The Middle Jurassic
Kheraiceras SPATH 1924
from the Indian Subcontinent

SUBHENDU BARDHAN, SUBRATA K. SARDAR & SUDIPTA K. JANA*)
3 Text-Figures, 3 Tables and 1 Plate

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Kheraiceras SPATH 1924
aus dem Mittleren Jura
des Indischen Subkontinents

Zusammenfassung


Abstract

Kheraiceras SPATH 1924 has a near circumglobal distribution except Subboreal and is marked by a "bio-event" (radiation) especially during the Late Bathonian and Early Callovian time. Such "bio-event" may blur the distinction of faunal provincialism and cut across geographic boundaries and thus help in establishing regional standard chronostatigraphy and interprovincial correlation. The present study reports six Kheraiceras species from the Indian subcontinent (Kutch, India and Baluchistan, Pakistan) including three new species. They are Kheraiceras cosmopolitum (PARONA & BONARELLI), K. bullatum (D’ORBIGNY), K. hannoveranum (ROEMER), K. sp. A, K. sp. B and K. sp. C (= Sphaeroceras bullatum D’ORBIGNY, NOETLING 1896). Biostratigraphic potentialities of Kheraiceras are also explored. Dimorphism is well understood in the genus, but specific dimorphic pairs are poorly known. At least at three instances, matching of pairs has been firmly established and two other new microconchs and one macroconch still lack their partners. Microconchs are of great help in species discrimination, biozonation and understanding evolution.

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1. Introduction

The genus *Kheraiceras*SPATH of the family Tulitidae (BUCKMAN 1921) has a near circumglobal distribution, particularly diverse in the Tethys. Although spanning a longer geologic time (Late Bathonian to Late Callovian, see HAHN [1969, 1971]), *Kheraiceras* is abundant and species-rich between the Late Bathonian and Early Callovian. During this time interval, *Kheraiceras* was distributed in many faunal provinces e.g., along the margins of the Tethys and the Pacific including Indonesia, North and South America (DONOVAN et al., 1981; MANGOLD, 1984; RICCARDI et al., 1989; SANDOWAL et al., 1990; WESTERMANN & RICCARDI, 1979). They are not, however, reported from the Boreal or Subboreal Provinces. This early radiational and migration-al event makes *Kheraiceras* biostratigraphically an important taxon. In many places of the world particularly in Europe (e.g., England), the Lower Callovian standard zonations are based mainly on *Macrocephalites* species in the absence of *Kheraiceras* and reineckeiids (CALLOMON et al., 1989). Submediterranean France (CARIOU, 1984) otherwise is dom-inated by *Kheraiceras* and reineckeiids, and macrocephala-lids are rare, thus making inter-provincial chronostrati-graphic correlation tentative. Kutch in western India is a place where all these taxa co-exist at some levels in great abundance and diversity. Many *Kheraiceras* species are new, while some precisely-dated forms were not known until recently in Kutch. This provides unique opportunity for further improving the resolution of regional standard bio-zonations and intercontinental correlation with some de-gree of confidence.

In the present study, we report six *Kheraiceras* species which include three new forms and two other ones undescribed previously from the subcontinent (for detailed tax-onomy see JANA et al., 2000). Dimorphism is now considered very important in understanding evolution within a lineage and must be taken into account in ammonite sys-tematics. Although dimorphism in *Kheraiceras* is evident, we know little about specific dimorphic pairs (for details see BARDHAN et al., 1994). In the present study we have been able to match pairs at three instances. Besides, there are two new microconchs and one macroconch species whose counterparts are still not known. So far *Kheraiceras* are described in the literature mainly by macroconchs and microconchs are often rare. We have found plentiful microconch specimens with well preserved peristome showing apertural modifications, of most of the species described here. This will be of great help in correlation and age determination.

2. Geological Background

The present *Kheraiceras* spp. are recorded from rocks belonging to the Chari Formation spanning the Upper Bath-onian to Oxfordian. The beds crop out in several structural domes including the present sections i.e., Jumara, Keera and Jhura (Text-Fig. 1). The Chari Formation, one of the four principal divisions of Kutch Mesozoic (see MITRA et al., 1979; KRISHNA, 1984) is a highly fossiliferous, regionally persistent unit. In J umara, the type area of the Chari Formation, the older Patcham Formation is partially ex-posed and the sequence represents a near continuous stratigraphy mainly during the Late Bathonian–Callovian. High resolution facies analysis revealed two different environmental milieus during the deposition of the Patcham and Chari Formations (DATTA, 1992). The Patcham Forma-tion represents sediments of shallow shelf carbonate en-vironment and the Chari Formation represents mid-shelf argillaceous environment (DATTA, 1992; FÜRSICH et al., 1992; FÜRSICH & OSCHMANN, 1993). The Chari Formation constitutes heterolithic facies including shale, sandstone and limestone which is occasionally oolitic. Carbonates, though distributed occasionally throughout the se-quence, are frequent in the lower part.

The specimens of the present *Kheraiceras* spp. have been collected from two sections in the mainland of Kutch i.e., J umara, the type section of the Formation and Keera, the type locality of *Kheraiceras cosmopolitum*. In both areas they are found only in limestone. In J umara, the specimens come from the Lower Chari Formation i.e., beds 4, 5, 6, and 7 of BARDHAN et al. [1994](equivalent to beds 10–21 of CARIOU & KRISHNA, 1988) (Text-Fig. 2). These beds are mainly grey shelly limestone (packstone/grainstone) intercalated with greenish to grey shale and white limestone (mudstone/wackestone) of varying thickness. At Keera, specimens come from bed 2 (BARDHAN et al., 1994) and equivalent to bed 1 of CARIOU & KRISHNA (1988) (Text-Fig. 3). It is a 65 m thick golden coloured oolitic limestone (packstone/grainstone) and characterised by chevron and hummocky cross-stratifica-tion indicating a high energy en-vironment (for detailed lithologic description and environment of deposition, see DATTA, 1992; BARDHAN et al., 1994).
Several standard zonations within the Bathonian–Callovian Stages of Kutch have been attempted and ammonite successions are being continuously revised since Spath (1927–1933). In recent years, several zonal schemes appear for different sections within mainland of Kutch (Mitra et al., 1979; Bardhan & Datta, 1987; Krishna & Westermann, 1987; Cariou & Krishna, 1988). Many of these suffer from lack of adequate control of precise stratigraphic and systematic positions of ammonites and other field data. We have been able to collect specimens bed by bed in many areas other than Jumara and Keera. The inconsistency in understanding quick lateral and temporal variation of different sedimentary facies has now been resolved.

We, here, provide a detailed biostratigraphic subdivision up to the level of faunal horizon for the Upper Bathonian – Lower Callovian Stages of Kutch (Table 1). Kheraiceras distribution is seen against this background. This is based on species of dominant ammonite families which have wide biogeographic distribution and potential for inter-provincial correlation (Tables 2, 3).
Table 1.
The faunal horizons of the Upper Bathonian and Lower Callovian in Kutch, India.

<table>
<thead>
<tr>
<th>Faunal Horizon</th>
<th>Other important species</th>
<th>Localities (Bed no.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XIII M. semilaevis</td>
<td>Subkossmatia opis, K. cosmopolitum, C. cobra, Colliotia ophyctea</td>
<td>7d, Jumara; 1b, Jara</td>
</tr>
<tr>
<td>XII M. formosus</td>
<td>Reinbeckia tyranniformis, K. cosmopolitum</td>
<td>7c, Jumara; 1b, Jara; 2e, 3, Keera</td>
</tr>
<tr>
<td>XI M. (K.) lamellosus</td>
<td>K. cosmopolitum</td>
<td>7b, Jumara; 2e, Keera</td>
</tr>
<tr>
<td>X M. (K.) dimerus</td>
<td>K. bullatum, K. cosmopolitum, C. furcula</td>
<td>7a, Jumara; 2d, Keera; 1a, Jara</td>
</tr>
<tr>
<td>IX K. bullatum</td>
<td>C. recuperoi, K. cosmopolitum</td>
<td>6b, Jumara; 2d, Keera</td>
</tr>
<tr>
<td>VIII M. (L.) diadematus</td>
<td>C. recuperoi</td>
<td>6a, Jumara; 2c, Keera</td>
</tr>
<tr>
<td>VII Kheraiceras cosmopolitum</td>
<td>K. bullatum, K. sp. B</td>
<td>5b, Jumara; 2b, Keera</td>
</tr>
<tr>
<td>VI M. (L.) transition</td>
<td>M. formosus, M. (K) lamellosus, M. (L) diadematus</td>
<td>5a, Jumara; 2a, Keera</td>
</tr>
<tr>
<td>V M. madagascariensis</td>
<td>K. cf. hannoveranum, S. congener</td>
<td>4b, Jumara; 23–27 Jhura</td>
</tr>
<tr>
<td>IV Sivajiceras congener</td>
<td>M. madagascariensis, M. (L) chrysoolithicus</td>
<td>4a, Jumara</td>
</tr>
<tr>
<td>III M. (Indocephalites) chrysoolithicus</td>
<td>S. congener, Choffatia sp.</td>
<td>2,3, Jumara; 1, Keera</td>
</tr>
<tr>
<td>II Macrocephalites triangularis</td>
<td>Epistrenoceras sp. A</td>
<td>1b, Jumara; 15, Jhura</td>
</tr>
<tr>
<td>I Procerites hians</td>
<td>M. triangularis, Epimorphoceras decorum</td>
<td>1a, Jumara</td>
</tr>
</tbody>
</table>

3. Biostratigraphic Subdivision

1) Hians horizon
Procerites hians abundant along with Macrocephalites triangularis (f & m). Epimorphoceras decorum (single specimen, only the holotype) comes from this horizon.
Reference section: Bed 1a, Jumara.

2) Triangularis horizon
M. triangularis (f & m) dominant, P. hians continues. This horizon marks the presence of the typical Late Bathonian genus Epistrenoceras.
Reference section: 1b, Jumara; Bed 15 of Biswas (1977), J hura.

3) Chrysoolithicus horizon
Marked by the first appearance of M. chrysoolithicus and Sivajiceras congener and by the disappearance of M. triangularis and P. hians. Other allied species are Choffatia sp., cf. Oxycerites sp.
Reference section: 2 and 3, J umara; 1, Keera.

4) Congener horizon
S. congener abundant along with M. madagascariensis (f & m) M. chrysoolithicus continues along with Choffatia sp.
Reference section: 4a, J umara.

5) Madagascariensis horizon
M. madagascariensis (f & m) dominant along with S. congener. First appearance of Kheraiceras cf. hannoveranum; M. chrysoolithicus, Choffatia sp. continue.
Reference section: 4b, J umara; 23–27 (Biswas, 1977), J hura.

6) Transitorius horizon
Marks the first appearance of plentiful M. transitorius (f & m) along with M. formosus, M. diadematus, M. lamellosus. Also marked by the disappearance of M. madagascariensis and S. congener while M. chrysoolithicus continues. Choffatia sp. and K. cf. hannoveranum continue.
Reference section: 5a, J umara; 2a of Keera.

7) Cosmopolitum horizon
Marks the first appearance of Kheraiceras cosmopolitum, K. sp. B. and K. bullatum. M. transitorius sparse while other macrocephalitids continue along with Choffatia sp.
Reference section: 5b, J umara; 2b Keera.

8) Diadematus horizon
Reference section: 6a, J umara; lower part of 2c, Keera.

9) Bullatum horizon
K. bullatum (f & m) fairly common. Macroconch is found in Keera and microconch in J umara. Macrocephalitids, C. recuperoi and K. cosmopolitum continue.
Reference section: 6b, J umara; lower part of bed 2d, Keera.

10) Dimerus horizon
Both f (magnumbilicatus) and m (dimerus) variants are common. Other macrocephalitids continue along with K. bullatum and K. cosmopolitum. Choffatia aff. furcula appears. C. recuperoi continues.
Reference section: 7a, J umara; upper part of bed 2d, Keera; bed 1a, J ara.

11) Lamellosus horizon
Abundant M. lamellosus (f & m) while other macrocephalitids continue. K. bullatum disappears. Choffatia recuperoi, K. cosmopolitum continues.
Reference section: 7b, J umara; 2e, Keera.

12) Formosus horizon
Reference section: 7c, J umara; 1b, J ara; 2e and 3, Keera.

13) Semilaevis horizon
Reference section: 7d, J umara; 1b J ara.
Table 2.
Zonation of the Bathonian and Callovian Stages in Kutch, India and its correlation with the East Pacific and Madagascar scale.

<table>
<thead>
<tr>
<th></th>
<th>KUTCH</th>
<th>EAST PACIFIC</th>
<th>ARGENTINA</th>
<th>NORTH CHILE</th>
<th>SOUTH MEXICO</th>
<th>MADAGASCAR</th>
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<td></td>
<td>ZONE</td>
<td>SUBZONE</td>
<td>FAUNAL HORIZON</td>
<td>ZONE</td>
<td>FAUNAL HORIZON</td>
<td>FAUNAL HORIZON</td>
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<td>LOWER</td>
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<td>PROXIMUM</td>
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<td>SEMILAEVIS</td>
<td>M. semilaesus</td>
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<tr>
<td></td>
<td>FORMOSUS</td>
<td>M. formosus</td>
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<tr>
<td></td>
<td>FORMOSUS</td>
<td>M. lamellosus</td>
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<tr>
<td></td>
<td>DIADEMATUS</td>
<td>M. dimerus</td>
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<td>DIADEMATUS</td>
<td>K. cf. bullatum</td>
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<tr>
<td></td>
<td>DIADEMATUS</td>
<td>M. diadematus</td>
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<td></td>
<td>BODENBENDERI</td>
<td>Kheraiceras cosmolitum</td>
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<td>Stehnocephalites</td>
<td>Choffatia</td>
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<td>LITHICUS</td>
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<td></td>
<td>TRIANGULARIS</td>
<td>Macrocephalites triangularis</td>
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<td>(Choffatia aff.</td>
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<td></td>
<td>TRIANGULARIS</td>
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<td>(Prohecticoeceras</td>
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### Table 3.
Zonation of the Bathonian and Callovian Stages in Kutch, India and its correlation with the zones of France, England and Germany.

<table>
<thead>
<tr>
<th>AGE</th>
<th>KUTCH</th>
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<th>GERMANY</th>
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<td>SUBZONE</td>
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<td>H. bogrense</td>
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<td>K. cf. bullatum</td>
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<td>M. transitorius</td>
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<td>Macrocephalites triangularis</td>
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4. Systematic Palaeontology

Family: Tulitidae BUCKMAN 1921
Subfamily: Bullatimorphitinae CALLomon, DIETL & NIEDERHOFER 1992
Genus: Kheraiceras SPATH 1924

*Kheraiceras cosmopolitum* (PARONA & BONARELLI 1895) f & m

(Pl. 1, Figs. 1–4)

It is an endemic form spanning the entire Lower Callovian and recently described in detail (BARDHAN et al., 1994). Shell is sphaeronic with highly inflated phragmocone (width : height = 2.8) and extremely depressed body chamber. It resembles some depressed variants of *K. bul- latum* from other areas (e.g., SANDOVAL et al., 1990, Pl. 9, Fig. 1a–c), but the nature of dimorphism differs. Both macro- and microconch not only have a much inflated phragmocone and depressed aperture but also have a more aberrantly coiled body chamber than those of *K. bul- latum*. Beginning of body chamber is marked by a whorl contraction and peculiar umbilical uncoiling which follows first a straight centrifugal line and then turns suddenly inwards with a U-turn. The microconch has relatively coarse, distant and less numbered secondary ribs than that of *K. bullatum*. The macroconch has feebly primaries which die out rapidly on the outer whorl.

*Kheraiceras bullatum* (D’ORBIGNY 1846) f & m

(Pl. 1, Figs. 5–6)

Macroconch shell medium sized, maximum diameter being about 60 cm. Body chamber ellipticonic, phragmocone relatively less depressed (W/H = 1.04 to 1.8) than that of *K. cosmopolitum*. Umbilicus is narrow with distinct margin and steeper wall. Flanks unlike those of *K. cosmopo- litum* may be wide, flat to gently curved. Width of body chamber contracts maximum at middle part from where it gradually increases while whorl height shows negative allometry with increasing diameter. Ribbing dense and fine in inner whorls, relatively coarse and distant, and restricted to the venter of the adult body chamber. The microconch resembles macroconch in many features, but smaller (f : m = 1.42) with modified aperture. Peristome with slightly flared collar followed immediately by terminal constriction. Ribs prominent, continue till the end.

The macroconchs of the present form are closely allied to the type specimens of *K. bullatum* (D’ORBIGNY) (see ARKELL, 1954, Text- Fig. 34): *K. bullatum* in Europe as well as in S. America is now known from the Late Bathonian. In the Early Callovian (RICCARDI et al., 1989; SANDOVAL et al., 1990). Up the sequence there is a distinct phyletic size decrease as experienced in Kutch as well as in France (see also KRISHNA & CARIQUO, 1990). Our smallest adult macroconch variant comes from the highest level of the stratigraphic range of the species. The smaller adult size of the Kutch form may actually represent transient of younger stratigraphy or may be due to geographic vari-

The microconch resembles the macroconch of *K. bul- latum* of both Kutch and European forms. In Kutch, both dimorphs come from coeval stratigraphic horizons, but significantly, they are mutually exclusive in geographic localities. While all macroconch specimens come from different levels at Keera within the Golden Oolite, the microconchiate forms are found only at J umara in different horizons. This may perhaps imply sexual segregation. *Amonites microstoma* D’ORBIGNY (see ARKELL, 1954, Text- Fig. 35) has a less depressed phragmocone than the present microconch and has gradual Bullatimorphites-like uncoiling of the body chamber.

Recently SANDOVAL et al. (1990) established a dimorphic pair of *K. bullatum* from the Upper Bathonian of Mexico. They described *Bomburites microstoma* as the possible microconch which differs from D’ORBIGNY’s form, but strongly resembles the Kutch variant. One specimen (Pl. 9, 3a–c) in fact, appears to be identical.

*Kheraiceras cf. hannoveranum* (ROEMER 1911) f & m

(Pl. 1, Figs. 7–9)

Macroconch with less inflated (W/H = 1.4) phragmocone and less contracted body chamber. Observed maximum shell diameter being 100 mm. Shell coarsely ornate on body chamber, secondaries broad, distant and convex aborally. The microconch replicates the macroconch except being smaller (f : m = 2). Aperture missing. Both primar- ies and secondaries are coarse, distant and are present till to the end.

It can be distinguished from other species of *Kheraiceras* by its coarsely ornate form, sutural pattern and nature of dimorphism. The present species is morphometrically intermediate between highly depressed *K. cosmopolitum* and relatively compressed *K. bullatum*.

The present Kutch form resembles the lectotype of European *K. hannoveranum* from the Upper Bathonian, Orbis Zone of Germany in having less inflated phragmocone and persistence of strong, coarse ribbing to the end. JAIN et al. (1996) also compared one of the variants (Pl. 1, Fig. 8; see also BARDHAN et al. [1998, Pl. 1, Figs. a–c]) of the present Kutch form with *K. cf. hannoveranum* (ROEMER 1911, Pl. 8, Fig. 1; HAHN 1971, Pl. 7, Fig. 3) and *K. cf. han- noveranum* (MANGOLD 1970, 303 Figs. 96–97, cited in JAIN et al., 1996) from the Upper Bathonian Retrocostatum Zone of Southern Jura. CALLOMON (1993) even showed a resem- bance of the Kutch specimen with *B. costatus* ARKELL (LISSEAU, 1923, p. 18, Fig. 2). But according to him the European form is larger and comes from an earlier zone, while the present form spans the Late Bathonian and the earliest Callovian. However, their close affinity to *K. han- noveranum* is evident and their smaller adult size may be due to geographic variation as well as to younger stratigraphic age, since phyletic size decrease is found in many species of *Kheraiceras*. *K. suevicum* (ROEMER, Pl. 7, Fig. 21) which CAL- LOMON (1993) compared with one of the present macroconchiate forms (Pl. 1, Fig. 8), has a comparable size and similar nature of ribbing to the present microconch. Recently SANDOVAL et al. (1990) described it as a microconch and synonymised it with *Bomburites microstoma*, microconch of *K. bullatum* from Mexico.

The finding of an adult microconch is very significant. It is strongly ornate on the outer whorl and ribbing con- tinues to the end without loosing strength. Unfortunately, we are not aware of any microconchiate forms of *K. han- noveranum* described so far. *K. bullatum* is also a closely comparable form but the macroconch of the present species differs from that of *K. bullatum* described here by its rela- tively larger adult size, less contracted body chamber and retention of course, distant ribbing throughout the last whorl. In *K. bullatum*, both in Europe and Kutch, ribs are finer, restricted mainly to the venter and disappear at the end. Moreover, the number of secondaries in this species
is higher than that of K. cf. hannoveranum. Remarkably, these differences are also observed at the microconchiate level.

**Kheraiceras sp. A m**

(Pl. 1, Fig. 11)

Small, diameter being about 30 mm. Strongly involute inner whorls, phragmocone highly inflated (W/H = 1.8). Aperture missing. Body whorl highly contracted, barely touches the penultimate whorl. Ribs very fine, dense, 34 on first half of outer whorl.

This unique specimen has been recorded from the lower horizon of Bed 2 Keera, which also yields microconchs of K. cf. hannoveranum. The present form is very distinct and shows no affinity to other microconch forms from Kutch or the Callovian of Europe. Surprisingly it strongly recalls the holotype of much older Bulatimorphites uhligi (P. POVIČ-HATZEG) (see ARKELL, 1954, Text-Fig. 36).

Both have characteristic fine, dense ribs persisting on the body chamber and involute inner whors. K. sp. A however is characterized by Kheraiceras-like aberrantly coiled outer whorl and the holotype of B. uhligi has incomplete body chamber.

**Kheraiceras sp. B m**

(Pl. 1, Fig. 12)

Small sized with phragmocone less depressed and evolute; highly contracted body chamber, width shows negative allometry during ontogeny. Bulatimorphites-like gradual uncoiling of umbilical seam. The aperture is marked by a deep constriction and preceded by a flared collar not well discernible in internal mould.

This species is from the basal part of a bed (J. umara) immediately above the Bathonian-Callovian boundary in Kutch. It is comparable with some European species e.g., Ammonites microstoma D’ORBIGNY refigured by ARKELL (1954, Text-Fig. 35) resembles the present form especially with respect to the nature of uncoiling, less depressed, evolute inner whors and presence of deep terminal constriction. A. microstoma is now considered to be a microconch of K. bullatum (WESTERMANN & RICCARDI, 1979; WESTERMANN & CALLOMON, 1988).

**Kheraiceras sp. C**

(= Sphaeroceras bulletum D’ORBIGNY, NOETLING 1896)

(Pl. 1, Fig. 10)

This species was described by NOETLING (1896) from the Upper Bathonian of Baluchistan. We recently inspected the only specimen kept at the repository (Type No. 2915) of the Geological Survey of India, Calcutta. The specimen is a hypermorphic giant, unusually large for the genus. It has an involute and cadiconic phragmocone (W/H = 2.7). The body chamber is in bare contact with the preceding whorl. Complete shell with 158 mm diameter. Both whorl height and width show positive allometry during late ontogeny. Primary ribs are prominent up to the end of the phragmocone, secondaries coarse, distinct and persist up to 3/4 of last whorl where they become obsolete and are restricted to the venter. NOETLING (1896) and ARKELL (1952) considered it to be conspecific with Kheraiceras bullatum of Europe. Recently, PANDEY and WESTERMANN (1988), and WESTERMANN and CALLOMON (1988) described it as K. cf. bullatum. Admittedly, it closely corresponds to the European form and K. bullatum is known from the Upper Bathonian of both Europe and South America (e.g., RICCARDI et al., 1989). But the adult size difference between them is remarkable and the Baluchistan form has coarse and distant secondaries. If they were conspecific, it would be the first Late Bathonian K. bullatum recorded from the Indian subcontinent. K. bullatum in both Europe and India shows phylectic size decrease with the advent of time and larger size of the Baluchistan form may be regarded as the older transient of the species.

5. Age and Correlation

The only species described from outside Kutch is “Sphaeroceras bulletum” D’ORBIGNY from the Polyphemus Limestone, Mazarndrik, Baluchistan (NOETLING, 1896). Judging from the faunal association which includes the Macrocephalites triangularis “group”, Clydoniceras baluchistanense (SPATH) and Choffatia (Homoeoplanulites) (SPATH), a Late Bathonian age of the species is certain (see also WESTERMANN & CALLOMON, 1988).

K. cf. hannoveranum appears in the Magadascariensis Subzone, Chrysoolithicus Zone (= upper Lower Macrocephalus Zone [SPATH 1933]) in the mainland of Kutch and continues up to the base of Transitorius Subzone of the succeeding Formosus Zone. M. magadascariensis is a large, involute species with highly variable whorl sections. It resembles M. verus = M. macrocephalus ZITTEL of Europe (WESTERMANN & CALLOMON, 1988). The European form first appeared in the lowest faunal horizon, Bullatus Subzone in Submediterranean France (CARIOU, 1984) and Faunal Horizon II of Subboreal Province (CALLOMON et al., 1989a; CALLOMON et al., 1989b). We, therefore, in a previous attempt with others (Datta et al., 1996) securely placed Magadascariensis Subzone at the Bathonian/Callovian boundary. Besides, the possible ancestor of magadascariensis i.e., triangularis comes from the immediately underlying Triangularis Zone and is widely believed by many of having a pre-Callovian affinity (BHAUMIK et al., 1993; CALLOMON, 1993; Datta et al., 1996). In the absence of any time-diagnostic ammonite taxa, the precise age determination could not, however, be conclusively made. But recently, new record of Epistrenoceras BENTZ, co-occurring with M. triangularis now resolves the long-standing age problem (KAYAL & BARDHAN, 1998). Epistrenoceras is an excellent marker for correlation as it is known only from Upper Bathonian horizons throughout the world (TORRONS, 1989; DIETL, 1988; WESTERMANN et al., 1984).

The present species i.e., K. cf. hannoveranum strongly resembles K. hannoveranum of Europe where the latter is considered as an important taxon of the middle Late Bathonian. Thus judging from this viewpoint the age of Magadascariensis Subzone can also be assigned to the Late Bathonian. However, unlike in Europe, this species continued further into the lowest Callovian in Kutch.

SPATH (1925) described Kheraiceras ? stansfieldi (Plate 1, Fig. 2a, b) from the “Lower Callovian”, Macrocephalus Zone of Madagascar. It is similarly depressed and has similar ribbing like K. cf. hannoveranum. Interestingly, it is recorded from the same locality and horizon from where Macrocephalites magadascariensis also comes.

K. hannoveranum is restricted to the Tethys and its margin including Europe and India. SANDOVAL et al. (1990) reported Bulatimorphites (Kheraiceras) bullatus from the Upper Bathonian Steinmanni Zone of South Mexico (Table 2). One specimen (Plate 9, Fig. 4a–c) appears to be coarsely ornamented with widely spacing ribbing and less inflated phragmocone. Body chamber is also less contracted. More important is that ribbing persists till to the end of
body chamber without any loss of strength. The body chamber is less aberrantly coiled and hence inner whorls are well exposed with relatively wide umbilicus. Thus it closely resembles the coeval Indian K. cf. hannoveranum of the present study.

Kheraiceras cosmopolitum, which is the most abundant, spans the entire Formosus Zone (Middle and Upper Macrocephalus Zones, Spath, 1933) (Datta, 1992). This zone can be approximately correlated with the Lower Callovian Macrocephalus and Gracillir Zones of France (see also Krishna & Westermann, 1985, 1987). K. bullatum (D’Orbigny) has a similar lower limit but lasted briefly in Kutch and persisted up to the top of Diadematus Subzone, i.e. Dimerus Faunal Horizon (Table 3). M. dimerus which is the characteristic ammonite of this level, is equivalent to M. kampius of England (Callomon, 1993). Krishna & Cariou (1990) also mentioned (not illustrated) the species from the same level at Keera and correlated it with the upper Herveyi Zone of Europe, Bullatus Subzone of France. K. cf. bullatum is also reported from the East Pacific Faunal Province. Here, it appears in the lower part of Steinmanni Zone (= upper part of the Retrocostatum Zone or coeval Aspidoides Zone of Europe) and is associated with Epistre noceras histricoides indicating Late Bathonian age (Sandoval et al., 1990). In Argentina it continues into the Vergarensis Zone (Riccardi et al., 1989, Fig. 2) which is equivalent to lower part of the Macrocephalus Zone of Submediterranean France. K. cosmopolitum, however, continued further in Kutch and persisted up to the top of the Semilaevis Subzone. In the upper part of the Formosus Subzone it occurs with Reineckeia anceps (Reinecke) (= R. indosabauda Parona & Bonarelli of Spath) (Kayal, pers. comm., 1999). This early appearance of Reineckeia in Kutch has been overlooked by many earlier workers (e.g., Krishna & Westermann, 1985; Krishna & Cariou, 1986, 1990; Cariou & Krishna, 1988) but not by Waagen (1875) and Spath (1927–33).

The Indian “type specimen” of “R. indosabauda”, described by Waagen as Perisphinctes rehmanni comes from his Macrocephalus shales (= bed 3, above the Golden Oolite of Keera, which also yields M. formosus). The holotype of Spath’s (1927) R. tyranniformis also interestingly comes from the Golden Oolite of Keera. Here, these two species co-occur with K. cosmopolitum and Macrocephalites spp. which belong to the Formosus Subzone (middle to upper part of the Dimerus Zone of Cariou & Krishna, 1988). One of us (S.B.) with others (Bardhan & Kayal, to be communicated) collected quite a sizeable number of specimens belonging to these two reineckeiid species from the same level at Keera and the equivalent levels at Jamara and Jara. In a recent report Jain et al. (1996) brings down the lower stratigraphic range of Reineckeia in Kutch even up to the Late Bathonian.

It is also interesting to note that first Reineckeia, like in Europe, appeared in Kutch at a level after the disappearance of Kheraiceras bullatum. This level judging by its macrocephalitid association may be correlated with the middle part of the Gracilis Zone including Michalskii Subzone of Cariou (1984). Recently Krishna & Cariou (1990) recorded Hecticoceras michalskii presumably from this level.

Finally, K. cosmopolitum disappeared at the top of the Semilaevis Subzone where all the Kutch macrocephalitids also ended. This corresponds to the Patina Subzone of the Gracilis Zone of France (see also Krishna & Cariou, 1990) and Faunal Horizon XVII, Enodatum Subzone, Britain (Callomon et al., 1989).

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Figs. 1–4: *Kheraiceras cosmopolitum* (PARONA & BONARELLI) f. & m.
- Fig. 1: Mostly internal mould with incompletely preserved adult body chamber, lateral view.
  - Holotype f, Type No. 2009, from the Golden Oolite of Keera, Bed 2.
- Fig. 2: Adult specimen with last quarter of body chamber missing, f.
  - From Bed 5, J umara, J UM/J/5, lateral view.
- Fig. 3: Young, phragmocone, internal mould f; note extremely depressed whorl section, apertural view.
  - From Bed 2, Keera.
- Fig. 4: Almost complete specimen m.
  - From Bed 7, J umara, J UM/J/6, lateral view.

Figs. 5–6: *Kheraiceras bullatum* (D’ORBIGNY) f. & m.
- Fig. 5: Adult with almost completely preserved body chamber, f.
  - Mostly internal mould, from Bed 2, Keera, J UM/K/12, lateral view.
- Fig. 6: Adult with terminal constriction preserved near the flank, m.
  - From Bed 6, J umara, J UM/J/12, lateral view.

Figs. 7–9: *Kheraiceras cf. hannoveranum* (ROEMER) f. & m.
- Fig. 7: Almost complete adult specimen f., other side damaged.
  - From Polyphemus Limestone, Mazar Drik, Baluchistan, kept in Indian Museum, Calcutta, no. H. 48.607, lateral view.
- Fig. 8: Adult with last 1/3 of the body chamber missing, f.
  - From Bed 4, J umara, J UM/P-2, lateral view.
- Fig. 9: Almost completely adult aperture missing, m.
  - From Bed 2, Keera, J UM/K/7, lateral view; note presence of coarse, distant ribbing to the end.

Fig. 10: *Kheraiceras sp. C* f.
- Complete adult specimen.
  - Polyphemus Limestone, Mazar Drik, Baluchistan, kept in repository Geological Survey of India, Calcutta, no. 2915, lateral view.

Fig. 11: *Kheraiceras sp. A* m.
- Adult with almost completely preserved body chamber.
  - Bed 2, Keera, J UM/K/16, lateral view.

Fig. 12: *Kheraiceras sp. B* m.
- Adult with lappet, Bed 5, J umara, J UM/J/15, lateral view.

All Figures 88 % of natural size
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