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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 Callovo-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 Jurassics (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).

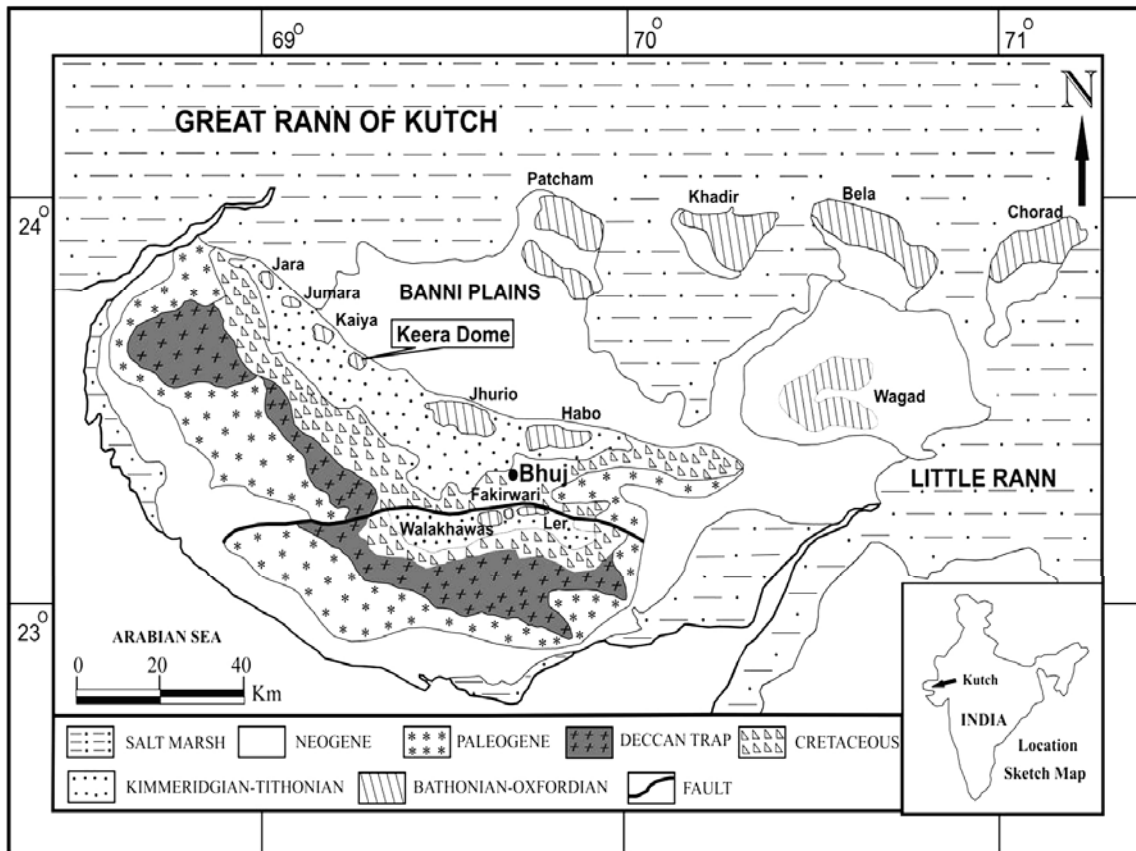


Fig. 1. Geological Map of Kachchh showing the study area (after: Fürsich et al., 1991)

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.

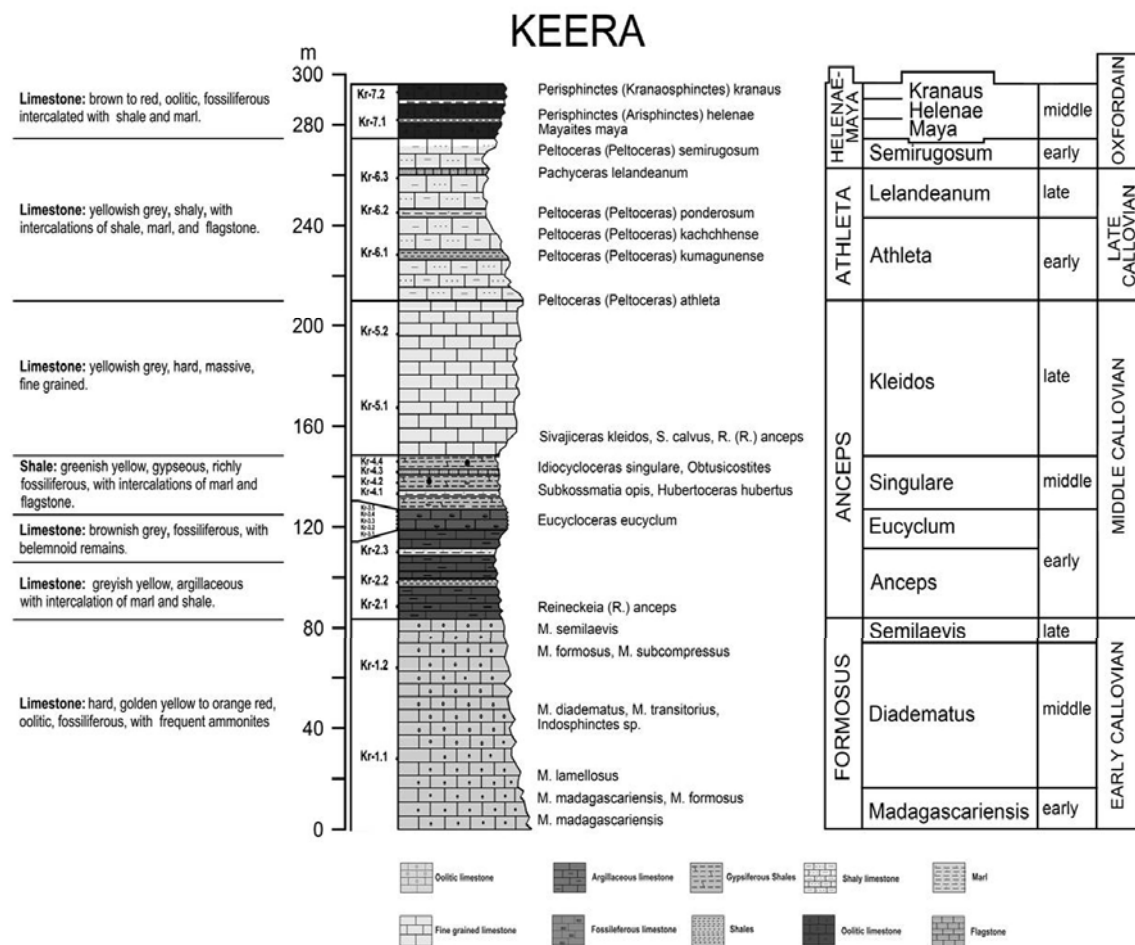


Fig.2. Litholog of the studied sequence at Keera Dome, Kachchh showing the ammonite occurrences and standard ammonite zones

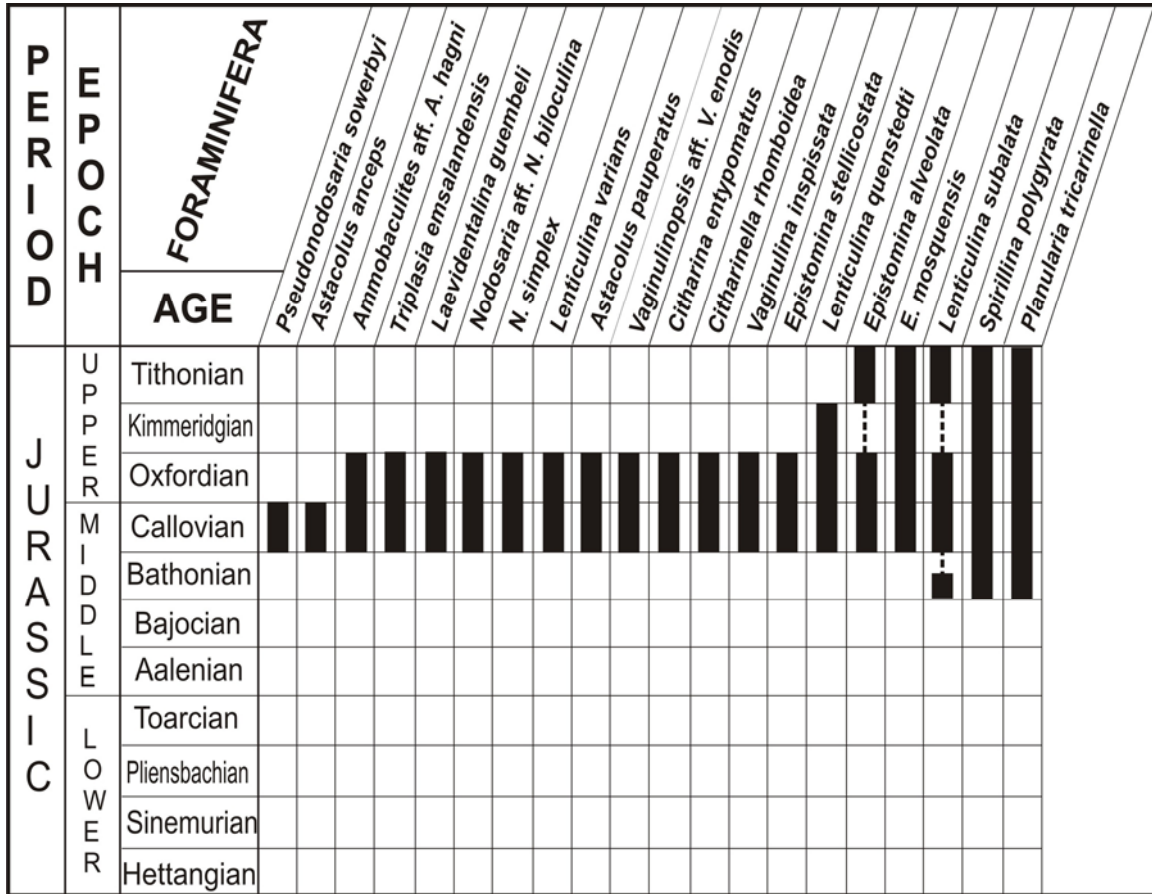


Fig.5. Indian ranges of the foraminiferal species recovered from Keera Dome, Kachchh.

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 tricarinnella*-*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 gümbeli*, *Lenticulina quenstedti*, *Citharina zaglobensis*, *Lenticulina nodosa*, *Nodosaria simplex*, *Lenticulina subalata*, *Pseudonodosaria sowerbyi*, *Astacolus anceps*, *Epistomina mosquensis*, *Citharina entypomatus*, *Astacolus pauperatus*, *Epistomina stelicostata*, *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 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 gümbeli*, *Lenticulina quenstedti*, *L. subalata*, *Astacolus anceps*, *Citharinella rhomboidea*, *Vaginulinoopsis* 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 (Kraeosphinctes) kraeus* 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: Madagascariensis, 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 - Athelta (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* (*Kranaosphinctes*) *helenae*] and Kranaus [*Perisphinctes* (*Kranaosphinctes*) *kranauis*]. 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

biostratigraphic work. This integrated approach is the way forward for doing foraminiferal biostratigraphy in Kachchh Jurassics as well as globally.

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REFERENCES

- ALHUSSEIN, M. (2014) Taxonomy of the Middle Jurassic benthic foraminifera of the Kachchh basin, Western India. *Beringeria*, v.44, pp.51-97.
- BARDHAN, S., DUTTA, R., CHANDA, P. and MALLICK, S. (2011) Systematic revision and sexual dimorphism in *Choffatia* (Ammonoidea: Perisphinctoidea) from the Callovian of Kutch, India. *Palaeoworld*, v.21, pp.29-49.
- BARDHAN, S., JANA, S., and ROY, P. (2010) Sexual dimorphism and polymorphism in a Callovian *Phlycticeras* (Ammonoidea) assemblage in Kutch, India. *Geobios*, v.43, pp.269-281.
- BHALLA, S.N. and ABBAS, S.M. (1978) Jurassic foraminifera from Kutch, India. *Micropaleontology*, v.24, pp.60-209.
- BHALLA, S.N. and TALIB, A. (1991) Callovian-Oxfordian foraminifera from Jhurio hill, Kutch, Western India. *Rev. Paléobiol.*, v.10, pp.85-114.
- BHAT, B.A., TALIB, A. and WASIM, S.M. (2016) Systematics, age, paleoecology and paleobiogeography of Jurassic foraminifera from Fakirwari Dome, Kutch, Gujarat, India. *Micropal.* v.62, pp.171-194.
- BHAUMIK, D., DATTA, K., JANA, S.K. and BARDHAN, S. (1993) Taxonomy and intra-specific variation of *Macrocephalites formosus* from the Jurassic Chari Formation, Kutch, Western India. *J. Geol. Soc. India*, v.42, pp.163-179.
- BISWAS, S.K. (1991) Stratigraphy and sedimentary evolution of the Mesozoic Basin of Kutch, West India: *In:* TONDON, S.K., PANT, C. C., and CASSHYAP, S.M. (eds.), *Sedimentary Basins of India: Tectonic context*, pp.74-103, Gyanodaya Prakashan.
- CALLOMON, J. H. (1993) On *Perisphinctes congener* Waagen, 1875, and the age of the Patcham Limestone in the Middle Jurassic of Jumara, Kutch, India. *Geol. Blätt. Nord-Bayer.*, v.43, pp.227-246.
- DATTA, K., BHAUMIK, D., JANA, S.K. and BARDHAN, S. (1996) Age, ontogeny and dimorphism of *Macrocephalites triangularis* Spath- the oldest Macrocephalitid Ammonite from Kutch, India *Jour. Geol. Soc. India*, v.47, pp.447-458.
- FÜRSICH, F.T., OCHMANN, W., JAITLY, A.K. and SINGH, I.B. (1991) Faunal response to transgressive-regressive cycles: examples from the Jurassic of western India. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* v.85, pp.149-159.
- GAUR, K.N. and TALIB, A. (2009) Middle-Upper Jurassic foraminifera from Jumara Hills, Kutch, India. *Rev. Micropaleontol.*, v.52, pp. 227-248.
- JAIN, S. (1997) On the earliest occurrence of Genus *Phlycticeras* Hyatt in Kachchh, Western India. *J. Geol. Soc. India*, v.49, pp.75-80.
- JAIN, S. (1998) On some new discoveries of subfamily Bullatimorphatinae from the Lower Chari sediments of Kachchh, W. India. *J. Geol. Soc. India*, v.43, pp.107-118.
- JAIN, S. (2002) Middle Jurassic Ammonite Biozonation in Western India: global implications. *Geol. Soc. America Ann. Meet.*, Colorado, Paper No.141-10, p.34.
- JAIN, S. and PANDEY, D.K. (1997). Revision of the age of heteromorph ammonite *Parapatoceras* from Kachchh, Western India. *J. Pal. Soc. India*, v.42, pp.133-139.

- JAIN, S. and PANDEY, D.K. (2000) Middle Jurassic Ammonite Biozonation in Kachchh, western India. Bull. Ind. Geol. Assoc., v.33, pp.1-12.
- JAIN, S., CALLOMON, J.H. and PANDEY, D.K. (1996) On the earliest known occurrence of the Middle Jurassic ammonite genus *Reineckeia* in the Late Bathonian of Jumara, Kachchh, Western India. Paläontol. Zeitsch., v.70, pp.129-143.
- KALANTARI, A. (1969) Foraminifera from the Middle Jurassic-Cretaceous successions of Koppet-Dagh Region (N.E. Iran). Nat. Iran. Oil Co., Geol. Lab., Publ. No. 3, pp.1-298.
- KRISHNA, J. and CARIOU, E. (1990) Ammonoid faunal exchanges during Early Callovian between the Indo-East African and Submediterranean Provinces: implication for the long distance east-west correlation. Newslet. Strat., v.23, pp.109-122.
- KRISHNA J. and CARIOU, E. (1993) The Tethyan Macrocephalitinae: evolutionary environmental and dispersal strategies. Geobios, v.15, pp.217-226.
- KRISHNA, J. and OJHA, J.R. (1996) The Callovian Ammonoid chronology in Kachchh, W. India. GeoRes. Forum, v.1-2, pp.151-165.
- KRISHNA, J. and OJHA, J.R. (2000) The intrabasinal correlation in the Middle Jurassic Callovian Stage of Kachchh (Gujarat) and Ammonoids-Foraminifer integration. Geophytology, v.28, pp.101-120.
- KRISHNA, J. and WESTERMANN, G.E.G. (1985) Progress report on the Middle Jurassic ammonite zones of Kachchh, W. India. Newslet. Strat., v.14, pp.1-11.
- KRISHNA, J. and WESTERMANN, G.E.G. (1987) The faunal associations of the Middle Jurassic ammonite genus *Macrocephalites* in Kachchh, Western India. Canad. Jour. Earth Sci., v.24, pp.1570-1582.
- KRISHNA, J., CARIOU, E. and ENAY, R. (1998) Succession of Macrocephalitinae assemblages as revealed at Keera in Kachchh, Western India. Proc. II Int. Symp. Jur. Strat., 1989, pp.383-394.
- KRISHNA, J., PANDEY, B. and OJHA, J.R. (2009a) *Gregoryceras* in the Oxfordian of Kachchh (India): Diverse eventful implications. Geobios, v.42, pp.197-208.
- KRISHNA, J., PANDEY, B. and PATHAK, D.B. (2009b) Characterization of *Dichotomoceras* in the Oxfordian of Kachchh. J. Geol. Soc. India, v.74, pp.469-479.
- PANDEY, D.K. and CALLOMON, J.H. (1995) Contribution to the Jurassic of Kachchh, Western India. III. The Middle Bathonian ammonite families Clydoniceratidae and Perisphinctidae from Pachchham Island. *Beringeria*, v.16, pp.125-145.
- PANDEY, J. and DAVE, A. (1993) Studies in Mesozoic foraminifera and chronostratigraphy of Western Kutch, Gujarat. Paleontographica Indica, no.1, pp.1-221.
- PRASAD, S. (1993) A note on the Middle Jurassic stratigraphic succession of Keera, Kachchh District, Gujarat. J. Geol. Soc. India, v.41, pp.156-161.
- PRASAD, S. (1998) Ammonite Biozonation of the Middle-Late Jurassic sediments with special reference to Keera and Jara, Kachchh district, Gujarat. J. Geol. Soc. India, v.52, pp.25-40.
- RAI, J. and JAIN, S. (2012) Early Jurassic Gondwanaland Break up - A nannofossil Story. DST Sponsored Field Workshop and Brainstorming Session on 'Geology of Kachchh Basin, Western India: Present Status and Future Perspectives', 2012, Kachchh University, Bhuj, Kachchh (Abstract).
- ROY, P., BARDHAN, S., MITRA, A. and JANA, S.K. (2007) New Bathonian (Middle Jurassic) ammonite assemblages from Kutch, India, J. Asian Earth Sci., v.30, pp.629-651.
- 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

- and evolutionary significance. *J. Asian Earth Sci.*, v.25, pp.679-685.
- SHOME, S. and BARDHAN, S. (2007) Genus *Himalayites* (ammonoidea) from the Upper Tithonian of Spiti Himalaya - a systematic revision of Uhlig's (1910) material. *J. Pal. Soc. India*, v.52, pp.217-224.
- SHOME, S. and BARDHAN, S. (2009) A New Late Tithonian ammonite assemblage from Kutch, Western India. *J. Pal. Soc. India*, v.54, pp.1-18.
- SINGH, C.S.P., JAITLEY, A.K. and PANDEY, D.K. (1982) First report of some Bajocian-Bathonian (Middle Jurassic) ammonoids, and age of the oldest sediments from Kachchh (Gujarat), India. *Newslet. Strat.*, v.11, pp.37-40.
- SPATH, L.F. (1924) On the Blacke collection of ammonites from Kutch, India. *Palaeontol. Indica*, New Ser. 9, Mem.2.
- SPATH, L.F. (1927-33) Revision of the Jurassic Cephalopod fauna of Kachh (Cutch): *Mem. Geol. Surv. Ind. Palaeontol. Indica*, New Ser. 9, Mem. 2, pp.1-945.
- TALIB, A. and BHALLA, S.N. (2006) Composition and age of the foraminiferal assemblage from Chari Formation, Jhurio hill, Kutch. *Ind. Jour. Pet. Geol.*, v.15, pp.67-81.
- TALIB, A. and GAUR, K.N. (2008) Foraminiferal composition and age of the Chari Formation, Jumara Dome, Kutch. *Curr. Sci.*, v.95: pp.367-373.
- TALIB, A., GAUR, K.N. and BHALLA, S.N. (2007) Callovian-Oxfordian boundary in Kutch Mainland, India-A foraminiferal approach. *Rev. Paléobiol.*, v.26, pp.625-630.
- TALIB, A., GAUR, K.N., SISODIA, A.K., BHAT, B.A. and IRSHAD, R. (2012) Foraminifera from Jurassic sediments of Keera Dome, Kutch. *J. Geol. Soc. India*, v.80, pp.667-675.
- TALIB, A., WASIM, S.M., SABEEHA AND ARKAN, M. (2016). Jurassic foraminifera from the Dharang Member, Habo Formation, Habo dome, Kutch, India: systematics, age, palaeoecology and palaeobiogeography. *J. Syst. Palaeontol.*, pp.1-24 (online).
- WAAGEN, W. (1873-75) Jurassic fauna of Kutch. *The Cephalopoda: Mem. Geol. Surv. Ind., Palaeontologica Indica*, New Series 914, pp.1- 247.