

**Pliensbachian nannofossils from Kachchh: Implications on the earliest Jurassic
transgressive event on the western Indian margin**

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Introduction

The Kachchh Basin, situated on the northwestern fringe of India, formed during early Jurassic by the southern extension of the Neo-Tethys at a palaeolatitude of 33°S. Current reports indicate that marine sedimentation started in response to the opening of the Arabian Sea during Early Jurassic (?Bajocian). This date is based on the earliest ammonite record (*Calliphylloceras heterophylloides*) of ?earliest Bajocian (~178 Ma; Pandey et al., 2013) or Latest Bajocian *Leptosphinctes* (~167.7 Ma; Singh et al., 1982) and/ or the ?Early Bajocian coral *Amphiastraea-Isastraea* assemblage (~171.6 Ma; Pandey and Fürsich, 1994) recorded from the Dingy Hill Member (Pachchham Island).

We report here a moderately diversified late Early Aalenian age calcareous nannofossil assemblage with reworked Early Jurassic Pliensbachian-Toarcian interval nannotaxa from the middle part of the Dingy Hill Member of the Kaladongar Formation (Fürsich et al., 2001) exposed at Point 16 hillock at Kuar Bet in the Pachchham Island. This section, (~10 m) shows alternating sandy fossiliferous limestones and calcareous sandstones with planar and concurrent stratification and flaser bedding and well preserved ichnotaxa viz. *Thalassinoides*, *Rhizocorallium*, and *Diplocraterion*. The calcareous sandstone level shows prominent bedding fissility and one sample (PAT-2; GPS location: 23° 59' 40" N; 69° 42' 28" E; Fig. 3) has yielded datable calcareous nannofossils of moderate diversity. The present nannofossils assemblage containing *Lotharingius contractus* and *Triscutum sullivanii* from Kuar Bet has now yielded a more precise late Early Aalenian age with reworked Pliensbachian-Toarcian interval nannotaxa.

Nannofossil Record

The assemblage includes *Lotharingius contractus* and *Triscutum sullivanii* of late Early Aalenian age with reworked nannofossils of Pliensbachian-Toarcian interval viz. *Axopodorhabdus cylindratus*, *Biscutum finchii*, *Bussonius prinsii*, *Crucirhabdus primulus*, *Crepidolithus pliensbachensis*, *Discorhabdus criotus*, *D. striatus*, *Lotharingius contractus*, and *Triscutum sullivanii*. Rai (2007) and Rai and Jain (2012) from Pachchham Island have

previously reported Pliensbachian-Toarcian (Early Jurassic) interval nannofossils. Besides these, *Biscutum* sp., *Crepidolithus crassus*, *C. granulatus*, *Diazmatolithus lehmanii*, *Ethmorhabdus gallicus*, *Micula staurophora*, *Mitrolithus elegans*, *Octopodorhabdus* sp., *Parhabdolithus liassicus*, *Schizosphaerella* sp., *Triscutum sullivanii*, *Tubirhabdus patulus*, *Watznaueria barnesae* and *W. fossacincta*. The recovered nannofossils were compared with global marker charts (Bown, 1998; Mattioli and Erba, 1999; Sandoval et al., 2012).

Bathonian- Callovian age nannofossil assemblages from three Mainland domes (Jara, Jumara, Habo) and Oxfordian – Kimmerigian age nannofossil assemblages from Waagad Highland (Rai, unpublished data) have also yielded Pliensbachian- Aalenian age reworked nannofossils. Reworked Pliensbachian- Toarcian age nannofossils viz. *Mitrolithus lenticularis* and *Miravetesina fascula* have also been recorded from quaternary age nannofossil assemblage recovered from Allahbund and Trangdi Bet area. This suggests that the earliest transgressive event in Kachchh Basin, western India might have occurred at least in Pliensbachian time (Rai & Jain, 2013).

Ammonite data

Ammonites, in general, provide most precise dates for Jurassic. However, the Early Jurassic basal sediments of the Kachchh Basin lack ammonite record. Hence, to better appreciate this early duration, it is imperative to look beyond Kachchh, and into the Indian subcontinental region and neighbouring ammonite yielding localities such as the Himalaya (Nepal, Tibet, Spiti, etc.), Pakistan and Madagascar for precise ages for the basal sediments of the Kachchh Basin. The Pliensbachian and Aalenian are devoid of ammonites from the Indian subcontinent, whereas Early Toarcian is quite rich in ammonites. Higher sea level record might explain this rich record that not only provided newer niches but also made previously unavailable land areas.

Available ammonite data do not help in dating the basal sediments of Kachchh but it is intriguing to ponder as to why Pliensbachian ammonites are not recorded in Kachchh, whereas other body fossils (pelecypods, gastropods and corals) and microfossils (Nannofossils) are profuse. Closer sample might yield Pliensbachian and Aalenian ammonites from Kachchh.

Discussion

Biostratigraphic

We have followed stratigraphic ranges of marker nannofossil taxa as given in Gradstein, et al. (2004). The presence of *Lotharingius contractus* Bown and Cooper (FAD at base of NJ8b) and *Triscutum sullivanii* (FAD NJ8b) suggests the age of lowest sediments of Kuar Bet Island as late Early Aalenian (Gradstein, et al., 2004). The presence of *B. prinsii* (FAD NJ4 and LAD NJ8b), *Biscutum finchii* (FAD at NJ4b and LAD at NJ6), *Crepidolithus*

granulatus (FAD NJ4a and LAD NJ4b) *C. plienschbachensis* (LAD base of NJ4b), *Crucirhabdus primulus* (LAD NJ5a), *Discorhabdus criotus* (FAD base of NJ7) and *D. striatus* (FAD straddling the NJ6 and NJ7), *Mitrolithus elegans* (FAD NJ2a and LAD Upper Plienschbachian), suggests the nannofossil assemblage between NJ4a to NJ7 Zones of Early Plienschbachian to Middle Toarcian and is considered reworked in Aalenian (de Kaenel et al., 1996; Gradstein et al., 2004; Veiga de Oliveira et al., 2007; Jain, 2008; Rai and Jain, 2012; Sandoval et al., 2012). This equates with the Tethyan ammonite interval between the Early Plienschbachian Jamesoni to the Middle Toarcian Variabilis (Gradstein et al., 2004) zones not yet recovered from India.

All data, as of now does suggest that the age of the present nannofossil assemblage represents a 10 Ma interval span (ca. 190-180Ma) and that the earliest marine sediments in Kachchh date back to Early Plienschbachian NJ4a nannofossil Zone and are within the Tethyan ammonite Jamesoni Zone (Gradstein, et al., 2004). Thus, the Dingi Hill Member of the Kaladongar Formation is at least of late Early Aalenian age.

Palaeogeographic

The nannofossil record suggests that after faulting of the Indian plate in its western margin, the transgressive event within the Kachchh basin took place during the Plienschbachian. This early transgression is ~16 Ma prior to the previously proposed Early Bajocian (coral and ammonite based) or the Latest Bajocian ammonite-based records. In this context, the record of coeval Upper Plienschbachian age nannofossils from the Masirah Island (Sultanate of Oman, Arabia; Von Salis and Immenhauser, 1997) and ?Aalenian – Bajocian (NJ8bZone) age nannofossils from Kuwait (Kadar & Crittenden 2012) further strengthens the present record. Additionally, reworked Plienschbachian-Aalenian age nannofossils (*Crepidolithus granulatus* Bown, 1987; *Diductius constans* Goy, 1979; *Mazaganella protensa* Bown, 1987; *Mitrolithus elegans* Deflandre, 1954; *Parhabdolithus liasicus* Deflandre, 1952; *Similiscutum orbiculus* de Kaenel & Bergen, 1993; *Triscutum tiziense* de Kaenel & Bergen, 1993) recovered from the Callovian sediments of the Jara Dome (occupying the westernmost extremity of the Kachchh Basin; Rai, 2006), Bathonian-Callovian age nannofossil assemblages from Jumara Dome, Callovian age assemblage from easternmost Habo Dome and Oxfordian – Kimmerigian age nannofossil assemblages from Waagad Highland have also yielded Plienschbachian-Aalenian age reworked nannofossils. These findings attest to the presence of marine conditions at least since the Plienschbachian time in Kachchh Basin, western India (Rai, 2007; Rai and Jain, 2013). In this context, it is interesting to note that from sub-surface sediments in a well in Banni south of Pachchham Island, Rheatic-Liassic palynoflora (Latest Triassic; 199.6-203.6 Ma) have been recorded (Koshal, 1975).

Palaeoenvironment

Patel et al. (2010) suggested that the sedimentary sequence exposed at Kuar Bet were deposited in the tidally influenced, high and low energy foreshore-shoreface transitional environment. The facies association and associated trace fossils suggests fluctuation in sea level marking various sequence boundaries. Based on the presence of intercalated sandstone-shale facies (the ISS of Patel et al., 2010), we are of the opinion that the sample yielding the nannofossil assemblage most likely came from an MFS (Maximum Flooding Surface) of the HST (Highstand System Tract).

It is proposed that both global eustatic rise coupled with local tectonics during the Pliensbachian-Toarcian boundary interval led to the early introduction of this new nannofossil assemblage marking the presence of marine conditions within the Kachchh Basin, for the first time.

Conclusions

1. The oldest rocks exposed in Kuar Bet (Pachchham Island) are of marine origin and are constrained to be late Early Aalenian based on nannofossils with reworked Pliensbachian-Toarcian age nannotaxa.
2. The earliest transgressive event in the Kachchh basin occurred ~15 Ma prior to the previously proposed ?Early Bajocian coral and ammonite-based or Late Bajocian ammonite-based records.
3. It is proposed that the global eustatic rise coupled with local tectonics were responsible for Pleinsbachian (Early Jurassic) nannofossil introduction within the Kachchh Basin.
4. Record of Pliensbachian – Toarcian age nannofossils from Masirah Island of Sultanat of Oman and ?Aalenian – Bajocian (NJ8b Zone) age nannofossils from Kuwait respectively supports this contention.