study them. In view of this, the Department of Geology, Aligarh Muslim University, has undertaken a comprehensive foraminiferal study of the Kutch Jurassic which has enhanced our knowledge regarding the foraminifera, depositional environment, microbiostratigraphy and palaeobiogeography of these rocks. An attempt is made here to determine the Callovian-Oxfordian boundary on foraminiferal evidence in the Kutch Mainland.

In the Kutch region, Jurassic rocks are exposed in three east-west trending anticlinal ridges. The middle ridge is the most conspicuous and is included in the Kutch Mainland. It is broken up into a number of domal outcrops, viz., Jara, Jumara, Nara, Keera, Jhurio, and Habo hills from west to east having quaquaversal dips (beds dipping in all directions away from the centre). Jumara and Jhurio are the two prominent domes of the middle ridge which are selected for the purpose of the present study. These domes have been subjected to extensive geological investigations in the past and are famous in the Jurassic stratigraphy of Kutch for their abundant megafossils including ammonites and good exposures. Jhurio Dome is located nearly 10 km north of Bhuj while the Jumara Dome is about 75 km northwest of Bhuj, the district headquarters of Kutch (Fig. 1). The two hills are separated from one another by a distance of about 50 km in an east-west direction.

The most widely accepted classification of Jurassic of Kutch divides these rocks into Patcham, Chari, Katrol and Umia formations in ascending order. However, in the Jumara and Jhurio domes only the first three formations are exposed. Of all the exposures of the Jurassic rocks of Kutch, Chari Formation is the thickest and best developed in these domes, exposing a total thickness of about 245 m in Jumara and 325 m in Jhurio dome. Jumara dome is the type area of Jumara Formation, an alternate name for the Chari Formation coined by BISWAS (1977) in a later proposed lithostratigraphic classification of the Jurassic rocks of Kutch.

In the Jumara Dome, good exposures of Chari Formation are developed in two nala cuttings (nala = dry seasonal stream), locally known as Teen-phuar and Barh nalas, situated on the northern and northwestern flanks respectively of the dome. These sections were selected for the purpose of the present study. Chari Formation of the Jumara Dome is mainly composed of carbonate rocks with abundant megafossils including ammonites which have been used for dating and biozonation of these sediments. A small basic intrusion in the form of a dolerite sill is exposed in Barh nala section. The Chari Formation of Jumara Dome is divided into six litho-units which are numbered from 1 to 6 and prefixed with the letters Jm to denote Jumara Dome.

¹ Department of Geology, Aligarh Muslim University, Aligarh 202002, India. E-mail : talib04@rediffmail.com
² Dharam Samaj College, Aligarh 202001, India.
³ A-525, Sarita Vihar, New Delhi 110076, India.
In the Jhurio Dome, good exposures of Chari Formation are found in Sonwa nala-cutting located about 2 km west of Jhura village. The rocks of Chari Formation in this dome are dominated by shales with subordinate sandstones and limestones. Chari Formation of Jhurio Dome is divided into ten litho-units and numbered from 1 to 10, prefixed with Jh to denote Jhurio Dome. Prolific foraminiferal fauna comprising 53 species from Jhurio Dome and 51 species from Jumara Dome sections were recovered and they are employed to date these sediments and mark the Callovian-Oxfordian boundary in these sections.

II. FORAMINIFERAL BIOSTRATIGRAPHY

The use of foraminifera for precise age determination of post-Mesozoic sediments is well established. Although foraminifera are excellent for biostratigraphy of Lower Jurassic sediments (HERRERO et al., 1996) but they are not reliable for precise dating of the Middle-Upper Jurassic rocks in the Indian region as species with restricted vertical range are rare in Middle to Upper Jurassic sediments of Kutch (BHALLA & ABBAS, 1976; KALIA & CHOWDHURY, 1983; BHALLA & TALIB, 1985, 1991; TALIB & FAISAL, 2006, 2007). The problem becomes further accentuated with dominance of nodosariids and vaginulinids during this period which are fairly long-ranging and exhibit a high degree of inter- as well as intra-specific variations. Such species are hardly of any stratigraphic value unless their range of morphologic variation with time is thoroughly investigated. GRADSTEIN (1978) and later PANDEY & DAVE (1993), however, recommended the use of species of Garantella, Reinholdella, and reticulate Epistomina in Jurassic biostratigraphy. WILLIAMSON & STAM (1988) also opined that species of Epistomina are useful biostratigraphic markers, at least up to stage level. However, only two species of Epistomina could be recovered from the Jhurio and Jumara sequences which along with other fairly short ranging species are employed to date these sediments.

During the course of our investigation, however, a few species were recovered from the Jhurio and Jumara hill sections which are confined to Cretaceous, viz., Ammobaculites gowdai BHALLA & ABBAS, Frondicularia kutchensis BHALLA & ABBAS, Astacolus apheractus.

Fig. 1: Geological map of Kutch, India, showing the study areas (after FURSICH et al., 1991).
LOEBLICH & TAPPAN, Vaginulinopsis eritheles LOEBLICH & TAPPAN, and Patellinella poddari SUBBOTINA & SRIVASTAVA. These species have been reported from several regions of the world and only occur in Callovian-Oxfordian strata. Therefore, the sections of Chari Formation exposed at Jhurio and Jamara domes in the Kutch Mainland have been assigned to a Callovian-Oxfordian age. The stratigraphical ranges of a few species in the present assemblage enable us to further distinguish the Callovian from the Oxfordian strata.

The following foraminiferal species occurring in the present assemblage are regarded as indicating Callovian: Tribrachia inelegans LOEBLICH & TAPPAN, Astacolus anceps (TERQUEM), A. pauperatus (JONES & PARKER), Marginulina bhatiai (BHALLA & TALIB), Vaginulinopsis eritheles LOEBLICH & TAPPAN, Citharina clathrata (TERQUEM), C. heteropleura (TERQUEM), Citharinella aff. C. compara LOEBLICH & TAPPAN, and Epistomina mosquensis UHLIG. These include species which are either restricted to Callovian or are long-ranging but do not extend beyond the Callovian, or species which commence in the Callovian and extend beyond it but have been regarded as representative of Callovian strata by various authors.

Species confined to Callovian are Tribrachia inelegans LOEBLICH & TAPPAN, Marginulina bhati (BHALLA & TALIB), and Citharinella aff. C. compara LOEBLICH & TAPPAN. Tribrachia inelegans occurs in the Callovian sediments of the U.S.A. (LOEBLICH & TAPPAN, 1950b). Marginulina bhatiai is described from the Callovian of Kutch (BHALLA & TALIB, 1985) whereas Citharinella compara is reported from the Callovian of North America (LOEBLICH & TAPPAN, 1950b) and Canada (WALL, 1960). Taxa which are long-ranging but do not extend beyond the Callovian include Astacolus pauperatus (JONES & PARKER), Citharina clathrata (TERQUEM), and C. heteropleura (TERQUEM). C. heteropleura ranges from Bathonian to Callovian (BHALLA & ABBAS, 1976) while Astacolus pauperatus and Citharina clathrata range from Hettangian to Callovian (BHALLA & ABBAS, op. cit.).

Astacolus anceps though ranges from Bajocian to Oxfordian, PANDEY & DAVE (1993) considered it as a zonal marker of Protoacostina diffugiformis - Astacolus anceps Zone of Upper Callovian age in Kutch. Foraminiferal species which commence in the Callovian and extend beyond it, but have been regarded as representative of Callovian age, are Vaginulinopsis eritheles LOEBLICH and TAPPAN and Epistomina mosquensis UHLIG. Although the geological range of Vaginulinopsis eritheles is Callovian to Oxfordian, it has been considered by WALL (1960) to be one of the diagnostic species for the Callovian in Canada. Epistomina mosquensis is taken as characterizing Callovian strata in Iran (KALANTARI, 1969). It also occurs abundantly in Callovian deposits of the Volga region and the disappearance of this species in a stratigraphic sequence may be taken as the indication of the dawn of the Oxfordian age (fide SUBBOTINA et al., 1960). BARTENSTEIN et al. (fide KALANTARI, 1969) have also given a similar range to E. mosquensis in Germany. PANDEY & DAVE (1993) considered it as an important species of the Callovian in Kutch.

Species useful in separating Oxfordian strata in the present sections include Ammomarginulina cragini LOEBLICH and TAPPAN, Trocholina nodulosa SEIBOLD & SEIBOLD, Marginulina oxfordiana GORDON, Vaginulina ectypa LOEBLICH and TAPPAN, and Epistomina alveolata MYATLIUK.

KALANTARI (1969) considered Trocholina nodulosa to be the representative of the Oxfordian in Iran. Marginulina oxfordiana has been reported from the Oxfordian of England (GORDON, 1965) and India (BHALLA & TALIB, 1991) and Vaginulina ectypa is known to occur in the Oxfordian of U.S.A. (LOEBLICH & TAPPAN, 1950a). Other species which may be of some help in indicating Oxfordian strata are Ammomarginulina cragini and Epistomina alveolata. Ammomarginulina cragini has not been recorded from strata older than Oxfordian (BHALLA & TALIB, 1991). Although Epistomina alveolata ranges from early Callovian to Early Portlandian (SINGH, 1977), it has been mostly recorded from Kimmeridgian rocks in Russia (MYATLIUK; fide SINGH, 1977) and seems to have reached its peak after the Callovian. Upper portions of the present sections are also characterized by the disappearance of Epistomina mosquensis similar to the Lower Oxfordian of Volga region of Russia (SUBBOTINA et al., 1960).

III. CALLOVIAN-OXFORDIAN BOUNDARY

Although much palaeontological and biostratigraphic work has been done on the Jurassic rocks of Kutch, no attempt has yet been made to delineate the Callovian-Oxfordian boundary on a regional scale either on mega- or microfaunal evidence. An attempt is made here in this direction on foraminiferal evidence.

A glance at Fig. 2 reveals that the litho-units Jh 1 to Jh 3 in the Jhurio Dome section are characterized by the presence of the following foraminiferal species: Tribrachia inelegans, Astacolus anceps, A. pauperatus, Marginulina bhati, Vaginulinopsis eritheles, Citharinella clathrata, C. heteropleura, Citharinella aff. C. compara, and Epistomina mosquensis. None of these species extend beyond the litho-unit Jh 3 and as discussed above, this assemblage favours a Callovian age for litho-units Jh 1 to Jh 3.

Litho-units Jh 4 to Jh 10 are considered to belong to the Oxfordian as this part of the sequence possesses Ammomarginulina cragini, Marginulina oxfordiana, and Epistomina alveolata. Further evidence of Oxfordian age for this portion of the succession is provided by the disappearance of Epistomina mosquensis in Lithounit Jh 4 and beyond. The Callovian-Oxfordian boundary, therefore, should be placed between the litho-units Jh 3 and Jh 4 in the Jhurio Dome section (Fig. 3).
In the Jumara Dome section litho-units Jm 1 to Jm 5 are regarded as belonging to Callovian as this portion of the sequence is characterized by the presence of Astacolus anceps, A. pauperatus, Marginulina bhatiai, Citharina clathrata, and Epistomina mosquensis which do not occur above litho-unit Jm 5. Litho-unit Jm 6 is given an Oxfordian age as it contains Ammomarginulina cragini, Trocholina nodulosa, and Vaginulina ectypa. Furthermore, as in the Jhurio Dome section, this litho-unit is also characterized by the disappearance of Epistomina mosquensis. Hence, it seems reasonable to place the Callovian-Oxfordian boundary between the lithounits Jm 5 and Jm 6 in the Jumara Dome section.

In view of the above discussions, it is concluded that the Callovian-Oxfordian boundary should be placed between litho-units Jh 3 and Jh 4, about 85 m from the base of the exposed Chari Formation, in the Jhumo Dome section whereas in the Jumara Dome section, it is between litho-units Jm 5 and Jm 6, about 100 m from the base of the exposed Chari Formation (Fig. 3).

The present delineation of the Callovian-Oxfordian boundary is, however, tentative and should be supported and/or modified with further evidence from ammonites which are in abundance in these rocks but need detailed study and revision.

ACKNOWLEDGEMENTS

We are grateful to the Chairman, Department of Geology, Aligarh Muslim University, and authorities of Dharam Samaj College, Aligarh, for providing laboratory facilities. Thanks are also due to Council of Scientific and Industrial Reasearch, Government of India, New Delhi, for funding the study.

REFERENCES


**Fig. 3:** Callovian-Oxfordian boundary in Kutch Mainland, India.


SINGH, P. (1977) - Late Jurassic *Epistomina* from the subsurface of Banni deep Well-2, Kutch. *Proceedings of the 4th Indian Colloquium on Micropalaeontology & Stratigraphy*, Dehradun : 30-35.


TALIB, A. & S.M.S. FAISAL (2007) - On the occurrence of...
microfossils (Foraminiferida) in the Jurassic rocks of Ler Dome, Kutch Mainland, Gujarat. *Current Science*, Bangalore, 92: 595-596.


Accepté août 2007