



CALLIPHYLLOCERAS HETEROPHYLLOIDES (OPPEL, 1856) FROM THE BASALMOST JURASSIC SUCCESSION OF SADHARA DOME, KACHCHH, INDIA

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ABSTRACT

We record and illustrate a septate (85 mm D) *Calliphyloceras heterophylloides* (Oppel, 1856) from the basalmost sediments of Sadhara Dome near the eastern end of Goradongar, Patcham 'Island', Kachchh, India. This is the oldest ammonoid-bearing horizon of the exposed Mesozoic sediments in the Kachchh Basin. In view of the correlation of the Late Bajocian *Leptosphinctes* bed of Kaladongar to the base of bed 32 of our column which is about 164 m younger than the *Calliphyloceras*-bearing bed 2, the age of present *Calliphyloceras*-bearing horizon is suggested here as Early Bajocian or older.

Keywords: Jurassic, ammonoids, *Calliphyloceras*, Sadhara, Kachchh

INTRODUCTION

The extremely rich ammonoid record from the Jurassic of Kachchh (Fig. 1), known through the early works of Sowerby (1840), Waagen (1871, 1873-75) and Spath (1924, 1927-33), makes Kachchh the most important Jurassic locality on the Gondwanian Tethyan Margin (GTM) between N. Africa to NW Australia. These early works were mostly restricted to the Callovian-Tithonian ammonoids, and unfortunately also lacked the required stratigraphic precision. In recent decades, Krishna and co-workers (Krishna, 2005; Krishna *et al.*, 1996a,b, 1998, 2000, 2009a,b,c, 2011; Krishna and Ojha, 1996; Krishna and Pathak, 1991, 1993; Pandey *et al.*, 2010) have developed highly refined zonal schemes in the four stages of the Callovian-Tithonian interval. It may be noted that the exposed pre-Callovian sediments in Kachchh are a few hundred meters thick in several sections spread throughout the basin. These, however, were considered invariably devoid of ammonoids. In the 1980s, Middle and Late Bathonian ammonoids were discovered (Singh *et al.*, 1982, 1983; Pandey *et al.*, 1984; Agrawal and Pandey, 1985; Krishna and Cariou, 1993; Krishna and Pathak, 1994) along with a single Late Bajocian *Leptosphinctes* (Jaitly and Singh, 1983). According to Fürsich *et al.* (2001), the Late Bajocian *Leptosphinctes* bed is traceable laterally for over 100 kms in the basin. It is also to be mentioned that the second example of *Leptosphinctes* or of any other Bajocian ammonoid is not yet known in spite of a few hundred meters pre-Late Bajocian exposed succession in several stratigraphic sections, particularly in the island belt close to the northern margin of the basin.

Against this background, our present ammonoid find from the basal bed at Sadhara, in spite of its limitations in context of definite age assignment, is considered extremely significant from various geological angles. The said ammonoid has recently been found in early 2011 field season, while sampling the Sadhara stratigraphic section for magnetostratigraphic studies. The ammonoid in question came from the bed No. 2 (ca 3 m above the exposed base, Fig. 2) of the Sadhara stratigraphic section.

LITHOSTRATIGRAPHIC REMARKS

The Sadhara Dome of Patcham 'Island' is located in the north of village Sadhara, about 15 km east of a small town Khavda (Fig. 1). It is a nearly circular dome with its exposed centre along small cliffs and stream beds. The oldest lithostratigraphic classification for Mesozoic sedimentary succession of Kachchh Basin (inclusive of Patcham 'Island') is of Stoliczka in Waagen (1871, 1873-75) which includes the organization of entire Mesozoic sedimentary record into four units as Patcham, Chari, Katrol and Umia in ascending order. This scheme of Stoliczka has been subjected to a few minor modifications by later workers of the Kachchh Mesozoic. Later other workers (Biswas, 1977; Pandey *et al.*, 1984; Fürsich *et al.*, 1994, 2001, etc.) during their studies of sedimentary succession of Patcham 'Island' gave their own lithostratigraphic nomenclatures instead of using the scheme of Stoliczka which resulted in a considerable confusion, particularly among young researchers due to increasing multiplicity of lithostratigraphic unit names. However, the majority of workers on Kachchh Mesozoic continue to use Stoliczka's scheme. The top of Patcham Formation is clearly marked by marker limestone beds in the entire Kachchh Basin (Raimalro Limestone in Island and equivalent limestones in the Mainland), while base is unexposed.

The succession at Sadhara Dome up to Raimalro Limestone (Fig. 2) is thus included here in the Patcham Formation (includes Kaladongar Formation and Goradongar Formation only up to Raimalro Limestone Member of Biswas, 1977; both Khavda Formation and Patcham Formation of Fürsich *et al.*, 1994, 2001); however, the early part of the Chari Formation (Modar Hill Member of the Goradongar Formation of Biswas, 1977 and Macrocephalus Beds of the Chari Formation of Fürsich *et al.*, 1994, 2001) is also exposed. About 248 m thick sedimentary succession of the Patcham Formation (Fig. 2) is developed here between two marker limestone beds - Coral Limestone at the exposed base and Raimalro Limestone at the top. The entire sedimentary record between these two limestone beds is a predominantly siliciclastic succession intercalated with a few carbonate and mixed siliciclastic-carbonate rocks which are poorly fossiliferous, occasionally yielding bivalves, corals, gastropods and extremely rare ammonoids.

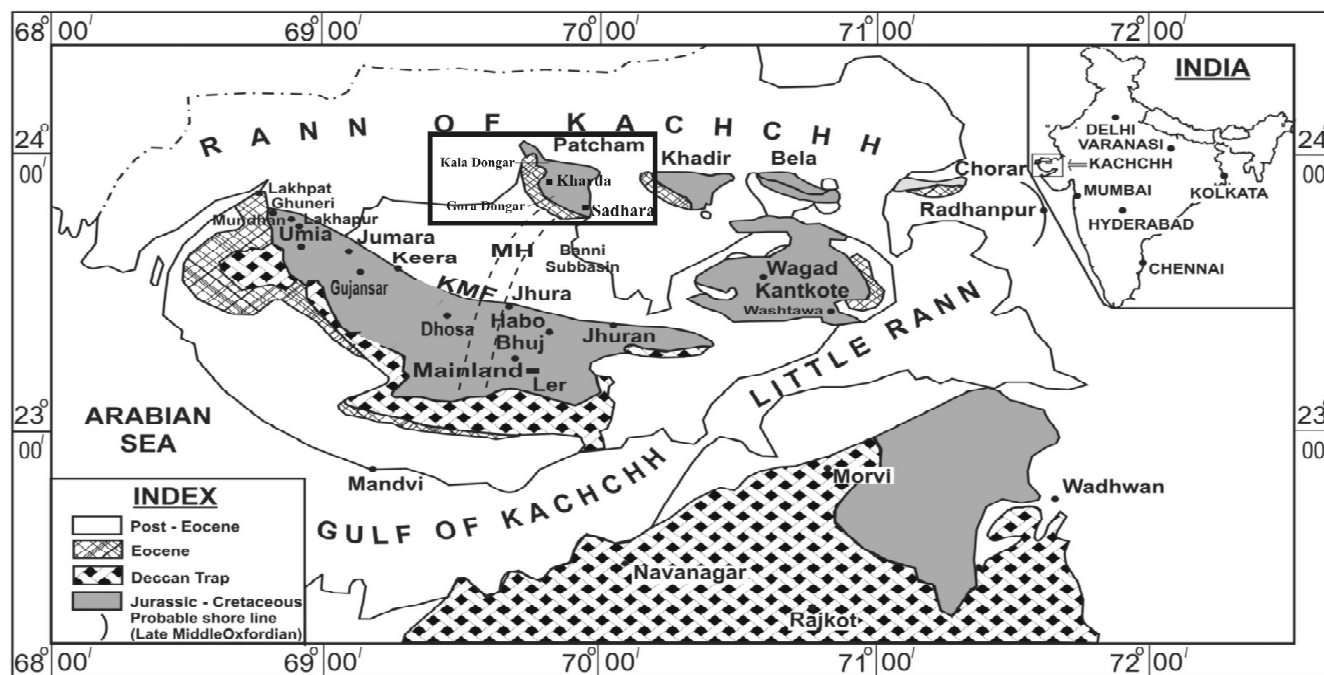


Fig. 1. Schematic geological map of Kachchh with important Jurassic localities.

SYSTEMATIC PALAEOONTOLOGY

Suborder **Phylloceratina** Arkell, 1950

Superfamily **Phyllocerataceae** Zittel, 1884

Family **Phylloceratidae** Zittel, 1884

Subfamily **Calliphylloceratinae** Spath, 1927

Genus **Calliphylloceras** Spath, 1927

(Type Species: *Phylloceras disputabile* Zittel, 1869)

Calliphylloceras heterophylloides (Oppel, 1856)

(Pl. I, figs. 1-3)

Ammonites heterophylloides Oppel, 1856, p. 373.

Phylloceras heterophylloides (Oppel), Neumayr, 1871, p. 331, pl.15, figs. la-c. - Bayle, 1878, pl. 42, figs. 1, 2, 5-8. - Roman & Gennevaux, 1912, p. 94.

Phylloceras gr. de *P. heterophylloides* (Oppel), Roman & Pétouraud, 1927, p. 16, pl. 2, figs. 9,10.

Calliphylloceras heterophylloides (Oppel), Joly, 1977, p.213, pl. 10, figs. 2,3,7, pl.11, figs.1-5,9 pl. 12, figs. 1,6,7, pl. 21 figs. 1,3, pl. 44, figs. 5-10, pl. 45, figs. 1-4, 12a,b, pl. 50, figs. 1a,b,2, figs. 89-95.

Calliphylloceras cf. *heterophylloides* (Oppel), Rulleau, 1998, p.31.

Calliphylloceras? sp. Rulleau, 1998, p.32, pl.7, fig. 1a,b.

Calliphylloceras disputabile (Zittel, 1869), *heterophylloides* (Oppel, 1856), - Joly, 2000, p. 79, pl. 17, fig. 4, pl. 18 figs. 1a,b, figs. 164-165

Lectotype: Designated by Joly (1977, p. 213) from Saint-Vigor near Bayeux (Calvados)

Material: Single specimen, No. SD2/1/2011

Horizon: Bed No. 2 (3 m above the exposed base, Fig. 2)

Locality: Core of Sadhara Dome, Patcham 'Island', Kachchh.

Dimensions (in mm):

| D | U | H | W | W/H % |
|----|----|----|------|-------|
| 85 | 06 | 47 | ? 33 | ? 70 |
| 60 | - | 33 | 21 | 63 |

(D = Diameter, U = Umbilicus, H = Whorl height, W = Whorl width)

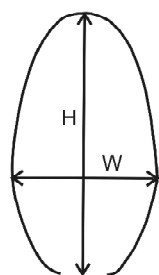
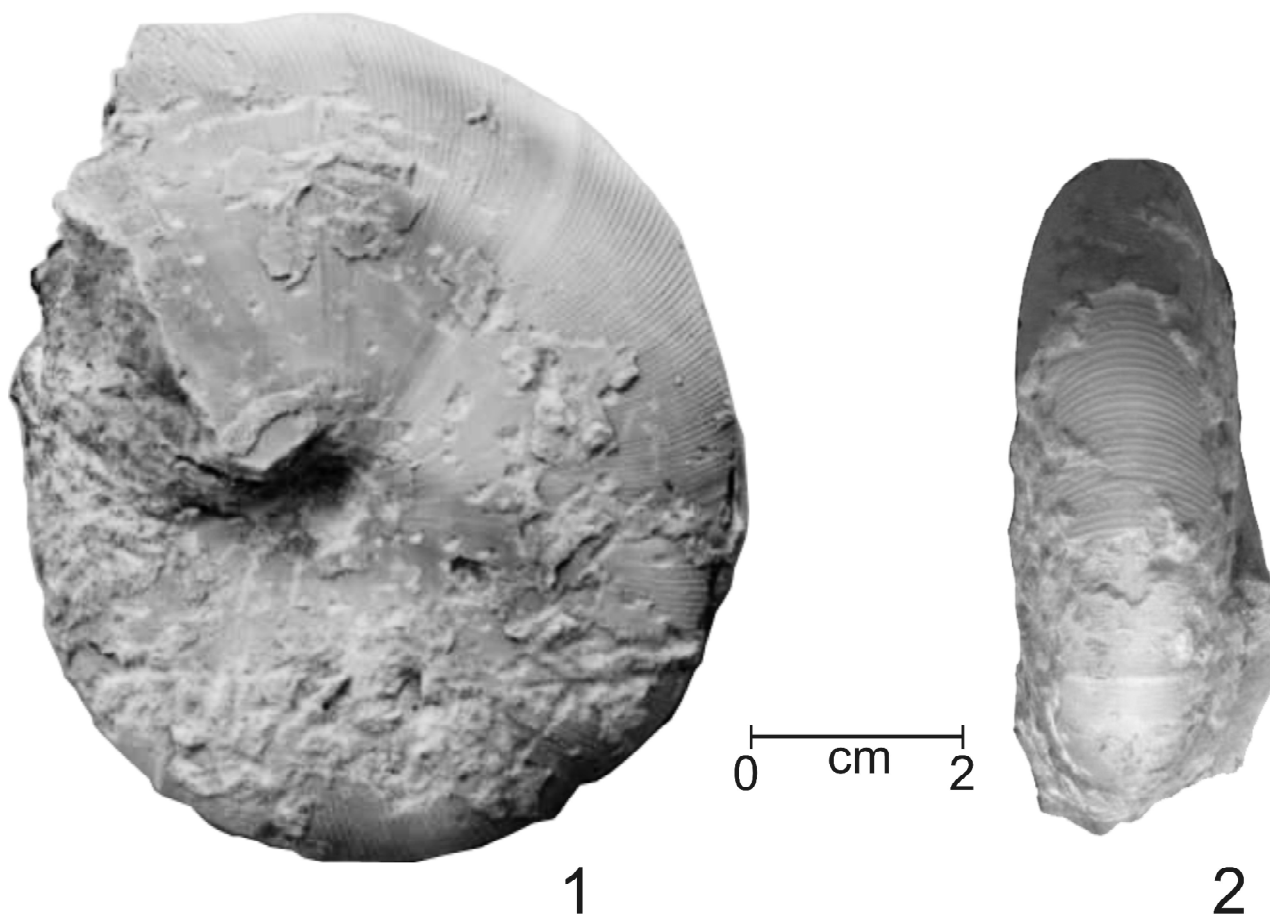
Description: Size 85 mm D, entirely septate, compressed, whorl section elliptical, maximum whorl thickness immediately below the mid laterals, strongly involute, umbilicus narrow and deep, umbilical wall steep to vertical, umbilical shoulder rounded, laterals broadly convex, ventre curved, 4 feeble constrictions on last preserved whorl, each constriction preceded by ventral ridge, ribs/flare fine, dense, from near umbilical margin, prorsiradiate on laterals, projected forward and uninterrupted on the ventre, suture undecipherable.

Remarks: The present specimen resembles *Calliphylloceras heterophylloides* (Oppel, 1856, p. 213) and *Calliphylloceras disputabile* (Zittel, 1869) *heterophylloides* (Oppel, 1856) Joly 2000, p. 79, Pl. 17, fig 4, Pl. 18 figs. 1a,b, figs. 164 and 165 in morphology, ornamentation and whorl section. It is also comparable with *Calliphylloceras disputabile* (Zittel, 1869) except for maximum whorl thickness at umbilical shoulder and little more compressed whorl section in the latter. We agree with Joly (2000) that it is very difficult to separate *C. disputabile* (Zittel, 1869) from *C. heterophylloides* (Oppel, 1856) with certainty. In fact these could be extreme variants of a single species. *C. achtalense* (Redlich, 1894) differs from the present specimen in having more constrictions per whorl, maximum whorl thickness at umbilical shoulder and subrectangular whorl section at comparable diameter (phragmocone).

EXPLANATION OF PLATE I

Calliphylloceras heterophylloides (Oppel, 1856), Bed No. 2, Sadhara Dome, eastern Goradongar, Patcham 'Island', Kachchh.

1. Lateral view, 2. Ventral view, 3. Whorl Section



D 60 mm
H 33 mm
W 21 mm

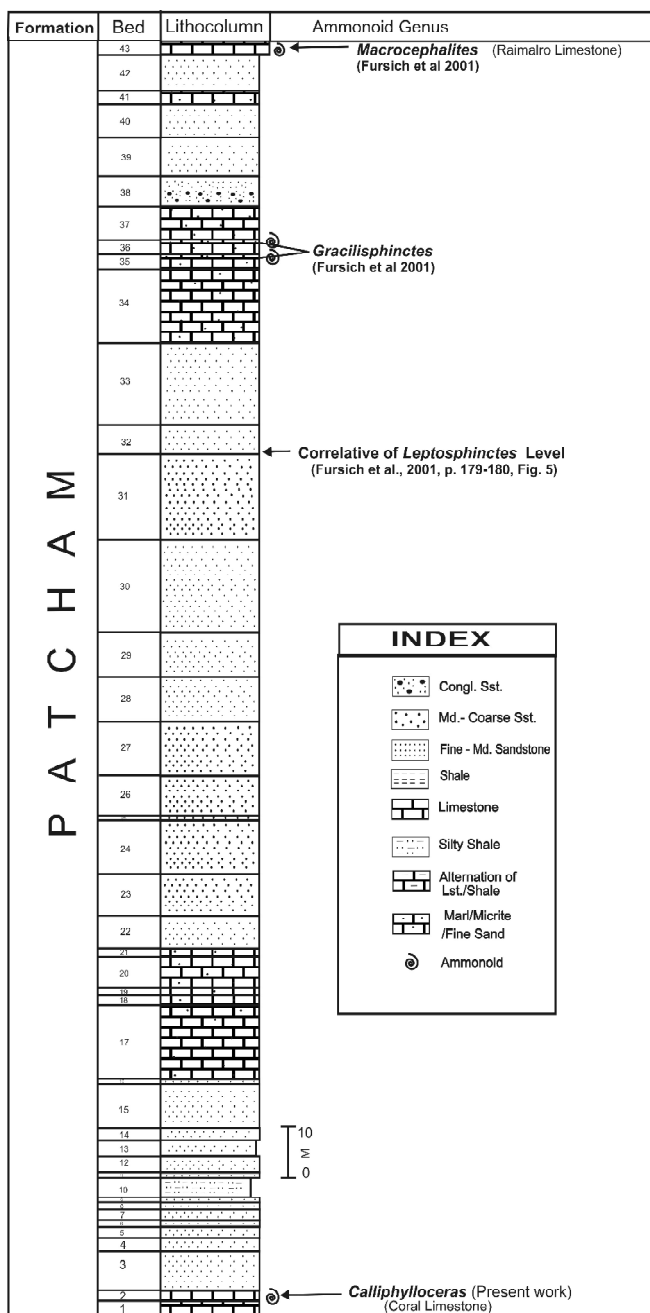


Fig. 2. Lithocolumn of the Patcham Formation at Sadhara Dome, eastern Goradongar, Patcham 'Island', Kachchh.

GEOGRAPHIC DISTRIBUTION AND AGE

Calliphylloceras heterophylloides (Oppel, 1856) is so far known from Humphriesianum Zone, of latest Early Bajocian or Parkinsoni Zone of latest Late Bajocian age (Joly, 2000) from France. *Leptospinctes* of Late Bajocian age recorded by Jaitly and Singh (1983) from Kaladongar of Patcham 'Island' has been the oldest ammonoid known so far from Kachchh. Fursich *et al.* (1994, 2001) have correlated the *Leptospinctes*-bearing bed of Jaitly and Singh (1983) with the 0.5 m thick basal unit E1-a of the Goradongar Yellow Flagstone Member at Sadhara Dome section which, in our lithostratigraphic column, lies at the base of the bed 32 (Fig. 2). The *Calliphylloceras heterophylloides* (Oppel, 1856) recorded here is from the coral-

rich limestone bed (bed 2 of Fig. 2) which is ca 164 m below bed 32. This ca 164 m succession in sequence stratigraphic context includes at least one 2nd order sequence of Early Bajocian age. Thus, the present record of *Calliphylloceras heterophylloides* is here best assigned to Early Bajocian, however, it could be even older than Bajocian age.

CONCLUSIONS

The prime significance of the present research is the discovery of the oldest ammonite-bearing level in the entire exposed Mesozoic sedimentary succession of the Kachchh Basin. The age of the present record of *Calliphylloceras heterophylloides* is either Early Bajocian or older. Since still older sediments are exposed in nearby Kaladongar locality (Biswas, 1977; Fursich *et al.*, 2001; Pandey and Dave, 1993), Aalenian or even Toarcian age of the oldest exposed sediments in the Kachchh Basin in the Dingy Member (Biswas, 1977) cannot be ruled out in particular context of recent record of in situ Aalenian–Toarcian coccoliths from the Dingy Member (Rai and Jain, 2012).

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REFERENCES

- Agrawal, S.K. and Pandey, D.K. 1985. Biostratigraphy of the Bathonian – Callovian beds of Goradongar in the Pachchham "Island", District Kachchh (Gujarat). *Proceedings of the Indian National Science Academy*, A 51 : 887-903.
- Arkell, W.J. 1950. A classification of the Jurassic ammonites. *Journal of Paleontology*, 24 : 354-364.
- Biswas, S.K. 1977. Mesozoic rock stratigraphy of Kutch. *Quarterly Journal of Geological Mining and Metallurgical Society of India*, 49 (3 & 4) : 1-52.
- Bayle, E. 1878. Fossiles principaux des terrains. Atlas. *Mémoire pour servir à l'explication de la carte géologique détaillée de la France*, 4, 1ère partie.
- Fursich, F.T., Pandey, D.K., Callomon, J.H., Oschmann, W. and Jaitly, A.K. 1994. Contributions to the Jurassic of Kachchh, western India. II. Bathonian stratigraphy and depositional environment of the Sadhara Dome, Pachchham Island. *Beringeria*, 12 : 95-125.
- Fursich, F.T., Pandey, D.K., Callomon, J.H., Jaitly, A.K. and Singh, I.B. 2001. Marker beds in the Jurassic of the Kachchh basin, Western India: their depositional environment and sequence-stratigraphic significance. *Journal of the Palaeontological Society of India*, 46 : 173-198.
- Hyatt, A. 1887. The fossil cephalopods of the Museum of Comparative Zoology. *Bulletin of the Museum of Comparative Zoology, Harvard University*, 1 : 71-102.
- Jaitly, A.K. and Singh, C.S.P. 1983. Discovery of Late Bajocian *Leptospinctes* BUCKMAN (Jurassic Ammonitina) from Kachchh, Western India. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 2 : 91-96.
- Joly, B. 1977. Les Phylloceratidae malgaches au Jurassique. Généralités sur quelques Phylloceratidae et quelques Juraphyllitidae. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon*, 67: 1- 471.
- Joly, B. 2000. Les Juraphyllitidae, Phylloceratidae, Neophylloceratidae (Phylloceratataceae, Phylloceratine, Ammonoidea) de France au Jurasique et au Crétacé, *Geobios*, n.s., 174 : 1-202.
- Krishna, J. 2005. Update on Kachchh Jurassic Ammonoid Zonation: Summarised Intra-Basinal to Global Perspectives, p. 63-68. In:

- Supplementary Publication* (Eds. Raju, D.S.N. *et al.*), Association of Petroleum Geologists, India.
- Krishna, J. and Cariou, E.** 1993. The Tethyan Macrocephalitinae: Evolutionary, Environmental and Dispersal Strategies, *Geobios* m.s. **15** : 227-236.
- Krishna, J. and Ojha, J.R.** 1996. The Callovian Ammonoid Chronology in Kachchh (India). *GeoResearch Forum*, **1-2** : 151-166.
- Krishna, J., Pandey, B. and Ojha, J.R.** 2009a. *Gregoryceras* in the Oxfordian of Kachchh (India): diverse eventful implications. *Geobios*, **42**: 197-208.
- Krishna, J., Pandey, B., Ojha, J.R. and Pathak, D. B.** 2009b. Reappraisal of the age framework, correlation, environment and nomenclature of Kachchh Mesozoic Lithostratigraphic Units in Wagad. *Journal of Scientific Research, Banaras Hindu University, Varanasi*, **53**: 1-20.
- Krishna, J., Pandey, B. and Pathak, D. B.** 2009c. Characterization of *Dichotomoceras* in the Oxfordian of Kachchh (India). *Journal Geological Society of India*, **74** : 469 -479.
- Krishna, J., Pandey, B. and Pathak, D. B.** 1996a. Ammonoid Chronology in the Tithonian of Kachchh (India). *GeoResearch Forum*, **1-2**: 205-214.
- Krishna, J., Pathak, D. B. and Pandey, B.** 1996b. Quantum Refinement in the Kimmeridgian Ammonoid Chronology in Kachchh (India). *GeoResearch Forum*, **1-2**: 195-204.
- Krishna, J., Pandey B. and Pathak D. B.** 2011. Current Status of the Jurassic ammonoid Stratigraphic Framework in the Indian Subcontinent with Focus on the Tectonically Controlled Regional Transgressive – Regressive Couplets. *Journal of Geological Society of India, Mem.* **78**: 140-176.
- Krishna, J. and Pathak, D. B.** 1991. Ammonoid Biochronology of the Kimmeridgian Stage in Kachchh, India. *Journal of the Palaeontological Society of India*, **36**: 1-13.
- Krishna, J. and Pathak, D. B.** 1993. Late Lower Kimmeridgian – Lower Tithonian virgatospinctins of India: Evolutionary succession and biogeographic implications. *Geobios*, m.s. **15** : 217-226.
- Krishna, J. and Pathak, D. B.** 1994. Stratigraphic, Biogeographic and Environmental Signatures in the Ammonoid Bearing Jurassic - Cretaceous in the Himalaya on the South Margin of the Tethys. *Journal of Himalayan Geology*, **4(2)**: 151-167.
- Krishna, J., Pathak, D.B. and Pandey, B.** 1998. Development of Oxfordian (Early Upper Jurassic) in the most proximal exposed part of Kachchh basin at Wagad outside the Mainland Kachchh. *Journal Geological Society of India*, **52** : 513-522.
- Krishna, J., Pathak, D. B., Pandey, B. and Ojha, J.R.** 2000. Transgressive sediment intervals in the Late Jurassic of Kachchh, India. *GeoResearch Forum*, **6**: 331-332.
- Neumayr, M.** 1871. Jurastudien 3 – Phylloceraten der Dogger und Malm. *Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt*, **21**: 297-378.
- Oppel A.** 1856. Dei Juraformation Englands Frankreichs und Südwestlichen Deutschlands. *Abdruck des Würternbergen naturwissen-schaftlichen Jahreshefte*, **12-14**: 1- 857.
- Pandey B., Krishna, J. and Pathak D.B.** 2010. Review of the ammonoid subfamily Virgatospinctinae with special reference to its evolutionary succession in the Indian subcontinent on the Gondwanian Tethyan margin. *Journal of Scientific Research, Banaras Hindu University, Varanasi*, **54(1&2)** : 21-34.
- Pandey, D.K., Singh, C.S.P. and Agrawal S.K.** 1984. A note on the new fossil find from Goradongar Pachchham "Island", district Kachchh (Gujarat). *Journal of Scientific Research, Banaras Hindu University*, **34(1)**: 299-310.
- Pandey, J and Dave, A.** 1993. Studies of Mesozoic Foraminifera and chronostratigraphy of western Kachchh, Gujarat. *Paleontographica Indica*, **1** : 1-221.
- Rai, J. and Jain, S.** 2012. Early Jurassic Gondwanaland Break up – A Nannofossil Story. National Level Field based Workshop on Geology of Kachchh Basin, western India: Present Status and Future Perspectives, *Department of Earth and Environmental Science, KSKV Kachchh University, Bhuj, Kachchh (India)* Abstracts : 84-85.
- Redlich, K.A.** 1894. Der Jura der Umgebung von Alt-Achtala, ein Beitrag zur Kenntnis des Jura der Kaukasus-Länder. *Beiträge Paläontologie und Geologie österreich-Ungarns und des Orients*, **9** : 55-81.
- Roman, F. and Gennevaux, M.** 1912. Etudes sur les terrains jurassiques de la region du Pic St. Loup. *1er fasc. Jurassique inférieur et moyen. Librairie Louis Vallat, Montpellier* : 1-120.
- Roman, F. and Pétouraud, Ch.** 1927. Etude sur la faune du Bajocien Supérieur du Mont-d'Or Lyonnais (Ciret). 1. Céphalopodes. *Documents des Laboratoires de géologie de la Faculté des Sciences de Lyon*, **11(9)** : 1-7.
- Rulleau, L.** 1998. Evolution et systématique des Phylloceratidae et des Lytoceratidae du Toarcien et du Dogger inférieur de la region lyonnaise. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon*, **149** : 1-167
- Singh, C.S.P., Jaitly, A.K. and Pandey, D.K.** 1982. First report of some Bajocian - Bathonian (Middle Jurassic) ammonoids and the age of the oldest sediments from Kachchh, Western India. *Newsletters on Stratigraphy*, **11(1)**: 37-40.
- Singh, C.S.P., Pandey, D.K. and Jaitly, A.K.** 1983. Discovery of *Clydoniceras* Blake and *Gracilisphinctes* Buckman (Bathonian – Middle Jurassic ammonites) in Kachchh, western India. *Journal of Paleontology*, **57(4)**: 821-824.
- Sowerby, J.** 1840. A notice respecting some fossils collected in Kutch. *Transaction of the Geological Society London*, **2**, **5(3)**: 715-719.
- Spath, L. F.** 1924. On the Blake collection of ammonites from Kachh. *Paleontologia Indica, Geological Survey of India, Calcutta*, **9(1)** : 1-29.
- Spath, L. F.** 1927-33. Revision of the Jurassic Cephalopod fauna of Kachh (Kutch). *Paleontologia Indica, Geological Survey of India, Calcutta*, **9(2)**: 1-945.
- Waagen, W.** 1871. Abstract of results of examination of the ammonite fauna of Kutch with remarks on their distribution among the beds and probable age. *Record of Geological Survey of India*, **4(4)**: 89-101.
- Waagen, W.** 1873-75. Jurassic fauna of Kutch Cephalopoda. *Paleontologia Indica, Calcutta*, **9(1)**: 1-247.
- Zittel, K.A.** 1869. Bemerkungen über Phylloceras taticum Pusch sp. uneinige andere Phylloceras-Arten. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, **19**: 59-68.
- Zittel, K.A.** 1884. Handbuch der Paleontologie, Cephalopoden. *R. Oldenbourg édit., München et Leipzig*, **2**: 329-522.

