Integrated Benthic Foraminiferal and Ammonite Biostratigraphy of Middle to Late Jurassic Sediments of Keera Dome, Kachchh, Western India

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Abstract

Early Callovian to Middle Oxfordian foraminiferal assemblages are tagged with precise ammonite occurrences for the first time from the Jurassic sediments of Chari Formation exposed at Keera Dome, Kachchh, Western India, with precise dating and marking of the Callovian-Oxfordian boundary. Four ammonite zones and nine subzones are correlated with seven foraminiferal zones, enabling accurate and reliable regional biostratigraphic analysis. Such integrated work will lead to precise dating of the otherwise hard-to-date foraminiferal assemblages from Kachchh.

Keywords: Benthic foraminifera, Ammonites, Biostratigraphy, Keera Dome, Kachchh, Western India

INTRODUCTION

Kachchh is well known for its prolific ammonite records (Waagen, 1873-75; Spath, 1924, 1927-33; Singh et al., 1982; Krishna and Westermann, 1985, 1987; Bhaumik et al., 1993; Krishna and Cariou, 1990, 1993; Callomon, 1993; Pandey and Callomon, 1995; Datta et al., 1996; Jain et al., 1996; Jain and Pandey, 1997, 2000;
Jain, 1997, 1998, 2002; Krishna and Ojha, 1996, 2000; Shome and Bardhan, 2005, 2007, 2009; Roy et al., 2007; Krishna et al., 2009a, b; Bardhan et al., 2010, 2011; Rai and Jain, 2012). However, rich foraminiferal occurrences have been recently recorded from the Kachchh Jurasses (Bhalla and Abbas, 1978; Bhalla and Talib, 1991; Pandey and Dave, 1993; Gaur and Talib, 2009; Alhussein, 2014; Talib et al., 2016; Bhat et al., 2016) but only a few biostratigraphic studies using foraminifera have been carried out so far. An integration of foraminiferal and ammonite data may provide more accurate and reliable results in biostratigraphic analysis of the Jurassic sediments of Kachchh.

Hence, it is imperative that an attempt be made to identify and establish marker Jurassic foraminiferal species (at least on a regional scale) and integrate the foraminiferal biozones with the available high resolution ammonite zonal data to make the former more useful for biostratigraphic applications. The present study is, thus, an attempt in this direction. A well exposed Kachchh Jurassic outcrop (Keera Dome) was selected for this purpose (Fig. 1). Another reason for this selection is the fact that this dome has also been extensively studied for its ammonite content and thus, has a well established and dated ammonite biozonation (Prasad, 1993, 1998; Krishna et al., 1998; Krishna and Ojha, 1996, 2000; SJ, personal observation).

Fig. 1. Geological Map of Kachchh showing the study area (after: Fürsich et al., 1991)
The Jurassic rocks of Kachchh are grouped into four formations, viz., Patcham, Chari, Katrol, and Umia, in ascending order (Waagen, 1873-75). The Keera Dome displays sediments from the Chari to Katrol formations. However, the presence of Patcham Formation at the base of the section is controversial (Prasad, 1998). Here, it must be mentioned that the basal few meters of sediments, viz., Friable Sandstones (see also Prasad, 1998) has not been sampled but have yielded fragmentary specimens of the Late Bathonian marker *Macrocephalites triangularis* Spath (Prasad, 1998), indicative of late Bathonian age.

The Chari Formation in this area, which is the subject of the present study, is grouped into four informal members, viz., A, B, C, and D. These are further divided into seven lithounits designated as lithounits Kr-1 to Kr-7 in ascending order (Fig. 2). The Katrol Formation is devoid of foraminifera and, therefore, not included in the present study.

![Fig.2. Litholog of the studied sequence at Keera Dome, Kachchh showing the ammonite occurrences and standard ammonite zones](image-url)
**FORAMINIFERAL BIOSTRATIGRAPHY**

The foraminiferal assemblages recovered from Keera Dome comprises of thirty species (Fig. 3). All the species recovered are illustrated with a systematic account of the species reported for the first time from Indian region in a separate publication (Talib et al., 2012). However, most are long ranging and hence, unsuitable for precise dating (Fig. 4). In recent years some workers have attempted to establish marker foraminiferal species with biostratigraphic utility in the Indian region but with little success (Pandey and Dave, 1993; Talib and Bhalla, 2006; Talib et al., 2007, Talib and Gaur, 2008).

Interestingly, only one species of the present assemblages, *Vaginulina inspisata* appears to be globally restricted within two stages, i.e., Callovian and Oxfordian (Fig. 4) but a number of other species show short ranges within the Indian region, essentially confined to

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**Fig.3.** Frequency of foraminiferal species and correlation of foraminiferal and ammonite biozones, Keera Dome, Kachchh (SJ*). The ammonite biozones are based on the observations by one of us (SJ). The present biozonation also incorporates previous works by Prasad 1993, 1998; Krishna et al., 1988 and Krishna and Ojha 1996, 2000 with field inputs from Late J. H. Callomon, United Kingdom, to SJ.**
Callovian and Oxfordian stages (Fig. 5). Therefore, on the basis of these species, viz., *Ammobaculites* aff. *A. hagni*, *Triplasia emslandensis*, *Laevidentinella* gümbeli, *Nodosaria* aff. *N. biloculina*, *N. simplex*, *Lenticulina varians*, *Astaclolus puperatus*, *Citharina entypomatus*, *Citharinella rhomboidea*, *Vaginulina inspiassata*, and *Epistomina stellicostata*, a Callovian to Oxfordian age is suggested for the sequence at Keera Dome.

On the basis of a few short ranging species in the present assemblages restricted to a single stage as well as some species although long ranging but frequently reported from Callovian or Oxfordian strata from different parts of the world, an attempt is made here to mark the Callovian-Oxfordian boundary within the studied sequence.

Species identified as characteristic of Callovian in the present assemblages include *Pseudonodosaria sowerbyi* and *Epistomina mosquensis*. *Pseudonodosaria sowerbyi* is restricted to Callovian in the Indian region and occurs in Lithounit Kr-3. *Epistomina mosquensis* is known for its long range globally but in Kachchh Pandey and Dave (1993) and in Iran (Kalantari, 1969) considered it a representative Callovian species, its last appearance is in Lithounit Kr-6. In view of the above, it may be inferred that Lithounits Kr-1 to Kr-6 belong to Callovian.

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**Fig. 4.** Global ranges of the foraminiferal species recovered from Keera Dome, Kachchh.
Fig.5. Indian ranges of the foraminiferal species recovered from Keera Dome, Kachchh.

Representative Oxfordian species recognized in the present assemblages is *Vaginulinopsis* aff. *V. enodis*. *Vaginulinopsis enodis* ranges from Callovian to Oxfordian in India but Kalantari (1969) regarded it as representative of Oxfordian in Iran. This species is, therefore, regarded as representative of Oxfordian in this region and on this basis Lithounit Kr-7 is considered as belonging to Oxfordian. The Callovian/Oxfordian boundary, consequently, lies between lithounits Kr-6 and Kr-7.

The broad foraminiferal biozones erected for the Kachchh Basin by Pandey and Dave (1993) are compared with the more refined and ammonite-constrained assemblage-based current benthic foraminiferal biozones (Fig. 3). These are:

1. **Barren Zone** - No foraminifers: This zone includes Lithounit Kr-1 and is devoid of foraminifera. This is equivalent to the Diadematus subzone of middle Early Callovian age.

2. **Planularia tricarinella-Lenticulina quenstedti Assemblage Zone**: Includes Lithounit Kr-2. Apart from zonal name species it includes *Laevidentalina guembeli*, *Spirillina polygyrata*, *Citharina zaglobensis* and *Lenticulina nodosa*. This zone has an early
Middle Callovian age and is equivalent to Anceps subzone.

3. Spirillina polygyrata-Planularia tricarinella Assemblage Zone: Incorporates Lithounit Kr-3 and includes Laevidentalina gumbeli, Lenticulina quenstedti, Citharina zaglobensis, Lenticulina nodosa, Nodosaria simpllex, Lenticulina subalata, Pseudonodosaria sowerbyi, Astacolus aniceps, Epistomina mosquensis, Citharina entypomatus, Astacolus pauperatus, Epistopoma stellicostata, Vinelloidea aff. V. bigoti, and Nodosaria aff. N. biloculina, in addition to zonal name species. This zone is equivalent to the Eucyclum subzone of upper early Middle Callovian age.

4. Ammobaculites alaskensis-Triplasia emslandensis Assemblage Zone: Includes Lithounit Kr-4. Along with the zonal name species, this zone includes Planularia tricarinella, Spirillina polygyrata, Lenticulina quenstedti, Lenticulina subalata, Ammobaculites aff. A. hagni, Ammobaculites sp., Triplasia althoffi jurassica, Lenticulina varians, Lagenammina pseudodifflugiformis and Reophax sterkii. This zone is assigned a middle Middle Callovian age as it is equivalent to the Singulare subzone.

5. Ammobaculites alaskensis-Triplasia althoffi jurassica Assemblage Zone: This zone includes Lithounit Kr-5. In addition to zonal name species it includes Triplasia emslandensis, Lenticulina varians, Lagenammina pseudodifflugiformis, Reophax sterkii, Haplophragmium aequale, and Ammobaculites coprolithiformis. It is equivalent to Kleidos subzone of late Middle Callovian age.

6. Epistomina mosquensis-Planularia tricarinella Assemblage Zone: This zone encompasses Lithounit Kr-6 and apart from the zonal name species includes Spirillina polygyrata, Lenticulina quenstedti, and Epistomina alveolata. This zone is equivalent to Athleta Zone of Late Callovian age.

7. Citharina zaglobensis-Planularia tricarinella Assemblage Zone: Incorporates Lithounit Kr-7 and along with zonal name species includes Laevidentalina gumbeli, Lenticulina quenstedti, L. subalata, Astacolus aniceps, Citharinella rhomboidea, Vaginulopsis aff. V. enodis, and Vaginulina inspissata. This zone is correlated with Helenae-Maya ammonite Zone of Early to Middle Oxfordian age.

AMMONITE BIOSTRATIGRAPHY

The present ammonite biostratigraphy of the Keera Dome is based on data from Prasad (1993, 1998), Krishna et al. (1998) and Krishna and Ojha (1996, 2000) along with field observations by one of us (SJ) and Late J. H. Callomon, United Kingdom. (personal communication). Four ammonite zones and nine subzones are identified here spanning Early Callovian to Middle Oxfordian (Fig. 3). The oldest ammonite appearing at the bottom of the sequence in Lithounit Kr-1 is Macrocephalites madagascariensis indicating Early Callovian age while the last ammonite which occurs at the top of Lithounit Kr-7 is Perisphinctes (Kranaoosphinctes) kranacus suggesting Middle Oxfordian age and indicating an Early Callovian to Middle Oxfordian interval for the studied sequence.

Thus, the age suggested by foraminiferal assemblages is less refined
but does support the larger stage age inferred by ammonites (Callovian and Oxfordian) (Fig. 3).

The ammonite *Macrocephalites formosus* spans the entire Early Callovian duration and forms the first ammonite zone divisible into three subzones: Madagascarriensis, Diadematus and Semilaevis dominated by *M. madagascariensis*, *M. diadematus* and *M. semilaevis*, respectively.

The presence of *Reineckeia* (*Reineckeia*) *anceps* marks the beginning of Middle Callovian and the Anceps Zone as such is divisible into four subzones: Anceps, Eucyclum, Singulare and Kleidos dominated by *Reineckeia* (*R.*) *anceps*, *Eucycloceras eucyclum*, *Idiocycloceras singulare*, and *Sivajiceras kleidos*, respectively.

The Late Callovian Athleta Zone is divisible into two subzones - Athleta (dominated by *Peltoceras athleta*) and Lelandeanum (*Pachyceras lelandeanum*).

The Oxfordian Helenae-Maya Zone is divisible into four subzones namely Semirugosum (*Peltoceras semirugosum*), Maya (*Mayaites maya*), Helenae [*Perisphinctes (Kranaoosphinctes) helena*] and Kranaus [*Perisphinctes (Kranaoosphinctes) kranau*]. The occurrence of *Pachyceras lelandeanum* in the topmost beds of Lithounit Kr-6 indicates a Late Callovian age and of *Peltoceras (Peltoceras) semirugosum* in the lowermost beds of the overlying Lithounit Kr-7, an Early Oxfordian age.

The Callovo-Oxfordian boundary, therefore, lies between lithounits Kr-6 and 7 for the present study.

CONCLUSION

The present study concludes:

1. The study helped in the identification of a number of relatively short ranging representative foraminiferal species that are confined to Callovian and Oxfordian stages. These include *Ammobaculites hagni*, *Triplasia emslandensis*, *Laevidentalina gümbeli*, *Nodosaria biloculina*, *N. simplex*, *Lenticulina varians*, *Astacolus pauperatus*, *Vaginulinopsis enodis*, *Citharina entypomatus*, *Citharinella rhomboidea*, *Vaginulina inspissata*, and *Epistomina stellicostata*. *Pseudonodosaria sowerbyi* and *Epistomina mosquensis* are considered as representative of Callovian and *Vaginulinopsis enodis* of Oxfordian in the Kachchh region. All these are likely to be useful for biostratigraphic studies in this region.

2. Based on ammonite data, the Jurassic sequence exposed at Keera Dome, Kachchh, Western India is dated from Early Callovian to Middle Oxfordian. The foraminiferal assemblages indicate a slightly less accurate but almost similar age range - from Callovian to Oxfordian. Both the ammonite and foraminiferal data suggest the placement of the Callovo-Oxfordian boundary between Lithounits Kr-6 and Kr-7.

3. Four ammonite Zones and nine subzones are correlated with seven foraminiferal Zones. This correlation has yielded a considerably more refined foraminiferal biozonation than any one proposed so far for the Kachchh Jurassics. The ammonite biostratigraphy, as put forward by Prasad (1998), well reflects field observations.

4. The correlation of foraminiferal and ammonite zones provides an accurate and refined resolution to foraminiferal biozones making them more useful for
biostatigraphic work. This integrated approach is the way forward for doing foraminiferal biostratigraphy in Kachchh Jurassics as well as globally.

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REFERENCES


SHOME, S. and BARDHAN, S. (2005) Record of a new species of Erymnoceras Hyatt, 1900 (Ammonoidea) from the Middle Jurassic of eastern Kutch and its stratigraphic


