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Callovian−Oxfordian hecticoceratins from western India: Their biostratigraphic and palaeobiogeographic implications

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Abstract The Kutch Basin of western India is famous for its rich assemblages of the Callovian−Oxfordian ammonites. The family Oppelidae Douvillé is the second most diverse ammonite group after perisphinctids during the Middle−Upper Jurassic. Hecticoceratinae is the most diverse subfamily within Oppelidae and has wide palaeobiogeographic (near cosmopolitan) and temporal distributions (Bathonian−Oxfordian). Some species were well time-diagnostic and thus help in interprovincial correlation. The taxonomy of the subfamily Hecticoceratinae of Kutch was in a state of flux until recently. It was not revised since Spath's (1927−1933) great contribution. Many genera and species were morphogenera or morphospecies and they again suffer from excessive subjective splitting. It was therefore badly needed for a comprehensive taxonomic revision of the subfamily with modern aspects of systematics *i.e.*, sexual dimorphism and population dynamics. A lithostratigraphic framework has already been well documented in the Kutch Basin of western India. A high resolution biostratigraphy incorporating stage-intrastage fossil assemblages have been used in interbasinal correlation based on the Callovian−Oxfordian hecticoceratins. Near cosmopolitan distribution of many hecticoceratin genera were widely used for biostratigraphic zonation as well as an understanding of the palaeobiogeographic pattern. The phylogeny of the subfamily Hecticoceratinae has been used to construct the cladograms depicting area relationships among different provinces during the Callovian−Oxfordian.

Key words Kutch, India, Hecticoceratinae, ammonite, Callovian, Oxfordian, biostratigraphy, palaeobiogeography

1 Introduction

The Oppelidae are the second most diverse ammonite groups after perisphinctids during the Middle−Upper Jurassic. Hecticoceratinae is the most diverse subfamily within oppelids and has a wide palaeobiogeographic and temporal distributions. It is taxonomically well studied in the Mediterranean (Elmi, 1967). This subfamily is known mostly by macroconchs only, although dimorphism has long been recognized (Zeiss, 1956). Elmi (1967) recognized microconchiate groups within Hecticoceratinae but did not establish dimorphic pairs at generic level. In one case, he recognized dimorphism within a genus *i.e.*, *Brightia* s. st. (microconch) and *Brightia* (macroconch), and showed separate evolutionary lineages for each.

Hecticoceras Bonarelli is the type genus of the sub-

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family Hecticoceratinae. It has stratigraphic importance and is widely used to demarcate subzones and horizons. *H*. (*Chanasia*) *michalski* Lewinsky, *H. boginense* Petitclerc, *H. proximum* Elmi and *H*. (*Ch*.) *turgidum* (Loczy) are used as zonal indices for the Michalski, Boginense, Proximum and Turgidum horizons respectively in the Subtethyan Province of Europe (Cariou, 1984). In Kutch, Hecticoceratinae is represented by eight genera ranging from the Middle Bathonian to Lower Oxfordian (see Spath, 1927−1933 and present study). The genus *Hecticoceras* is represented by two species *H. giganteum* Spath and *H*. aff. *turgidum* Loczy which are now synonymised under *H. giganteum*, which ranges from the top of the Lower to basal Middle Callovian in Kutch (see Roy and Bardhan, 2007). I have also addressed sexual dimorphism within *Hecticoceras giganteum* based on additional topotypes and other materials along with type specimens. The nature of sexual dimorphism appears to be differing from that of Oppelinae and *Prohecticoceras*. The microconch is less strongly ornamented and lack primaries on the body chamber (Roy *et al*., 2007). Thus it comes close to *Jeanneticeras* Zeiss, a microconchiate genus described by Elmi (1967) within the Hecticoceratinae. Within the scope of the present work, the taxonomic revision has been done for the Hecticoceratinae of Lower Callovian to Oxfordian of Kutch. Eleven biological species have been described under six genera and sexual antidimorphs are paired within the genera *Kheraites* Spath, *Putealiceras* Buckman, *Sublunuloceras* Spath and *Brightia* Rollier. *Kheraites crassefalcatum* and *K. igobilis* have been paired as sexual antidimorphs; *Putealiceras bisulcatum* a smaller variant with a tricarinate venter has now been paired with *Putealiceras trilineatum*. Sexual dimorphism has also been established within *P. intermedium* [male and female] and *P. vijaya* [male and female]. *Pseudobrightia dhosaensis* an exclusive Lower Oxfordian genus described earlier by Spath (1927−1933) has now been redesignated as *Putealiceras dhosaense*. *Sublunuloceras discoides* Spath, an Upper Callovian hecticoceratin described by Spath (1927−1933) with wide variation in size, I have some recognized smaller variants with a lappet now, so sexual dimorphism have also been addressed. A new species, *Brightia callomoni* has been described from the Upper Callovian−Oxfordian of Kutch, which is identical with Spath′s Brghtia sp. ind. and sexual antidimorphs are recognized. With these revised taxonomic data high resolution biostratigraphy has been addressed and palaeobiogeographic patterns have been analyzed using Brooks Parsimony Analysis (Brooks, 1985, 1990; Wiley, 1988a, 1988b; Wiley *et al*., 1991) on the basis of the phylogeny of the subfamily Hecticoceratinae.

2 Geological setting

The Kutch Basin opened up with the initial fragmentation of Gondwana during the Middle Jurassic and sedimentation began soon due to repeated transgression and regression events (Biswas, 1977). The Jurassic rocks of Kutch range in age from Bajocian to Tithonian and cover nearly half of the area of Kutch, including both the mainland and three ‘islands’ separated by an intervening expanse of salt-flat known locally as the Rann (Figure 1). The regional structure consists of three parallel, NW−SE trending anticlines. The Jurassic rocks are best developed in the central anticline (Wynne, 1872; Rajnath, 1932), situated towards the north of the mainland. These anticlines are superimposed by a set of zones of culmination that crop out as topographical domes, as at Jara, Jumara, Keera and Jhura, which contain the world famous Callovian sequence. The domal outcrops are disturbed by Deccan Trap intrusions and their northern flanks are truncated by an east−west trending fault. The major lithostratigraphic units in ascending order are the Patcham, Chari, Katrol and Bhuj Formations (Mitra, *et al*., 1979; Krishna, 1984). Among these, the Patcham and Chari Formations are present as inliers and are surrounded by the younger Katrol Formation. Despite frequent spatiotemporal facies changes, ammonites are abundant in these two older formations (Jana *et al*., 2005).

The specimens of the present study have been collected from the Jara, Jumara and Keera sections of the Chari Formation. Detailed lithostratigraphic successions of each section, along with the vertical distribution of the major ammonite species are shown in Jana *et al*., (2005, figures 3−5). Significant sedimentological works and detailed facies analyses are now available (Datta, 1992; Fürsich and Oschmann, 1993; Fürsich *et al*., 1994). The Chari Formation is represented by a heterolithic facies association consisting of shale, limestone and sandstone deposited in a mid-shelf environment. The Lower Callovian part of this formation is dominated by shale-limestone (packstone/wackestone) alternations while the base of the Middle Callovian consists of siliciclastics.

Hecticoceratin ammonites are distributed throughout the Patcham and Chari Formations spanning the Middle Bathonian to Oxfordian (see Spath, 1927−1933; Kanjilal, 1980; and Figure 2, Roy, pers. obs.).