Albian and Cenomanian ammonites of the eastern margin of the Lut block (East Iran)

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Abstract: Upper Albian and Lower Cenomanian ammonites occur on the eastern margin of the Lut block in eastern Iran. The ammonite assemblages described herein are from the Nimboolook and Kerch sections located west of Qayen. The following taxa are described: Mantelliceras mantelli (J. SOWERBY, 1814), Mantelliceras saxbii (SHARPE, 1857), Mantelliceras sp. 1, Mantelliceras sp. 2, Mantelliceras sp. 3, Sharpeiceras laticlavium (SHARPE, 1855), Sharpeiceras schlueteri (HYATT, 1903), Puzosia (Puzosia) mayoriana (ORBIGNY, 1841), Hyphoplites costosus C.W. WRIGHT & E.V. WRIGHT, 1949, Mortoniceras (Mortoniceras) cf. fallax (BREISTROFFER, 1940), Mantelliceras cf. mantelli (J. SOWERBY, 1814), Calycoceras (Gentoniceras) aff. gentoni (BRONGNIART, 1822), Idiohamites fremonti (MARCOU, 1858), Mariella (Mariella) sp., Mariella (Mariella) dorsetensis (SPATH, 1926), and Turrilites costatus LAMARCK, 1801. The ammonite assemblages clearly indicate a late Albian-middle Cenomanian age for the Nimboolook section and late Albian-early Cenomanian age for the Kerch section.

Key-words:
• Albian;
• Cenomanian;
• Cretaceous;
• ammonites;
• systematic paleontology;
• biostratigraphy;
• Qayen;
• Lut block;
• Iran.

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1. Introduction

The central Iran area is bounded to the east by the Lut Block (AGHANABATI, 2011). Cretaceous deposits are widely exposed on the eastern margin of the Lut block. TIRRUL et al. (1983), FAUVET and EFTKHAR NEZHAD (1990), RAISOSSADAT and SKELTON (2005), KHAZAEE et al. (2011), BABAZADEH et al. (2010), RAISOSSADAT et al. (2012), MOULODI et al. (2014) and SHARIFI et al. (2015) have published on aspects of the area’s regional geology, Cretaceous stratigraphy and macro- and micro-paleontology. The focus of this study is on the discovery and description of upper Albian and middle Cenomanian ammonites. The ammonite fauna described here comes from two sections. The Nimbolook section is located at 59°01′ 20″E 33°52′15″N and the Kerch section is located at 58°52′45″E 33°37′15″N (Figs. 1-2).

This paper is one of the few paleontological studies of eastern Iran. For many of the species described, this is the first record from eastern Iran.

2. Stratigraphy

2.1. KERCH SECTION:

This section consists of a succession of 255 m of marl and marly limestone which contains ammonites. The carbonate succession overlies an Albian igneous unit (FAUVET and EFTKHAR NEZHAD, 1990) and underlies a siliciclastic unit of red conglomerate and sandstone. The sequence straddles the Albian-Cenomanian boundary (Figs. 3-4). Ammonites are scarce with 17 specimens collected, all from the upper third of the section. Ammonites identified are Mantelliceras mantelli (J. SOWERBY, 1814), Mantelliceras saxbii (SHARPE, 1857), Mantelliceras sp. 1, Mantelliceras sp. 2, Sharpeiceras latilavium (SHARPE, 1855), Sharpeiceras schluteri (HYATT, 1903), Puzosia (Puzosia) mayoriana (ORBIGNY, 1841) and Hyphoplites costosus C.W. WRIGHT & E.V. WRIGHT, 1949 (Figs. 7-8). The ammonite assemblage suggests that the section is of late Albian - early Cenomanian age.
2.2. NIMBOLOOK SECTION

In the Nimbolook section, a carbonate succession, 92 m thick, conformably overlies Aptian-Albian sedimentary rocks (Moulodi, 2013) and underlies red conglomerate and sandstone. The carbonates are divisible into two units (Figs. 5-6). The lower unit consists of 55 m of thickly bedded light grey non-ammonite-bearing limestone and the upper consists of 33 m of medium-bedded pink limestone with ammonites. Ammonites are very scarce with eight specimens recovered. The limestone includes biosparite and biomicroparite (wackestones and packstones), which contain abundant molluscan debris (pelecypods, gastropods, and ammonites).

Ammonites identified include Mortoniceras (Mortoniceras) cf. fallax (Breistroffer, 1940), Mantelliceras sp. 3, Mantelliceras cf. mantelli (J. Sowerby, 1814), Calycoceras (Gentoniceras) aff. gentoni (Brongniart, 1822), Idiohamites fremonti (Marcou, 1858), Mariella (Mariella) sp., Mariella (Mariella) dorsetensis (SPATH, 1926) and Turrilites costatus Lamarck, 1801 (Fig. 9). Based on the ammonite occurrences, this section is assigned a late Albian - middle Cenomanian age.

3. Conventions

The collected ammonites are classified after the Treatise of Invertebrate Palaeontology, part L (Wright et al., 1996). Shell measurements are given in centimeters, in the following order; Diameter (D), whorl height (Wh), whorl breadth (Wb) and breadth of umbilicus (U). The abbreviations used to indicate the source of specimens are as follows: Ni, Nimbolook section; Ke, Kerch section.
| Stages | Substages | Sample number | Lithology | Thickness (m) | Description |
|--------|-----------|---------------|-----------|---------------|-------------|
| ?      | ?         |               |           |               |             |
| Cenomanian | Lower     | Sk30, Sk29, Sk28, Sk27, Sk26, Sk25, Sk24, Sk23 | Marly limestone, light yellow, thin to medium bedded |
| Albian | Upper     | Sk22, Sk21, Sk20, Sk19, Sk18, Sk17, Sk16, Sk15, Sk14, Sk13, Sk12, Sk11, Sk10, Sk9, Sk8, Sk7, Sk6, Sk5, Sk4, Sk3, Sk2, Sk1 | Marls, cream-colored with ammonites, nodular, thin bedded |
|        |           |               | Marly limestones, light yellow colour, thin to medium bedded |
|        |           |               |           |               | Cover |
|        |           |               |           |               | Igneous rocks |

Scale (m): 25 0
Figure 4: Stratigraphic columns of the Kerch section (▲ A), view of the Kerch section (▲ B), and marl and marly limestone beds (▼ C).

4. Systematic paleontology

Suborder Ammonitina HYATT, 1889
Superfamily Desmoceratoidea
ZITTEL, 1895
Family Desmoceratidae ZITTEL, 1895
Subfamily Puzosiinae SPATH, 1922
Genus and Subgenus Puzosia
BAYLE, 1878

Puzosia (Puzosia) mayoriana
(ORBIGNY, 1841)

Fig. 7, Ke-1, Ke-2, and Ke-3
1990 Puzosia mayoriana mayoriana (ORBIGNY, 1841); MARCINOWSKI and WIEDMANN, p. 55, Pl. 5, fig. 5.
1991 Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); DELAMETTE and KENNEDY, p. 442, Pl. 8, fig. 26.
1994 Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); KENNEDY, p. 220, Pl. 2, figs. 10-12, 18; Pl. 5, figs. 1-9.
1996 Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); KENNEDY et al., p. 312, Pl. 39, figs. 4-5.
1998 Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); KAPLAN et al., p. 71, Pl. 1, figs. 12-13; Pl. 9, figs. 1, 11-12; Pl. 10, figs. 3-5.
2000 Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); LEHMANN, p. 55, Pl. 1, figs. 1, 9.
2004 Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); KENNEDY and JOLKICEV, p. 372, Pl. 1, figs. 4-6.
2005 Puzosia (P.) mayoriana (SOWERBY); REBOULET et al., p. 125, Fig. 3.A.
Figure 5: The Nimbo look section. Geological map, re-drawn after BERTHIAUX et al. (1981).

2007 

2007

2008

2013

Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); SZIVES et al., p. 96, Pl. XIII, fig. 9; Pl. XIV, fig. 7; Pl. XIX, fig. 8; Pl. XXVIII, figs. 8, 10, 13.

Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); KENNEDY and LATIL, p. 460, Pl. 1, figs. 1-6; Pl. 3, fig. 1.

Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); KENNEDY et al., Pl. 8, figs. 15-16.

Puzosia (Puzosia) mayoriana (ORBIGNY, 1841); REBOULET et al., p. 177, Fig. 5.

Material: Ke-1, Ke-2, and Ke-3, all crushed to varying degrees.

Description: Ke-1 is the largest (diameter 11.6 cm) and best preserved specimen of P. (P.) mayoriana from the Kerch section. All specimens have an oval whorl section, rounded flanks, broadly rounded ventrolateral shoulder and convex venter. Specimens have 1-2 well-developed constrictions on the last whorl. The constrictions are sharper in Ke-2. They arise from the umbilical wall, straight on the lower
half of the flank, convex on the ventrolateral shoulder and flexing back and concave on the venter. Convex constrictions are most visible in Ke-1 and Ke-2. Specimens have 14-38, flexuous and dense ribs, arranged parallel to the constrictions. The constrictions are flanked by a collar rib, feeble on the flanks, but coarse-flexuous and dense ribs, arranged parallel to the constrictions. The constrictions are flanked by the ventral ribs. The siphonal groove is engraved on the venter and passes through the ventrolateral tubercles. Ke-5 has similar ornamentation but is less well preserved.

Dimensions (in cm):

| Sample number | D   | Wh  | Wb  | Wb/Wh | U  |
|---------------|-----|-----|-----|-------|----|
| Ke-1          | 11.6| 3.5 | 2.4 | 0.68  | 0.35|
| Ke-2          |     | 3.1 | 2.1 | 0.67  | -  |
| Ke-3          |     | 3.1 | 2.3 | 0.74  | -  |

Occurrence: upper Albian to upper Cenomanian. Based on co-occurrence with specimens Ke-4, Ke-5, Ke-9 and Ke-10, both Ke-1 and Ke-2 are upper Albian and Ke-3 is lower Cenomanian.

**Superfamily Hopliticeae**

**H. DOUVILLÉ, 1890**

**Family Hoplitidae**

**C.W. WRIGHT & E.V. WRIGHT, 1949**

**Hyphoplites costosus**

*Fig. 7, Ke-4 and Ke-5*

1949 *Hyphoplites costosus; C.W. WRIGHT & E.V. WRIGHT, p. 484, Pl. XXIX, fig. 7.a-b.*

1971 *Hyphoplites costosus C.W. WRIGHT & E.V. WRIGHT, 1949; KENNEDY, p. 43.*

1984 *Hyphoplites costosus C.W. WRIGHT & E.V. WRIGHT, 1949; KENNEDY and JUIGNET, p. 116, Figs. 3.g-j, 3.p, 8.h.*

1985 *Hyphoplites costosus C.W. WRIGHT & E.V. WRIGHT, 1949; IMMEL and SEYED-EMAMI, p. 92, Pl. 1, figs. 4-5.*

2007 *Hyphoplites costosus C.W. WRIGHT & E.V. WRIGHT, 1949; SZIVES et al., p. 101, Pl. 46, figs. 18, 23, 25-30.*

Material: Ke-4 and Ke-5.

Description: Ke-4 is a half whorl of a discoidal shell. Ribs are sickle-shaped, fine and dense, and commence at the umbilicus. There are eight large pairs from the umbilical tubercle and strengthen into bullae at mid-flank. There are eight large and prominent ventrolateral tubercles. The venter is flat and the ribs are slightly curved on it. The keel is crossed by the ventral ribs.

Dimensions (in cm):

| Sample number | D   | Wh  | Wb  | Wb/Wh | U  |
|---------------|-----|-----|-----|-------|----|
| Ke-4          | 4.0 | 1.4 | 0.7 | 0.50  | 0.32|
| Ke-5          |     | 0.4 | 0.1 | 0.25  | -  |

Occurrence: This species occurs in upper Albian strata of Hungary (SZIVES et al., 2007) and the lower and middle lower Cenomanian of southern England (C.W. WRIGHT & E.V. WRIGHT, 1949). *Hyphoplites costosus* has been found below *M. mantelli* (at the base of the Cenomanian) in the Kerch section.

**Superfamily Acanthoceratoidea**

**GROSSOUVRE, 1894**

**Family Brancoceratidae**

**SPATH, 1934**

**Subfamily Mortoniceratinae**

**H. DOUVILLÉ, 1912**

**Genus and subgenus Mortoniceras**

**MEEK, 1876**

**Mortoniceras (Mortoniceras) cf. fallax**

*BREISTROFFER, 1940*

*Fig. 9, Ni-1*

1995 *Mortoniceras fallax* (BREISTROFFER, 1940); LATIL, 71, Pl. 3, figs. 1-3; Pl. 4.

2002 *Mortoniceras (Mortoniceras) fallax* (BREISTROFFER, 1940); AMÉDRO, p. 68, Pl. 2, figs. 2-3.

2002 *Mortoniceras (Mortoniceras) pachys* (SEELEY, 1865); AMÉDRO, p. 82, Pl. 9, fig. 1.

2008 *Mortoniceras (Mortoniceras) fallax* (BREISTROFFER, 1940); KENNEDY et al., p. 60, Pl. 6, figs. 1-3; p. 68, Pl. 10, figs. 8-11, 16.

Material: Ni-1, specimen broken.

Description: Ni-1 is the only specimen attributable to this species. The whorl section is almost quadrangular. The ornamentation is distinct, and consists of eight ribs that extend in pairs from the umbilical tubercle and strengthen into bullae at mid-flank. There are eight large and prominent ventrolateral tubercles. The venter is flat and the ribs are slightly curved on it. The keel is crossed by the ventral ribs.

Dimensions (in cm):

| Sample number | D   | Wh  | Wb  | Wb/Wh | U  |
|---------------|-----|-----|-----|-------|----|
| Ni-1          |     | 2.7 | 2.5 | 0.92  | -  |

Occurrence. Mortoniceras (*M.*) fallax Zone, England, Belgium, France, Hungary, Armenia and Madagascar (AMÉDRO, 2008; KENNEDY, 2008) and Iran (this study).

**Family Acanthoceratidae**

**GROSSOUVRE, 1894**

**Subfamily Mantelliceratinae**

**HYATT, 1903**

**Genus Mantelliceras HYATT, 1903**

**Mantelliceras mantelli**

*(J. SOWERBY, 1814)*

*Fig. 7, Ke-6, Ke-7, and Ke-8*

1979 *Mantelliceras mantelli* (J. SOWERBY, 1814); KENNEDY et al., p. 32, Pl. 6, figs. 1, 3; Pl. 8, fig. 4.

1981 *Mantelliceras mantelli* (J. SOWERBY, 1814); SEYED-EMAMI and ARYAI, p. 32, Pl. 8, figs. S.a-c.

1985 *Mantelliceras mantelli* (J. SOWERBY, 1814); IMMEL and SEYED-EMAMI, p. 99, Pl. 4, fig. 5.

1984 *Mantelliceras mantelli* (J. SOWERBY, 1814); WRIGHT and KENNEDY, p. 99, Figs. 20.A-D, 26.A, C, E; Pl. 16, fig. 5; Pl. 17, figs. 1, 3; Pl. 18, figs. 1-3; Pl. 19, figs. 1-6; Pl. 21, figs. 2, 4; Pl. 24, fig. 3; Pl. 36, fig. 1.

1991 *Mantelliceras mantelli* (J. SOWERBY, 1814); DELAMETTE and KENNEDY, p. 447, Pl. 9, figs. 4-6, 19-21.

1994 *Mantelliceras mantelli* (J. SOWERBY, 1814); KENNEDY, p. 222, Pl. 7, figs. 1-2, 9.
| Stages | Sub stages | Samples number | Lithology | Thickness (m) | Description |
|--------|------------|----------------|-----------|---------------|-------------|
| Cenomanian | Middle | Tk14, Tk13 | Red conglomerate and sandstone |
| Lower | | Tk12, Tk11 | | 50 | |
| Upper | | Tk10, Tk9 | Limestone, grey to pink, thinly bedded, with ammonites |
| ? | | Tk8, Tk7 | | 80 | |
| Albion | | Tk6, Tk5 | Limestone, grey colour, massive, with marl at base |
| | | Tk4, Tk3 | | 70 | |
| | | Tk2, Tk1 | Marl, cream colour, thinly bedded |
| | | | | 0 | |
Figure 6: Stratigraphic columns of the Nimbolook section (A), upper half of the Nimbolook section (B) and basal contact of the Nimbolook section (C).
1998 Mantelliceras mantelli (J. Sowerby, 1814); 
KENNEDY et al., p. 115, Pl. 17, figs. 12-13; Pl. 19, figs. 1-9.
2011 Mantelliceras mantelli (J. Sowerby, 1814); 
MOSAVINIA and WILMSEN, p. 178, Fig. 3.A-E
(with full synonymy).
2015 Mantelliceras mantelli (J. Sowerby, 1814); 
KENNEDY et al., p. 2, Figs. 1. A-G, 3.D-G.
2015 Mantelliceras mantelli (J. Sowerby, 1814); 
KENNEDY and GALE, p. 264, Pl. VII, fig. 3; Pl. 
VIII, figs. 1, 5.
Material: Ke-6, Ke-7, and Ke-8.
Description: Ke-6 is the largest and best preserved specimen of 
M. mantelli inform the Kerch section. The umbilicus is filled with sediments. Coiling is evolute to moderately involute, 
with a normal expansion rate and a sub-rounded to polygonal whorl section. Orna-
mentation is distinct. There are 13 primary, 
strong, radial and straight ribs that arise from 
umbilical shoulder, and secondary ribs are loca-
ted between them. The primary ribs carry um-
bilical and lateral tubercles while ventro-lateral 
tubercles occur on all ribs. Ribs crossing the 
venter bear strong ventrolateral clavi.
Ke-7 consists of a half whorl that is smaller 
and less well preserved than Ke-6. Ke-7 bears 
17 strong ribs that are alternately and regularly 
long and short. Ribs are slightly curved on the 
sides in contrast to those of Ke-6. Two rows of 
bullae are visible on the primary ribs of the 
flanks while a single row is present on the sec-
condary ribs. On the venter, all ribs are linked 
tubes and tubercles are arranged parallel to each 
other. Ke-6 is similar than Ke-7, but its lateral 
ribs are more sinuous and its lateral tubercles 
are barely visible, due to erosion.
Occurrence: M. mantelli has a world-wide 
distribution. It is common in the lower two 
thirds of the lower Cenomanian and only rarely 
found above (KENNEDY, 1994).
Dimensions (in cm):

| Sample  | D   | Wh  | Wb  | Wb/Wh | U   |
|---------|-----|-----|-----|-------|-----|
| Ke-6    | 4.1 | 1.9 | 1.7 | 0.89  | 0.64|
| Ke-7    | 3.5 | 1.2 | 1.3 | 1.08  | 0.17|
| Ke-8    | 3.5 | 1.7 | 1.3 | 0.76  | 0.20|

**Mantelliceras cf. mantelli**

(J. Sowerby, 1814)

Fig. 9, Ni-3

1984 Mantelliceras mantelli (J. Sowerby, 1814); 
WRIGHT and KENNEDY, p. 99, Pl. 16, fig. 5; Pl. 
17, figs. 1, 3; Pl. 18, figs. 1-3; Pl. 19, figs. 1-6.
1991 Mantelliceras mantelli (J. Sowerby, 1814); 
DELAMETTE and KENNEDY, p. 447, Fig. 9-4.
1998 Mantelliceras mantelli (J. Sowerby, 1814); 
KENNEDY et al., p. 115, Pl. 11, figs. 1-2; Pl. 
17, figs. 12-13; Pl. 19, figs. 1-9; Pl. 22, figs. 3-4; 
Pl. 23, fig. 8; Pl. 24, figs. 4-6; Pl. 25, figs. 1-5.
1985 Mantelliceras mantelli (J. Sowerby, 1814); 
IMMEL and SEYED-EMAMI, p. 99, Pl. 4, fig. 5.
2011 Mantelliceras mantelli (J. Sowerby, 1814); 
MOSAVINIA and WILMSEN, p. 180, Fig. 3.A-E.
2015 Mantelliceras mantelli (J. Sowerby, 1814); 
KENNEDY et al., p. 2, Fig. 1.A-G.

Material: Ni-3, specimen broken, abraded ventrally.

Description: The specimen is a half whorl 
bearing 17 ribs. Seven primary ribs arise at the 
umbilical seam and extend across the flanks, 
with secondary ribs located between them. The 
flanks are nearly flat and the whorl section is 
aval to rectangular. Some of the primary ribs 
strengthen into rounded tubercles on the 
middle of the sides. Tiny ventrolateral nodes 
occur in places. All ribs are straight, strong and 
radial on the flanks but diminish toward the 
venter. Other Mantelliceras found in Kerch section have more prominent ornaments and more convex flanks than Ni-3.

**Mantelliceras saxbii** (SHARPE, 1857)

Fig. 8, Ke-9

1971 Mantelliceras saxbii; KENNEDY and HANCOCK, p. 
437, Pl. 79, figs. 1-5; Pl. 80, figs. 1-4; Pl. 81, 
figs. 1, 4, 6-8; Pl. 82, figs. 2, 4-5.
1979 Mantelliceras saxbii (SHARPE, 1857); KENNEDY 
et al., p. 36, Pl. 7, fig. 5.
1985 Mantelliceras saxbii (SHARPE, 1857); IMMEL 
AND SEYED-EMAMI, p. 102, Pl. 6, fig. 5.
1991 Mantelliceras saxbii (SHARPE, 1857); 
DELAMETTE and KENNEDY, p. 454, Pl. 14, figs. 1-
4.
1994 Mantelliceras saxbii (SHARPE, 1857); KENNEDY, 
p. 224, Pl. 7, fig. 11.
1997 Mantelliceras saxbii (SHARPE, 1857); IMMEL 
et al., p. 169.
1998 Mantelliceras saxbii (SHARPE, 1857); KAPLAN 
et al., p. 118, Pl. 17, fig. 1; Pl. 19, figs. 1-9.
2008 Mantelliceras saxbii (SHARPE, 1857); KENNEDY 
et al., p. 130, Pl. 5, fig. 13.
2011 Mantelliceras saxbii (SHARPE, 1857); 
MOSAVINIA and WILMSEN, p. 182, Fig. 4.C, 4.F-
G.
2015 Mantelliceras saxbii (SHARPE, 1857); KENNEDY 
et al., p. 5, Fig. 7.K-L.
2015 Mantelliceras saxbii (SHARPE, 1857); KENNEDY 
and GALE, p. 267, Pl. VII, fig. 4; Pl. VIII, fig. 4.
Material: Ke-9.

Description: Ke-9 is oval in cross section and 
widest in the middle of the flanks that are gently 
curved near the venter. The umbilicus is moder-
ately deep, with a steep wall. The primary 
ribs arise from the umbilical shoulder. Secondary 
ribs arise at the middle of the flanks and are 
arranged irregularly between the primary 
ribs. In total there are 30 fine (contrast those of 
M. mantelli) and crowded narrow ribs. Tubercles 
are absent from the flanks, but occur in two 
rows bordering the venter. They are tiny, roun-
ded and, in some cases, barely visible, due to 
abrasion.

> **Figure 7:** Ke-1, Ke-2 and Ke-3: Puzosia (Puzosia) 
mayoriana (ORBIGNY, 1841); Ke-4 and Ke-5: Hypho-
plites costosus C.W. WRIGHT & E.V. WRIGHT, 1949; Ke-
6, Ke-7 and Ke-8: Mantelliceras mantelli (J. Sowerby, 
1814) (all scales: 1 cm).
Occurrence: Mantelliceras saxbii Zone of western Europe (Gale, 1995; Gale et al., 1996; Amédro, 2008) and throughout the lower Cenomanian, but common only in the middle of the substage. It is recorded all over Europe, Russia, North Africa, Angola, Madagascar, Iran and Kazakhstan. Kennedy et al. (2008) noted that this species is distinct from M. mantelli in the lack of lateral tubercles. Kennedy et al. (2008) noted that this species is distinct from Mantelliceras nitidum based upon the arrangement of the ribs and the compressed whorl section.

Dimensions (in cm):

| Sample number | D | Wh | Wb | Wb/Wh | U |
|---------------|---|----|-----|-------|---|
| Ke-9          | 4.0 | 1.8 | 1.1  | 0.61  | 0.22 |

Mantelliceras sp. 1

Fig. 8, Ke-10 and Ke-11

Material: Ke-10 and Ke-11, specimens broken.

Description: The ornamentation and the stratigraphic position suggest attribution to Mantelliceras but more definite identification is impossible. Ke-10 has about primary ribs (arising at the umbilical margin) and 11 irregular short secondary ribs (arising at mid-flank). The ribs are densely distributed, straight and linked on the venter, and bear ventrolateral tubercles. Ke-11 is a crushed specimen with two rows of ventrolateral tubercles and abraded, relatively widely spaced radial ribs on the sides.

Dimensions (in cm):

| Sample number | D | Wh | Wb | Wb/Wh | U |
|---------------|---|----|-----|-------|---|
| Ke-10         | 7.1 | 3.0 | 2.0  | 0.66  | -  |
| Ke-11         | 6.1 | 2.5 | 1.7  | 0.68  | -  |

Mantelliceras sp. 2

Fig. 8, Ke-12 and Ke-13

Material: Ke-12 and Ke-13

Description: Ke-12 may represent M. saxbii, based upon the arrangement of the ribs and the lack of lateral tubercles. Ke-13 has a rounded and wide venter, a circular whorl section, 18 strong and densely distributed ribs that arise from umbilical bullae. Ke-13 is similar to Mantelliceras nitidum (Crick, 1907) as described by Kennedy et al. (2015) (Fig. 4. A-D, G-L) but is too poorly preserved for confident specific determination.

Dimensions (in cm):

| Sample number | D | Wh | Wb | Wb/Wh | U |
|---------------|---|----|-----|-------|---|
| Ke-12         | - | -  | 1.9  | -     | -  |
| Ke-13         | 4.6 | 1.6 | 1.7  | 1.06  | -  |

Mantelliceras sp. 3

Fig. 9, Ni-4

Material: Ni-4.

Description: Ni-4 is a composite mould of the upper part of Nimbolook section. The umbilicus is covered by sediment and the ornamentation is visible only on the right side. Ni-4 has evolute coiling and a low expansion rate. The whorl section is oval and there are no tubercles, but 23-25 sharp ribs alternately long and short and dichotomously branching from the middle of the flanks.

Dimensions (in cm):

| Sample number | D | Wh | Wb | Wb/Wh | U |
|---------------|---|----|-----|-------|---|
| Ni-4          | 11.5 | 4  | 2.5  | 0.62  | -  |

Genus Sharpeiceras Hyatt, 1903
Sharpeiceras laticlavium (Sharpe, 1855)

Fig. 8, Ke-14

1971 Sharpeiceras laticlavium (Sharpe, 1855); Kennedy, p. 64, Pl. 27, fig. 1.a-c.
1979 Sharpeiceras laticlavium (Sharpe, 1855); Kennedy et al., p. 38, Pl. 8, figs. 1-2.
1984 Sharpeiceras laticlavium (Sharpe, 1855); Wright and Kennedy, p. 127, Figs. 29, 30, 34.a; Pl. 41, fig. 4.
1985 Sharpeiceras laticlavium (Sharpe, 1855) nigeriense subsp. nov.; Zaborski, p. 26, Fig. 31.a-b.
1991 Sharpeiceras laticlavium (Sharpe, 1855); Delamette and Kennedy, p. 454, Pl. 9, figs. 9-10.
1998 Sharpeiceras laticlavium (Sharpe, 1855); Kaplan et al., p. 126, Pls. 27-30, 32.
1994 Sharpeiceras laticlavium (Sharpe, 1855); Kennedy, p. 224.
2015 Sharpeiceras laticlavium (Sharpe, 1855); Kennedy et al., p. 11, Fig. 12.R.
2015 Sharpeiceras laticlavium (Sharpe, 1855); Kennedy and Gale, p. 274, Pl. X, fig. 3.

Material: Ke-14.

Description: The distinctive features of this species are the compressed, rectangular whorl section and very evolute coiling. The umbilicus features a steep wall. There are 24 coarse, straight ribs that originate from the umbilicus and extend across the sides of the whorl. All ribs bear umbilical, middle lateral and inner ventrolateral conical tubercles and much stronger outer ventrolateral clavi. The venter is flat and smooth. Ribs that reach the flanks disappear on the venter.

Dimensions (in cm):

| Sample number | D | Wh | Wb | Wb/Wh | U |
|---------------|---|----|-----|-------|---|
| Ke-14         | 5.0 | 2.1 | 0.7  | 0.33  | 0.26 |

Discussion: The flattened flank and coarser tuberculation separate this specimen from Sharpeiceras schlueteri. The difference between the two species is described in Delamette and Kennedy (1991).
Occurrence: Sharpeiceras laticlavium is a cosmopolitan species indicative of the lower Cenomanian. The species occurs in *N. caricatense*, *S. schlueteri* and *M. saxbii* Assemblage Zone faunas (Kennedy et al., 1979; Delamette and Kennedy, 1991; Kaplan et al., 1998).

**Sharpeiceras schlueteri (Hyatt, 1903)**

Fig. 8, Ke-15 and Ke-16

1982 *Sharpeiceras mexicanum* (Bose); Mancini, p. 254, Fig. 6.e.

1998 *Sharpeiceras schlueteri* (Hyatt, 1903); Kaplan et al., p. 128, Pls. 31-32; Pl. 33, figs. 3-4.

2005 *Sharpeiceras schlueteri* (Hyatt, 1903); Kennedy et al., Figs. 10.L, 24.D-E.

2015 *Sharpeiceras schlueteri* (Hyatt, 1903); Kennedy and Gale, p. 274, Fig. 18; Pl. X, figs. 2, 5, 10; Pl. XI, figs. 1-2.

Material: Ke-15 and Ke-16.

Description: Two specimens of *S. schlueteri* are found in the Kerch section. Ke-15 is the largest ammonite found there. Four coarse ribs that swell into umbilical, middle lateral, and inner and outer ventrolateral tubercles are preserved on the sides. Tubercles are strong and conical. In the adult, the inner ventrolateral tubercles tend to develop into a horn-like process (Kennedy, 1971). The inner ventrolateral tubercles are connected to a row of very prominent outer ventrolateral clavi by broad ribs. The sutures are clearly visible. The ornamentation of Ke-16 is similar to that of Ke-15 except that the ribs and tubercles are less prominent. Furthermore part of the umbilicus is visible although filled by sediment.

Dimensions (in cm):

| Sample number | D  | Wh  | Wb  | Wb/Wh | U  |
|---------------|----|-----|-----|-------|----|
| Ke-15         | -  | 6.5 | 3.9 | 0.60  | -  |
| Ke-16         | -  | 4.7 | 3.2 | 0.68  | -  |

Sample number D Wh Wb Wb/Wh U Ke-15 - 6.5 3.9 0.60 - Ke-16 - 4.7 3.2 0.68 -

Occurrence: It represents the Lower Cenomanian. Sharpeiceras schlueteri is a Subzone of the *M. mantelli* Zone and occurs in England, France, Germany, Angola, Mozambique, Texas and Peru (Kaplan et al., 1998; Kennedy et al., 2005) and Iran in this study.

**Subfamily Acanthoceratinae**

Grossouvre, 1894

**Genus Calycoceras Hyatt, 1900**

**Subgenus Gentoniceras Thomel, 1972**

**Calycoceras (Gentoniceras)**

**aff. gentoni** (Brongniart, 1822)

Fig. 9, Ni-5

1990 *Calycoceras* (*Gentoniceras*) *gventoni* (Brongniart, 1822); Wright and Kennedy, p. 219, Figs. 88.a-c, 69.a-b, 90.a-c; Pl. 56, figs. 1-3, 6-8; Pl. 57, figs. 2-3, 8; Pl. 58, fig. 7; Pl. 66, figs. 1-2.

1994 *Calycoceras* (*Gentoniceras*) *gventoni* (Brongniart, 1822); Kennedy and Juignet, p. 30, Figs. 1a, 2.d-e; 6.d-e, 6.j-k, 7.a-l, 8.e, 22.a-b.

1998 *Calycoceras* (*Gentoniceras*) *gventoni* (Brongniart, 1822); Kaplan et al., p. 156, Pl. 26, figs. 3-5.

2015 *Calycoceras* (*Gentoniceras*) *gventoni* (Brongniart, 1822); Meister and Piuz, p. 35, Pl. 9, fig. 1.

Material: Ni-5, broken specimen.

Description: Ni-5 is from the upper part of the Nimbolook section. The specimen has a mass-sive whorl and deep umbilicus. It has 20-22 robust ribs on the venter but no lateral or ventral tubercles are observed.

Dimensions (in cm):

| Sample number | D  | Wh  | Wb  | Wb/Wh | U  |
|---------------|----|-----|-----|-------|----|
| Ni-5          | 8.7| 3.7 | 2.0 | 0.54  | 0.17|

Occurrence: *Calycoceras* (*Gentoniceras*) *gventoni* occurs in the lower middle to lower upper Cenomanian (Kennedy and Juignet, 1994; Kaplan et al., 1998). The association of C. (*G.*) *gventoni* and *Turrilites costatus* in the same horizon at Nimbolook section, is of early middle Cenomanian age. The species is also known from France, England, Germany and central Iran.

**Superfamily Turrilitoidea Gill, 1871**

**Family Anisoceratidae Hyatt, 1900**

**Genus Idiohamites Spath, 1925**

**Idiohamites fremonti** (Marcou, 1858)

Fig. 9, Ni-2

1932 *Idiohamites fremonti* (Marcou, 1858); Adkins, p. 363.

1962 *Idiohamites fremonti* (Marcou, 1858); Swensen, p. 72, Pl. 2, fig. 11; Pl. 3, figs. 5, 9; Pl. 5, figs. 1-7.

1965 *Idiohamites fremonti* (Marcou, 1858); Clark, p. 28, Pl. 2, fig. 11; Pl. 5, figs. 5, 9; Pl. 7, figs. 1-7.

1987 *Idiohamites fremonti* (Marcou, 1858); Cobban, p. 221, Figs. 3.N, 4.A-J, 4.L.

Material: Ni-2.

Description: Ni-2 is part of a U-shaped body chamber that is coiled in a plane open spiral. Ornaments consist of 16 oblique ribs, pro-minent on the flanks but becoming faint towards the venter where they are replaced by two rows of ventral tubercles. Lateral tubercles are absent. The ribs are densely distributed and narrow on the straight shaft but are broader with more widely spaced on the hooked whorl.

**Figure 9:** Ni-1: Mortoniceras (*Mortoniceras*) cf. fallax (Breistroffer, 1940), Ni-2: *Idiohamites fremonti* (Marcou, 1858), Ni-3: *Mantelliceras cf. mantelli* (J. Sowerby, 1814), Ni-4: *Mantelliceras* sp. 3, Ni-5: *Calycoceras* (*Gentoniceras*) *gventoni* (Brongniart, 1822), Ni-6: Mariella (*Mariella*) dorsetensis (Spaeth, 1926), Ni-7: *Mariella* (*Mariella*) sp., Ni-8 and Ni-9: *Turrilites* (*Turrilites*) costatus (Lamarck, 1801) (all scales: 1 cm).
Occurrence: *I. fremonti* occurs in the Duck Creek limestone of northern Texas (upper Albian) (AOKINS, 1932). Since *I. fremonti* is recorded at almost the same horizon as *M. fallax* in the Nimbolook section, its occurrence indicates the upper Albian. The present specimen is the first record from Iran.

**Family Turrilitidae GILL, 1871**

**Genus and subgenus Mariella**

**Nowak, 1916**

**Mariella (Mariella) dorsetensis** (SPATH, 1926)

Fig. 9, Ni-6

1937 *Mariella dorsetensis* (SPATH); SPATH, p. 513.  
1970 *Mariella dorsetensis* (SPATH, 1926); MARCINOWSKI, p. 431, Pl. 3, fig. 1.  
1976 *Mariella (Mariella) dorsetensis* (SPATH, 1926); KLINGER and KENNEDY, p. 31, Figs. 3.a, 8.a; Pl. 7, fig. 31.  
1979 *Mariella (Mariella) dorsetensis* (SPATH, 1926); KENNEDY et al., p. 18, Pl. 1, fig. 9.  
1983 *Mariella (Mariella) dorsetensis* (SPATH, 1926); KENNEDY and JUGNET, p. 59, Fig. 22.f.

Material: Ni-6.

Description: Ni-6 consists of two whorls of an internal mould with sinistral turrilitid coiling. The whorl section is rounded. Ribs are not visible between the tubercles present but they are located in the axis. The first three rows of tubercles are exposed on the whorl surface, with a fourth being concealed in the whorl surface. The first row of tubercles is pronounced and elongated across the upper half. The next three rows are arranged on the lower half of the flank equidistant from each other. They are conical, tiny and offset from the first row.

Occurrence: Lower Cenomanian of England, France, Poland, Zululand (South Africa) and central Iran. The present specimen represents the first record from east Iran.

**Mariella (Mariella) sp.**

Fig. 9, Ni-7

Material: Ni-7.

Description: Ni-7 consists of three sinistral whorls with an oval whorl section. Ornamentation is visible on the first whorl and partially on the second. There are 13 transverse ribs on the first whorl and three rows of tubercles. The ribs appear at the upper whorl suture and are most prominent on the upper part of the flank. The first row of tubercles is a little stretched in the upper half. Tubercles on the lower half are conical and pointed and have a rounded base. In the third row, some tubercles merge to form a spiral ridge.

**Genus Turrilites LAMARCK, 1801**

**Turrilites costatus** LAMARCK, 1801

Fig. 9, Ni-8 and Ni-9

1965 *Turrilites* (*Turrilites*) costatus LAMARCK, 1801; CLARK, p. 53, Figs. 20a, b; Pl. 20, figs. 1-2, 7-8.  
1971 *Turrilites* costatus LAMARCK, 1801; KENNEDY, p. 30, Pl. 6, fig. 3; Pl. 8, figs. 12, 14.  
1982 *Turrilites* costatus LAMARCK, 1801; SEYED-EMAMI, p. 428, Fig. 4.4-5, 4.11.  
1983 *Turrilites* costatus LAMARCK, 1801; KENNEDY and JUGNET, p. 47, Figs. 25.a-o, 26.a-b, 27.a-i, 28.a-b, 28.d.  
1985 *Turrilites* (Turrilites) costatus LAMARCK, 1801; ZABORSKI, Pl. 10, figs. 9-10.  
1987 *Turrilites* costatus LAMARCK, 1801; COBBAN, p. 2, Fig. 4.  
1991 *Turrilites* costatus LAMARCK, 1801; DELAMETTE and KENNEDY, p. 458, Figs. 17.26-27, 17.29.  
1994 *Turrilites* (Turrilites) costatus LAMARCK, 1801; KENNEDY, p. 232, Pl. 12, figs. 14, 16-17, 20.  
1998 *Turrilites* costatus LAMARCK, 1801; KAPLAN et al., p. 214, Pl. 64, fig. 3; Pl. 65, figs. 7-8.  
2007 *Turrilites* costatus LAMARCK, 1801; WILMSEN et al., Figs. 5.c.

Material: Ni-8 and Ni-9.

Description: Ni-8 is a specimen with a perfect whorl. Tubercles are distributed regularly and equidistant from their neighbours such that the first, second and third rows occur in the lower, middle and upper third, respectively. In the first row, tubercles are elongate and prominent. Ribs are not seen between the tubercles but they are located in the axis. Ni-9 is a broken specimen with the ornamentation visible on one side.

Occurrence: *Turrilites* costatus has a middle Cenomanian acme at the base of the *A. rhoto-magense* Zone and is rarer in the lower part of the upper Cenomanian. It has a cosmopolitan distribution including the former U.S.S.R. territory, Poland, Germany, France, Iran, United States of America and England.

5. Biostratigraphy

Ammonites provide one of the most precise biostratigraphical tools for correlating Cretaceous sedimentary rocks. Cretaceous stages, boundaries and index faunas in Europe have been discussed by BIRKELUND et al. (1984) and HANCOCK (1991). The Albian and Cenomanian stages are discussed respectively by HART et al. (1996) and TRÖGER and KENNEDY (1996). Albian and Cenomanian ammonites biozonation (Table 1) have been considered by KENNEDY (1971), WRIGHT and KENNEDY (1984), OWEN (1999, 2002), HOEDEMÁKER et al. (2003), GALE et al. (2005), WILMSEN (2007), KENNEDY and LATIL (2007), and REBOULET et al. (2014).

The ammonite fauna collected from the Kerch section consists of seven taxa and that from the Nimbolook section is of eight taxa. Based on these faunas we suggest zones and subzones that are correlatable with the standard biozonation (Table 1).
Figure 10: Ammonite range chart in the Kerch section, eastern Iran.
Figure 11: Ammonite range chart in the Nimbolook section, eastern Iran.
Table 1: Ammonite zonation compiled after KENNEDY (1994), WRIGHT and KENNEDY (1984), HANCOCK (1991), MARCINOWSKI et al. (1996), GALE et al. (2005), WILMSEN (2007), KENNEDY and LATIL (2007), AMÉDRO (2008), KENNEDY et al. (2013), and REBOULET et al. (2014). Items marked in bold are recorded in this study.

| Stages and Substages | Zones and Subzones                  |
|----------------------|-------------------------------------|
|                      | **Turrilites acutus**               |
|                      | **Turrilites costatus**              |
|                      | **Cunningtoniceras inerme**          |
|                      | **Mantelliceras dixoni**             |
|                      | **Mantelliceras saxbii**             |
|                      | **Sharpeiceras schlueteri**          |
|                      | **Neostlingoceras carlitanense**      |
| **Cenomanian**       | **Arrhapheoceras briacensis**        |
|                      | **Morticeras perinflatum**           |
|                      | **Morticeras rostratum**             |
|                      | **Morticeras fallax**                |
|                      | **Morticeras inflatum**              |
|                      | **Morticeras pricei**                |
|                      | **Diplococeras cristatum**           |
| **Albian**           | **Morticeras fallax**                |
|                      | **Morticeras inflatum**              |
|                      | **Morticeras pricei**                |

It is possible to use the Mantelliceras mantelli Zone for the base of the Cenomanian in both sections. The M. mantelli zone fauna is: Mantelliceras mantelli, M. saxbii, M. sp., Sharpeiceras laticlavium, S. schlueteri in the Kerch section (Fig. 10) and Mantelliceras cf. mantelli, Mariella (Mariella) dorsetensis in the Nimbolook section (Fig. 11). At the Kerch section, the Sharpeiceras schlueteri subzone and the Mantelliceras saxbii subzone indicate the middle and upper lower Cenomanian, respectively. The *Morticeras fallax* zone marks the upper Albian in Nimbolook section. The uppermost Nimbolook section belongs to the lower middle Cenomanian and is defined by the *Turrilites costatus* subzone.

The ammonite assemblages clearly indicate a late Albian-middle Cenomanian age for strata containing ammonites in the Nimbolook section and a late Albian-early Cenomanian age in the Kerch section.

6. Conclusions

Ammonites presented here come from two sections at the eastern margin of the Lut block. The Kerch section consists of marl and marly limestone and Nimbolook is of limestone. Both sections pass upward into a siliciclastic unit (red conglomerate and sandstone). During a bed-by-bed search, almost all the ammonites collected were recovered from the upper half of the sections which belong to the upper Albian and the lower Cenomanian. We determine the position of the Albian - Cenomanian boundary in both sections with *M. mantelli* Zone. This paper is a preliminary contribution to our understanding of the ammonitic paleontology of the Lut block. The figured materials and the stratigraphic columns showing ammonite occurrence provide a foundation for further studies in the Lut block.

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