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Ammonites from Bathonian and Callovian (Middle Jurassic) North of Damghan, Eastern Alborz, North Iran

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Zitteliana 89, 253–270.

Abstract

The following Middle Jurassic ammonite families (subfamilies) are described from the Dalichai Formation north of Damghan (eastern Alborz), some of them for the first time: Phylloceratidae, Lytoceratidae, Oppeliidae (Hecticoceratinae), Stephanoceratidae (Cadomitinae), Tulitidae and Reineckeiidae. The fauna is typically Northwest-Tethyan and closely related to Central Europe (Subboreal – Submediterranean Provinces).

Key words: Ammonites, Dalichai Formation, Middle Jurassic, Alborz, Iran

Zusammenfassung

Aus der Dalichai Formation nördlich von Damghan (Ostalborz) werden einige mitteljurassische Ammoniten, teils zum ersten Mal, beschrieben. Folgende Familien und Unterfamilien sind vertreten: Phylloceratidae, Lytoceratidae, Oppeliidae (Hecticoceratinae), Stephanoceratidae (Cadomitinae), Tulitidae und Reineckeiidae. Die Fauna ist typisch für die Nordwest-Tethys und zeigt enge Beziehungen zu Zentraleuropa (Subboreale und Submediterrane Faunenprovinz).

Schlüsselwörter: Ammoniten, Dalichai Formation, Mittlerer Jura, Alborz, Iran

Introduction

The present study is a continuation of a larger research project on the ammonite fauna of the Dalichai and Lar formations in eastern Alborz and Binalud Range. The ammonites of the Dalichai Formation were studied largely by Seyed-Emami et al. (1985, 1989, 1995), Schairer et al. (1991) and in recent years by Majidifard (2003), Seyed-Emami & Schairer (2010, 2011a, b), Seyed-Emami et al. (2013), Raoufian (2014), Raoufian et al. (2011, 2014), Dietze et al. (2014), Parent et al. (2014) and Seyed-Emami et al. (2015). The studied ammonites come - except of one specimen - from the Parikhan section west of Shahrud (Seyed-Emami et al. 2013, fig. 3B) and are exclusively from the Dalichai Formation at Talu, north of Damghan (Fig. 1). At Talu as elsewhere in the Alborz Range, the Dalichai Formation is a sequence of greyish limestones and marlstones, overlying disconformably the Shemshak Group (Norian–Early Bajocian; Fürsich et al. 2009). It is followed gradually by the light and cliff building carbonates of the Lar Formation (Upper Jurassic). The outcrop at Talu was studied by Behfar (2009) and Behfar et al. (2012) in the frame of a MSc. thesis. For the present study, a new section nearby was chosen and collections were made by A. Raoufian (2015).

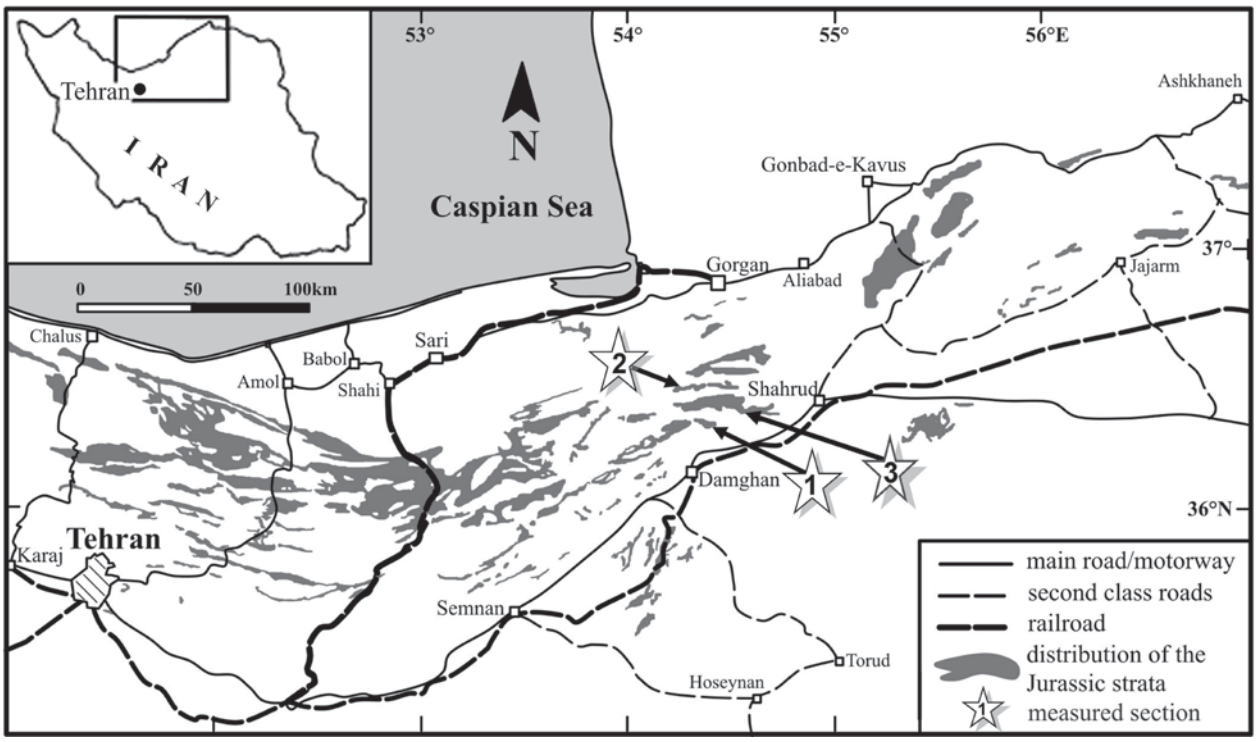
The greater part of the Morphoceratidae from Talu and Kelariz (Fig. 1) were previously studied by Dietze et al. (2014) and the Macrocephalitidae by Seyed-Emami et al. (2015).

2. Geological setting and specimen repository

2.1 Geological setting

The section Talu is located ca 19 km north of Damghan, E 54° 26’ 04”, N 36° 19’ 06” (see geological map of Damghan 1: 100,000 prepared by Alavi-Naini & Salehi Rad 1975).

The ammonites described in this study come from the upper part of the Dalichai Formation at Talu and are of Callovian age, except of a few specimens which have a Bathonian age. The new measured section at Talu (Fig. 2) has a thickness of 152 m and can be subdivided roughly into four members (from base to top):



Textfigure 1: Geographic map of central and east Alborz Mountains with location of the sections; 1= Talu, 2 = Kelariz, 3 = Parikhan.

Member 1: 15.5 m of brownish, sandy to fine-conglomeratic limestone with intercalation of marlstone.

Member 2: 60 m of greyish-green, argillaceous and very soft marlstone, with intercalation of marly limestone in the upper part. This unit contains few fragments of sponges, pelecypods, gastropods, crinoid ossicles and belemnites.

Member 3: 70 m of an alternation of greyish marly limestone and marlstone, with varying content of ammonites. Within this member, there are three distinct succeeding stratigraphic levels, consisting of few meters of condensed, reddish, nodular limestone and marls in "Ammonitico Rosso" facies:

Red Bed I: begins ca 95 m above the base of the section and is 1.5 m thick. It contains Late Bajocian ammonites (*Oxycerites*, *Parkinsonia*, Perisphinctidae etc.).

Red Bed II: begins ca 120 m above the base and is 2 m thick. It contains Early Bathonian ammonites (*Oxycerites*, *Cadomites*, *Parkinsonia*, Morphoceratidae and Perisphinctidae).

Red Bed III: begins ca 140 m above the base and is ca 4 m thick. It contains Callovian ammonites (Hecticoceratinae, Reineckeidae, Perisphinctidae, etc.). About 2 meters below this bed, there is a bed with fairly rich Macrocephalitinae.

The red beds are the most prominent features within the Dalichai Formation along the eastern Alborz and Binalud Mountains (Seyed-Emami et al. 2013). They represent condensation horizons of red nodular limestone and marls with iron coating and hardened surfaces. This lithology is widespread in the Alpine-Mediterranean Jurassic.

Member 4: 27 m, alternation of light-grey limestone and marlstone with intercalation of cherty limestones in the upper part. It contains Upper Callovian to Lower Oxfordian ammonites.

2.2 Specimen repository

The ammonites studied herein are deposited in the collections of the "Bayerische Staatssammlung für Paläontologie und Geologie" in Munich, Germany under the numbers SNSB-BSPG 2013 XX1V 40–62.

2.3 Measured parameters and abbreviations

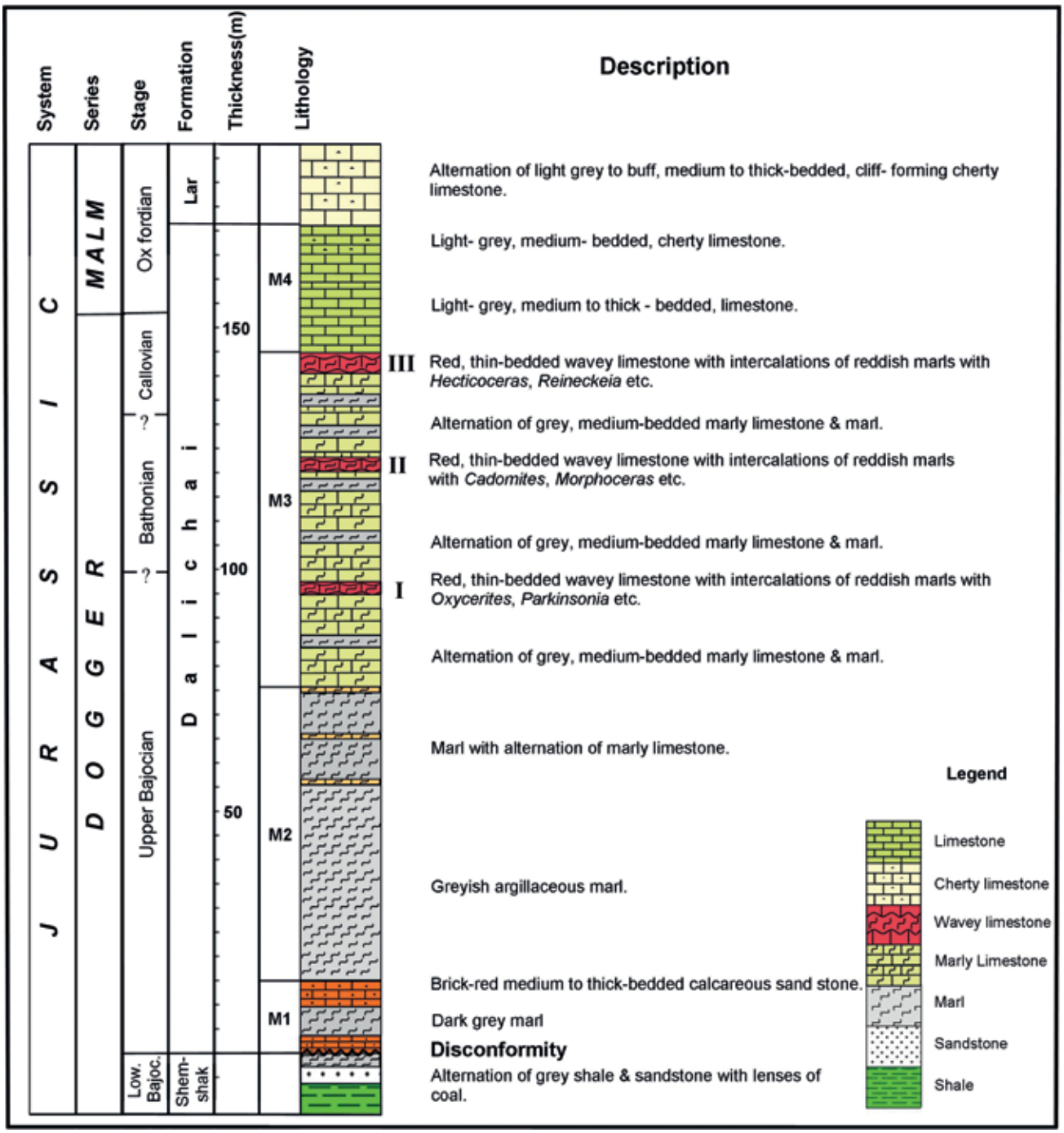
As far as possible, the following parameters are given: diameter (D) in mm; umbilical width (U), whorl height (H), whorl width (W) (all in % of diameter); number of primary ribs (PR) on a whorl, (SR) number of secondary ribs on a whorl; [m] = microconch, [M] = macroconch. All figures are in natural size, if not otherwise indicated.

3. Systematics

Family Phylloceratidae Zittel, 1884
Subfamily Phylloceratinae Zittel, 1884

Genus *Adabofoloceras* Joly, 1977

Adabofoloceras aff. *adabofolense* (Collignon, 1958)
Pl. 1, Fig. 1a, b



Textfigure 2: Stratigraphic log of the Talu section.

aff. 1958 *Adabofoloceras adabofolense* – Collignon, pl. 12, figs 63, 63a–b.

aff. 1976 *Adabofoloceras adabofolense* (Collignon) – Joly, p. 119, pl. 1, figs 1, 7; pl. 2, figs 1a–c, 3a–b, 4a–b, 6a–b, 10; pl. 38, figs 1a–b, 8–10, 11a–b; pl. 39, figs 10–12; 43, figs 7–9.

Material: One phragmocone from Talu (Col. Raoufian): SNSB-BSPG 2013 XXIV 40.

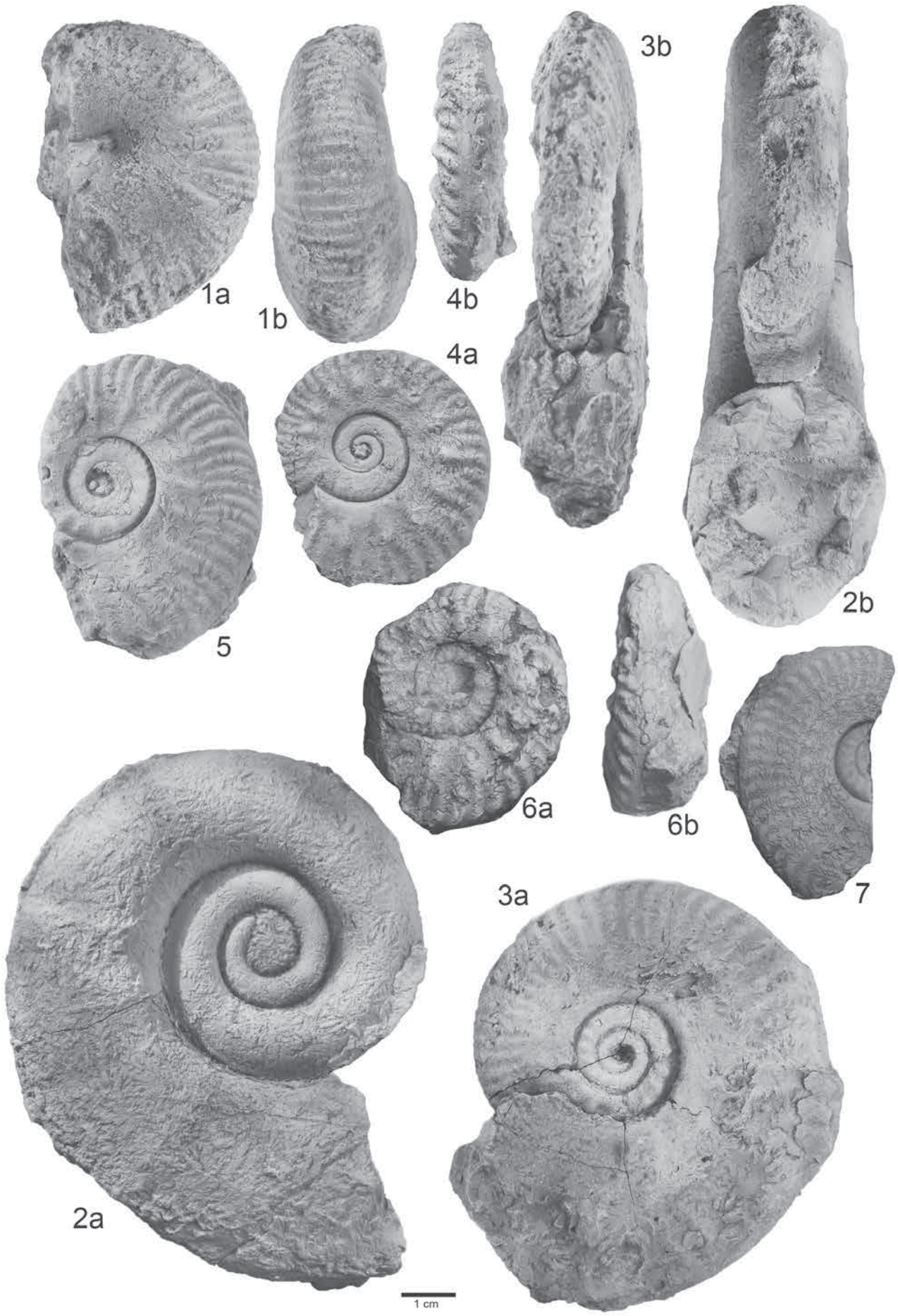
Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV56	54	7	55	45

Description: Highly involute Phylloceratidae with high-oval whorl section and an arched venter. The greatest whorl width is near to the mid-flank, from where the flank falls towards venter and umbilicus. The umbilicus is closed and funnel-shaped. The ribs are nearly rectiradiate and begin faintly within the inner flank. Towards the venter the ribs become distinctly coarser and bifurcate usually around the mid-flank, occassionally with intercalatory ribs. Suture line is not visible.

Discussion: Our specimen can be well compared to the holotype of Collignon (1958, pl. 12, figs 63, 63 a–b) being reproducted by Joly (1977: p. 119, pl. 1, fig. 1, pl. 38, figs a–b), from the Lower Callovian of Madagascar.

Textfigure 3: Field aspects of the Dalichai Formation north of Talu. **(a)** Postion of the Dalichai Formation between Shemshak and Lar formations. **(b)** Sharp contact between Shemshak and Dalichai formations with paleosoil (Mid-Cimmerian Event). **(c)** Position of the first, second and third Red Beds within the Dalichai Formation. **(d)** Aspect of Red Bed III at Talu. **(e)** *Reineckeia* in situ within the Red Bed III.

Plate 1: (1) *Adabofoloceras* aff. *adabofolense* (Collignon, 1958); Red Bed III, Talu, SNSB-BSPG 2013 XXIV 40. **(2)** *Lytoceras* sp.; Talu, SNSB-BSPG 2013XXIV 41. **(3–6)** *Hecticoceras* gr. *metomphalum* Bonarelli, 1894; Red Bed III, Talu. **(3)** SNSB-BSPG 2013 XXIV 42. **(4)** SNSB-BSPG 2013 XXIV 43. **(5)** SNSB-BSPG 2013 XXIV 44. **(6)** SNSB-BSPG 2013 XXIV 46. **(7)** *Hecticoceras (Lunuloceras)* sp.; Red Bed III, Talu, SNSB-BSPG 2013 XXIV 47.


1a
1b
4b
3b
4a
2b
5
6a
6b
7
2a
3a
1 cm

Occurrence: From Red Bed III.

Family Lytoceratidae Neumayr, 1875
Subfamily Lytoceratinae Neumayr, 1875
Lytoceras sp.
Pl. 1, Fig. 2a, b

Material: One fully septated internal mould from Talu: SNSB-BSPG 2013 XXIV 41.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013XXIV 41	99	41	37	32

Description: The rather strongly eroded phragmocone has a diameter of nearly 100 mm. It is a serpenticone and evolute Lytoceratidae with circular to high oval, slightly higher than wide whorl section. Because of the strong erosion the ribbing is not well recognizable. So far visible, very faint radial and distant ribs can be recognized.

Age: Late Early to Middle Callovian (Red Bed III).

Family Oppeliidae Bonarelli, 1894
Subfamily Hecticoceratinae Spath, 1925

Genus *Hecticoceras* Bonarelli, 1894

Hecticoceras gr. *metomphalum* Bonarelli, 1894
Pl. 1, Figs 3a, b, 4a, b, 5, 6a, b;
Pl. 2, Figs 1a, b, 2a, b

1894 *Hecticoceras* (*Lunuloceras*) *metomphalum* n. f. – Bonarelli, p. 90.
1956 *Hecticoceras* (*Rossiensiceras*) *metomphalum metomphalum* (Bonarelli) – Zeiss, p. 54, pl. 2, fig. 4 (with synonymy).
2000 *Hecticoceras* (*Rossiensiceras*) *metomphalum* Bonarelli – Schairer et al., p. 55, fig. 14.
2000 *Hecticoceras metomphalum metomphalum* Bonarelli, 1894 – Besnosov & Mitta, p. 53, pl. 19, figs 3–5.
2003 *Hecticoceras* (*Putealiceras*) *metomphalum* (Bonarelli) – Majidifard, pl. 4, figs 1, 4.
2009 *Hecticoceras* (*Lunuloceras*) gr. *metomphalum* (Bonarelli, 1894) – Schlögl et al., p. 66, figs 5.9–11, 6.4–5.
2011b *Hecticoceras* (*Rossiensiceras*) aff. *metomphalum* (Bonarelli, 1894) – Seyed-Emami & Schairer, p. 376, fig. 3A.
2013 *Hecticoceras* (*Rossiensiceras*) gr. *metomphalum* (Bonarelli, 1894) – Seyed-Emami et al., p. 50, fig. 5f.
2014 *Hecticoceras metomphalum* Bonarelli, 1893 – Parent et al., pl. 2, figs 2–3.

Material: Six one-side preserved internal moulds from the third red-bed at Talu: SNSB- BSPG 2013 XXIV 42–46, 48.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV 43	43	36	40	-
BSPG 2013 XXIV 46	48	40	38	-
BSPG 2013 XXIV 48	at ca 55	ca 25	ca 46	ca 27
BSPG 2013 XXIV 45	58	26	47	-
BSPG 2013 XXIV 42	78	27	42	-

Description: Within the present collection we can distinguish roughly two morphotypes: Fairly involute and rather compressed forms with little to moderately coarse ornamentation (morphotype 1) and relatively depressed and evolute forms with coarse ornamentation (morphotype 2). We assign both morphotypes to a single taxon *H.* gr. *metomphalum*.

Discussion: The systematics of Hecticoceratinae is still a persistant problem and they are subdivided into many unnecessary and probably synonymous taxa. Particularly the metomphalum-group shows apparently a large intraspecific variability, as emphasized already by Schlögl et al. (2009: 66), Seyed-Emami & Schairer (2011b: 4) and Dietl (2013).

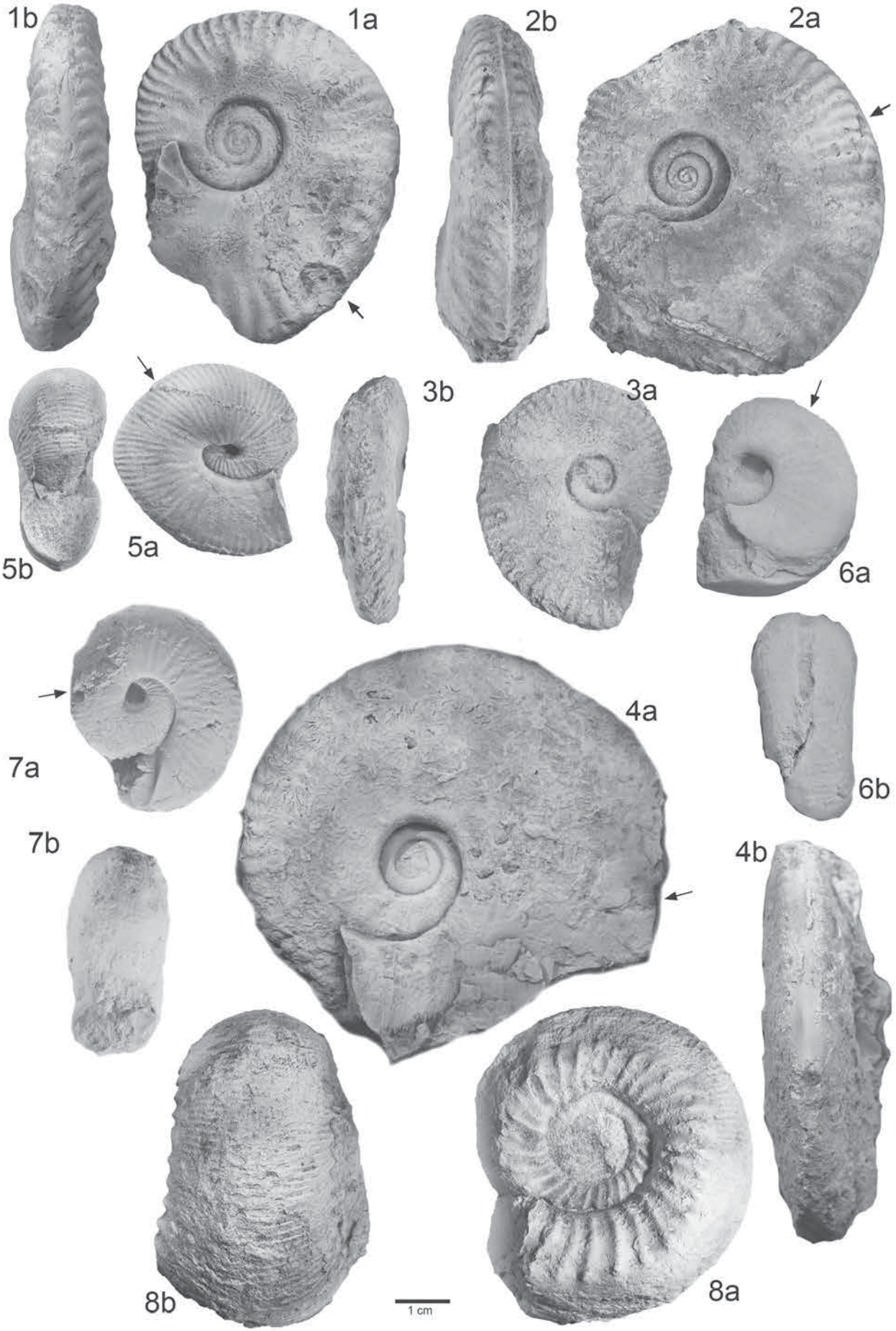
Morphotype 1. Rather involute and compressed forms with semi-coarse ornamentation: SNSB-BSPG 2013 XXIV 42, 48 (Pl. 1, Fig. 3 a, b; Pl. 2, Figs 2 a, b):

In specimen SNSB-BSPG 2013 XXIV48 (Pl. 2, Fig. 2 a, b) only one side is preserved. It is a partially eroded internal mould with a diameter over 65 mm. The body chamber begins at D = 53 mm. It is relatively involute with high-oval, slightly shouldered whorl cross-section and a sharp, low and narrow keel. The nearly smooth inner flank falls gently towards the rather sharp umbilical margin and is slightly concave. The umbilical wall is low and vertical. Ribbing is up to a diameter of 40 mm relatively fine, but later it becomes coarser. On the last half whorl of the phragmocone there are about 7–8 flat and blunt peri-umbilical tubercles, giving way to 3 to 4 blunt and concave outer ribs. On the body chamber the tubercles almost cease and the inner flank becomes smooth. On the outer flank there are still faint and distant ribs. Specimen SNSB-BSPG 2013 XXIV 42 is a large phragmocone with a diameter of nearly 80 mm. These forms can be attributed to the group of *Hecticoceras metomphalum metomphalum*.

Morphotype 2. Rather evolute and depressed forms with coarse ornamentation: SNSB-BSPG 2013 XXIV 43, 44, 45, 46 (Pl. 1, Figs 4a, b, 5, 6a, b; Pl. 2, Fig. 1a, b.). These forms can be best compared with the group of *Hecticoceras metomphalum multicostatum* Tsytovich, 1911.

SNSB-BSPG 2013 XXIV43 (Pl. 1, Fig. 4a, b) is a phragmocone with only one-side preserved. It is fairly evolute with a low keel and a smooth inner flank gently falling towards the low umbilicus. The umbili-

Plate 2: (1, 2) *Hecticoceras* gr. *metomphalum* Bonarelli, 1894; Talu. **(1)** SNSB-BSPG 2013 XXIV 45. **(2)** SNSB-BSPG 2013 XXIV 48. **(3)** *Hecticoceras* aff. *paulowi* (de Tsytovitch, 1911); Talu, SNSB-BSPG 2013 XXIV 49. **(4)** *Hecticoceras* (*Lunuloceras*) sp. nov.? [M]; Red Bed III, Talu, SNSB-BSPG 2013 XXIV 50. **(5)** *Bullatimorphites* (*Bomburites*) *microstoma* (Orbigny, 1846) [m]; Talu, SNSB-BSPG 2013 XXIV 55. **(6, 7)** *Bullatimorphites (Bomburites)* aff. *suevicus* (Roemer, 1911) [m]; Red Bed III, Talu. **(6)** SNSB-BSPG 2013 XXIV 56. **(7)** Parikhan (from scree): SNSB-BSPG 2013 XXIV 62. **(8)** *Cadomites* (*Cadomites*) cf. *costidensum* (Imlay, 1953), Talu (from scree), SNSB-BSPG 2013 XXIV 52.


1b
1a
2b
2a
5b
5a
3b
3a
6a
7a
4a
6b
7b
4b
8b
1 cm
8a

cal wall is low and vertical. The ribbing is coarse with slightly elongated prorsiradiate peri-umbilical tubercles (9 on a half-whorl). From the tubercles radiate mostly two concave outer ribs with occassionally an intercalate rib.

SNSB-BSPG 2013 XXIV 45 (Pl. 2, Fig. 1a, b) is a fairly involute phragmocone with a small fragment of the body chamber, which begins at D = 58 mm. The umbilical margin is rather sharp, with a low and steep umbilical wall. Whorl section is high oval with a low keel. The ribbing is rather coarse with prorsiradiate elongated peri-umbilical tubercles (8–9 on a half whorl), which give way to three concave external ribs above the mid-flank; occasionally with intercalated ribs.

Discussion: The different morphotypes of the group of *Hecticoceras metomphalum* are relatively frequent in the Dalichai Formation. Because of the condensation, it cannot be determined whether these are only morphotypes of a single species or different taxa of different age.

Age: Zeiss (1956: 45) recorded *H. metomphalum* from the Anceps to the Lamberti zone, Schlögl et al. (2009: 66) from the Middle Callovian (Coronatum Zone) and Dietl (2013) from the Middle Callovian (upper Jason Zone). Our specimens come from the Red Bed III at Talu. Considering the stratigraphic position of Macrocephalitidae from the same section (Seyed-Emami et al., 2015, p. 6, table 1), which occur ca 2 meters below the Red Bed III, the age of the herein described Hecticoceratinae is most probably late Early Callovian (Gracilis Chron) to early Middle Callovian (Anceps Chron).

Hecticoceras aff. *paulowi* (de Tsytovitch, 1911)
Pl. 2, Fig. 3a, b

aff. 1911	*Hecticoceras Paulowi* n. sp. – de Tsytovitch, p. 69, pl. 7, figs 8–12, pl. 8, figs 2–3.
aff. 1956	*Hecticoceras* (*Lunuloceras*) *paulowi* (de Tsytovitch) – Zeiss, p. 44, pl. 1, fig. 11 (with synonymy).
aff. 2009	*Hecticoceras* (*Lunuloceras*) *paulowi* cf. (de Tsytovitch, 1911) – Schlögl et al., p. 66, figs 5.4, 6.6.
aff. 2013	*Hecticoceras* (*Lunuloceras*) *paulowi* (de Tsytovitch) – Seyed-Emami et al., p. 50, figs 5 c–e.

Material: One eroded internal mould from Talu: SNSB-BSPG 2013 XXIV 49.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV 49	46	22	46	-

Description: Specimen (SNSB-BSPG 2013 XXIV49) is a partially eroded phragmocone with only one side preserved. It is relatively involute with high-oval whorl section and a sharp, low and narrow keel. The nearly smooth inner flank falls gently towards the umbilical margin. The umbilical wall is low and steep. The ribbing is up to a diameter of ca 35 mm relatively fine and seemingly limited to the outer flank, but later it becomes slightly coarser. The inner part of the flank is up to a diameter of 35 mm almost smooth, but later indistinct, distant and thickened inner ribs appear.

Discussion: Concerning the rather smooth inner flank and the relatively narrow umbilicus the present specimen can be best compared with *H. paulowi*. "*Orbignyceras paulowi*" from the Upper Callovian of Herznach (Switzerland) as reported by Jeannet (1951, pl. 9, fig. 12) is very similar. It also can be compared with involute and smoothly ribbed morphotypes of the *H. metomphalum* group.

Age: Zeiss (1956: 45) and Fortwengler et al. (2012: 120) reported *H. paulowi* from the Upper Callovian (Lamberti Zone). Schlögl et al. (2009) reported it from the Middle Callovian (Coronatum Zone). The present specimen comes from the Red Bed III indicating a late Early to Middle Callovian age.

Hecticoceras (*Lunuloceras*) sp.
Pl. 1, Fig. 7

Material: An eroded half of a phragmocone from Talu: SNSB-BSPG 2013 XXIV 47.

Description: The half-preserved phragmocone has a diameter of nearly 50 mm. It is a discoidal, moderately evolute, carinate and slightly shouldered *Hecticoceras* with high-oval cross section. The umbilical margin is sharp, the umbilical wall vertical. The flank is slightly convex and falls from the tubercles slightly towards the umbilicus and the venter. The ribbing is rather fine and consists of short and prorsiradiate inner ribs which end shortly above the umbilicus at small and rounded tubercles. On a half-whorl, at a diameter of ca 50 mm, there are 12 to 13 tubercles. Two concave outer ribs radiate almost regularly from the tubercles. On the shoulder the ribs bend forward and end at the keel.

Discussion: The present form cannot be attributed to any known Hecticoceratinae yet. So far the best comparable taxon is *Hecticoceras pseudopunctatum* (Lahusen, 1883) in Jeannet (1951, p. 43, pl. 9, fig. 11) and Zeiss (1956, p. 40, fig. 4, 9).

Occurrence: Red Bed III.

Hecticoceras sp. nov.? [M]
Pl. 2, Fig. 4a, b

Material: A one-side preserved internal mould from Talu: SNSB-BSPG 2013 XXIV 50.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV 50	80	19	51	-

Description: The strongly eroded specimen has a diameter of more than 80 mm. Apart from a small portion of the body chamber the greater part of the last whorl belongs to the phragmocone. A slight

egression at a diameter of ca 80 mm indicates the beginning of the body chamber. It is a discoidal, carinate and involute *Hecticoceras* with high-oval, slightly shouldered whorl section and a low keel. The umbilical margin is rather sharp, with a vertical umbilical wall. The flank is slightly convex and falls from the mid-flank gently towards the umbilicus and the venter. The ribbing is falcoid. Probably due to erosion, the ribbing on the inner flank is somewhat obscure, but still some flat, broad and widely spaced ribs can be recognized. At about the mid-flank, the ribs give way to two or three slightly concave outer ribs, occasionally with an intercalate rib. Towards the venter the ribs become stronger and broader and somewhat scale-like. On the shoulder the ribs bend forward and reach up to the faint keel.

Discussion: The present specimen is characterized by its large size. Among the known taxa of *Hecticoceras* our specimen can be best compared to *H. paulowi*, especially to some specimens illustrated by Jeannet (1951, pl. 10, figs 1–3). After Jeannet (1951, p. 45) the taxon can reach a size of up to 90 mm. Another partially similar taxon is *H. lunuloides* (Kilian) in Lemoine (1932, pl. 13, fig. 9) and in Parent et al. (2014, pl. 2, fig. 5a–c) from the Binalud Mountains, northeast Iran. Most probably it represents a new species.

Age: Late Early to Middle Callovian (Red Bed III).

Family Stephanoceratidae Neumayr, 1875
Subfamily Cadomitinae Westermann, 1956

Genus *Cadomites* (*Cadomites*) Munier-Chalmas, 1892

Cadomites bremeri Tsereteli, 1968
Pl. 3, Fig. 2a–c

1968	*Cadomites bremeri* Tsereteli s. nov. – Tsereteli, p. 80, pl. 12, figs 1 (holotype), 2–4.
1974	*Cadomites* (*Cadomites*) *bremeri* Tsereteli, 1968 – Kopik, p. 22, pl. 3, fig. 3, pl. 4, figs 1a–c, pl. 5, figs 1a–c, pl. 6, figs 1a–b, pl. 7, figs 1a–b.
1997	*Cadomites* (*Cadomites*) *bremeri* Tser. – Mangold & Rioult, p. 59, pl. 16, fig. 1.
2007	*Cadomites bremeri* Tsereteli – Dietze et al., p. 114, fig. 8c.
2010	*Cadomites bremeri* Tsereteli, 1968 [M] – Zaton, p. 125, pl. 2C–H, Textfigs 6–7C–F (with synonymy).
2016	*Cadomites* (*Cadomites*) bremeri Tsereteli [M] – Sandoval, p. 239, pl. 7b.

Material: One one-side preserved phragmocone from Talu: SNSB-BSPG 2013 XXIV 51

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV51	59	28	39	-

Description: A still fully septated and moderately involute (semi-evolute) *Cadomites* with cadicone, broad-trapezoid whorl section. The flank falls steeply towards the umbilicus and merges gradually into the vertical umbilical wall. The umbilicus is deep and funnel-like. The ribbing is fine and dense. The slightly prorsiradiate inner ribs begin at the seam and end into relatively tiny tubercles at the ventro-lateral margin (the greatest whorl width). Mostly three to four fine and bundled ventral ribs radiate from the tubercles; they cross the arched venter. At a diameter of 32 mm there are 35 tubercles per whorl, at 50 mm there are 39.

Discussion: The present specimen matches best the specimen illustrated in Mangold & Rioult (1997, pl. 16, fig. 1). The similar *Cadomites rectelobatus* (Hauer) is more depressed and has a larger whorl width. Further similar taxa are *Cadomites* (*C.*) *orbignyi* (Grossovre) and *Cadomites* (*C.*) *daubenyi* (Gemmellaro). For a detailed discussion see Zaton (2010: 126).

Age: *Cadomites bremeri* is a widely distributed taxon and the index ammonite of the Bremeri Zone (Top Middle Bathonian) (Mangold & Rioult, 1997: 59; Sandoval, 2016, p. 238). At Talu it was collected loosely from the scree below Red Bed III.

Cadomites (*Cadomites*) cf. *costidensum* (Imlay, 1953)

Pl. 2, Fig. 8a, b; Pl. 3, Fig. 3a–c

cf. 1953	*Gowericeras costidensum* – Imlay, pl. 22, fig. 10–13
1974	*Cadomites (Cadomites) stegeus* (Buckman 1922) – Kopik, p. 17, pl. II, figs 2a, b, 3.
aff. 1989	*Cadomites* aff. *stegeus* (Buckman, 1922) – Seyed-Emami et al., p. 83, pl. 2, figs 1, 2.

Material: Two incomplete and one-side preserved internal moulds from Talu: SNSB-BSPG 2013 XXIV 52, 53.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV 52	56	36	36	ca 57

Description: Specimen pl. 2, fig. 8a, b is a fully septated, rather evolute phragmocone with cadicone to broad trapezoid whorl cross-section. The flank falls steeply towards the umbilicus and merges gradually into the short and vertical umbilical wall. The ornamentation consists of relatively coarse, slightly prorsiradiate and concave inner ribs, which end ventrolaterally into semi-coarse tubercles. From the tubercles radiate 3–4 fine and slightly convex ventral ribs. At a diameter of 56 mm there are 30 tubercles per whorl.

Discussion: Because of their lesser rib density the two specimens stand between *C. bremeri* and *C. oppitzi/altispinosus*. In Europe, we know little about *Ca-*

domites in the Retrocostatum Zone. Only Kopik described a few microconchs and his *C. stegeus* (p. 17, pl. II, figs 2a, b, 3) seems to be the same species as the Iranian specimen. Imlay (1953) desrcibed many species of *Cadomites* as *„Gowericeras“* from Canada of which *C. costidensum* is very close to the two specimens illustrated here; they also come from a similar stratigraphic level (lower part of Upper Bathonian).

Cadomites rectelobatus (Hauer) is much more inflated and has much wider whorls. *Cadomites* cf. *stegeus* (Buckman) in Pavia et al. (2008, pl.1, figs 6–7) is less broad and has coarser and less dense ribbing. In comparison with the very similar taxon *Cadomites daubenyi* (Gemmellaro, 1877) in Galácz et al. (2008, p. 58, pl. 2, fig. 8, pl. 4, fig. 3) and Pavia & Cresta (2002, p. 236, figs 161 a-d) our specimens are distinguished by a wider umbilicus and coarser ribbing. For further differences towards other similar species see Kopik (1974: 19).

Age*:* The type of *C. costidensum* comes from the Western Interior (USA). After Callomon (1984) this horizon corresponds to the Cranocephaloide Zone in the Boreal Realm, which represents the upper part of the Bremeri Zone in Europe. Our specimens were collected loosely from the scree above the Red Bed II and below Red Bed III.

Family Tulitidae Buckman, 1921

Genus *Bullatimorphites* Buckman, 1921

Bullatimorphites (?*Kheraiceras*) sp. [M]
Pl. 3, Fig. 1a, b

cf. 1983 *Bullatimorphites (Bullatimorphites) costatus* (Arkell) – Sandoval, p. 556, pl. 69, figs 1, 2, pl. 71, fig. 2.
cf. 1988 *Bullatimorphites (Bullatimorphites)* cf. *costatus* (Arkell) – Westermann & Callomon 1988, p. 81, pl. 17, fig. 5a, b.
1991 *Bullatimorphites* aff. *ymir* (Oppel) – Seyed-Emami et al., p. 72, pl. 3, fig. 1–4
2006 *Bullatimorphites (Bullatimorphites) perisphinctoides* Arkell – Topchishvili et al., pl. 33, fig. 1, pl. 34, fig. 1 (= *Bullatimorphites suevicus* Tsereteli, 1968)

Material: One incomplete and strongly eroded specimen from Talu: SNSB-BSPG 2013 XXIV 54.

Description: An incomplete specimen with a diameter of ca 103 mm. It comprises parts of the body chamber, indicated by a distinct eggression and simultaneous contraction of the whorl at about D = ca 80 mm. The phragmocone is fairly involute and depressed. The ribbing is little coarse on the phragmocone. Towards the body chamber it becomes coarser and ribs are more distant.

Discussion: In the upper part of the Bremeri Zone (*fortecostatum* horizon) there occur species that stand between the *bullatimorphus-costatus* group and *B. hannoveranus*. But they have a narrower umbilicus (as *B*. *costatus*), the ribbing is somewhat coarser and they are slightly smaller (110–140 mm). Typical specimens have already been illustrated under different names (see synonym list). On the internet there is a manuscript name: “*B. sandovali”,* for *Bullatimorphites novo* sp. 1 Sandoval, 1983. A similar, but older taxon is *B. latecentratus* (Quenstedt), designated and refigurd by Hahn (1971, p. 97, pl. 6, fig. 3a, b) and refigured by Arkell (1954, P. 109, fig. 35) and Schlegelmilch (1985, p. 134, pl. 52, fig. 2). Another similar taxon is *B. hermi* Seyed-Emami et al. (1998, p. 123, pl. 2, fig. 1, textfig. 3) which is very close to *B. hannoveranus* (Roemer).

Age: Bremeri Zone, upper part. The Iranian specimen is collected loosely from the scree above Red Bed II at Talu and may be little younger.

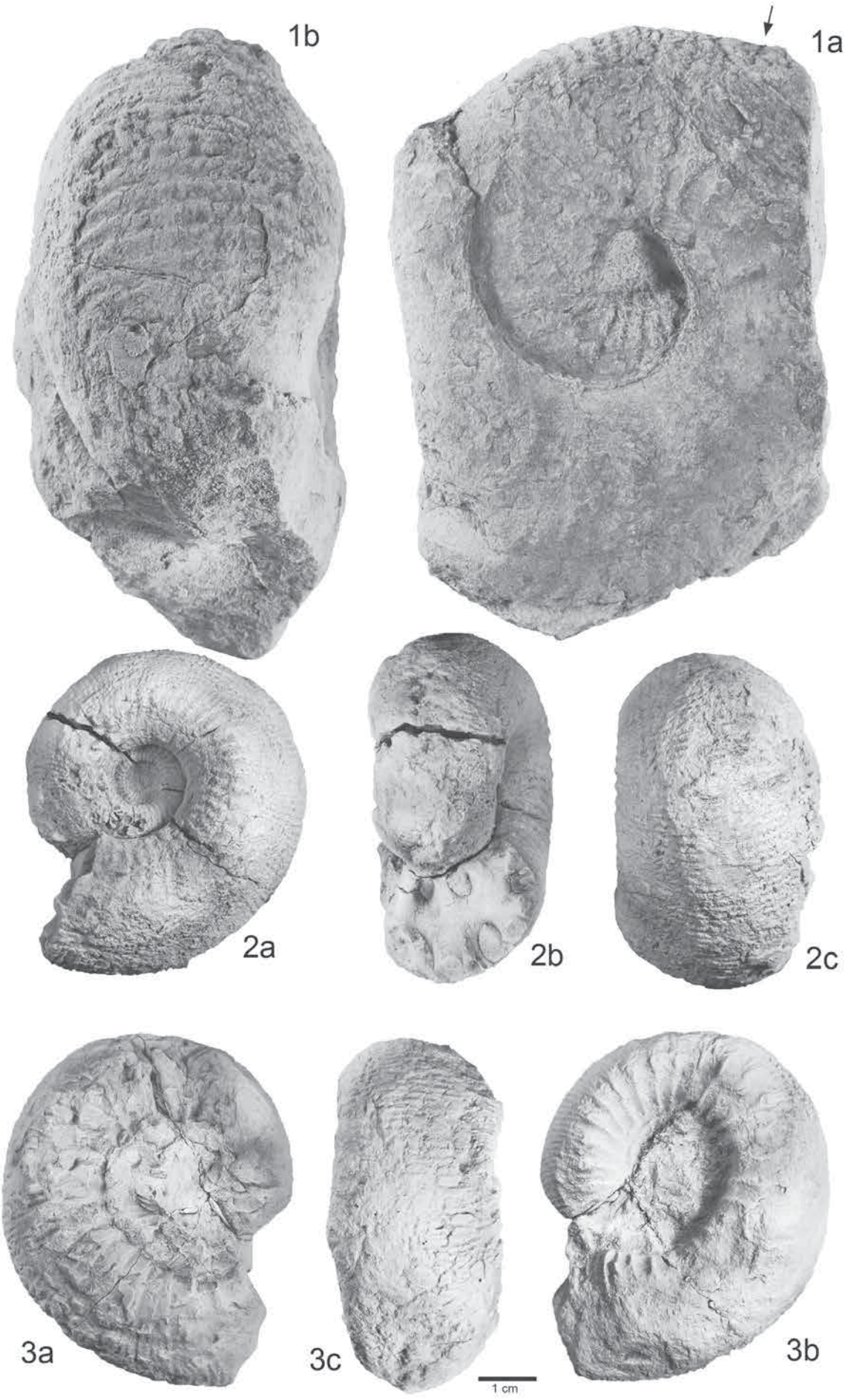
Bullatimorphites (*Bomburites*) *microstoma*
(Orbigny, 1846) [m]
Pl. 2, Fig. 5a, b

1939 *Sphaeroceras microstoma* d´Orb. – Kuhn, p. 472, pl. 6, fig. 3.
1954 *Ammonites microstoma* D´Orbigny sp. – Arkell, p. 108, fig. 35 (refiguration of the lectotype).
1971 *Bullatimorphites* (*Bomburites*) *microstoma* (d´Orbigny) – Hahn, p. 108, pl. 7, figs 5, 6; pl. 9, fig. 8.
aff. 1972 *Treptoceras microstoma* (D´Orbigny) – Krystyn, p. 291, pl. 20, fig. 3; textfig. 28.
1994 *Bullatimorphites bullatus* forme microconque *microstoma* (d´Orbigny, 1846) – Thierry et al., p. 132, pl. 56, figs 2a–c (refiguration of the holotype), 3a, b.
1995 *Bullatimorphites* (*Bomburites*) *microstoma* (d´Orbigny, 1846) – Mönnig, p. 71, pl. 10, fig. 1.
2003 *Bullatimorphite* (*Bomburites*) cf. *microstoma* (d´Orbigny) – Majidifard, p. 98, pl. 4, fig. 12.
2009 *Bullatimorphites* aff. (*Bomburites*) *suevicus* (Roemer) – Behfar et al., pl. 1, fig. 6.
2012 *Bullatimorphites* (*Bomburites*) aff. *microstoma* (Orbigny, 1846) – Behfar et al., pl. 1, fig. 6.
2016 *Kheraiceras* (*Bomburites*) *microstoma* (d´Orbigny) – Sandoval, p. 241, fig. 9c.

Material: One slightly distorted specimen, with a part of the body chamber from Talu: SNSB-BSPG 2013 XXIV 55.

Description: The slightly deformed specimen has a diameter of ca 38 mm. About half of the last whorl belongs to the body chamber, which is indicated by a clear egression and simultaneous contraction of the whorl and a distinct crinkle. The crinkle at the beginning of the body chamber may be strengthened by distortion. The phragmocone is ellipticone, involute, and moderately inflated. The ribbing is on the

Plate 3: **(1)** *Bullatimorphites* (*?Kheraiceras*) sp. [M]; Talu (from scree), SNSB-BSPG 2013 XXIV 54. **(2)** *Cadomites bremeri* Tsereteli, 1968; Talu, SNSB-BSPG 2013 XXIV 51. **(3)** *Cadomites* (*Cadomites*) cf. *costidensum* (Imlay, 1953); Talu (from scree), SNSB-BSPG 2013 XXIV 53.


1b
1a
2a
2b
2c
3a
3c
3b
1 cm

phragmocone fine, dense and slightly prorsiradiate, single or irregularly bifurcating above the umbilicus and higher up. On the body chamber the ribbing becomes slightly coarser and more widely spaced; the inner ribs are short, slightly thickened and bifurcate often irregularly on the flank.

Discussion: Arkell (1954: p. 108) could not observe any lappet on d'Orbigny's specimens and considered them rather to be small *Bullatimorphites*. But Thierry et al. (1994: p. 133) mentioned a short lappet, which can be seen on the figured specimen (pl. 56, fig. 2) and stated that the specimens were found together with *B. bullatus* and can be considered as microconch forms of the latter.

The present specimen, though a little smaller, can be well compared to *B. microstoma* in Thierry et al. (1994: pl. 56, fig. 2a, b), Kuhn (1939, pl. 6, fig. 3) and Hahn (1971, pl. 7, fig. 6). The very similar specimen *Bullatimorphites* (*Bomburites*) *suevicus* (Roemer) from the upper Bathonian (Hahn 1971, p. 106, pl. 8, figs 5, 6, 8, 10; Dietl 1994, p. 19, pl. 2, fig. 1) is more depressed and has a greater size.

Age: *Bullatimorphus* (*Bomburites*) *microstoma* is usually reported from the lower Callovian (Hahn 1971, p. 108; Kuhn 1939, p. 472; Thierry et al. 1994, p. 133) and Sandoval (2016, p. 242). The present specimen comes from the beds with *Macrocephalites*, ca 2 m below the Red Bed III, which corresponds also to Lower Callovian (Bullatus Zone) see Seyed-Emami et al. (2015, p. 19).

Bullatimorphites (*Bomburites*) aff. *suevicus*
(Roemer, 1911) [m]
Pl. 2, Figs 6a, b, 7a, b

aff. 1971 *Bullatimorphites* (*Bomburites*) *suevicus* (J. Roemer) – Hahn, p. 106, pl. 8, figs 5, 6, 8, 10.
aff. 1985 *Bullatimorphites* (*Bomburites*) *suevicus* (Roemer, 1911) – Schlegelmilch, p. 135, pl. 52, fig. 7.
2005 *Bullatimorphites* (*Kheraiceras*) *bullatus* (Orbigny) – Shafeizad & Seyed-Emami, pl. 1, fig. 18.
aff. 2015 *Bullatimorphites* (*Bomburites*) *suevicus* (Roemer, 1911) – Martin & Mangold, p. 55, pl. 22, figs 1–9 (with synonymy).

Material: One nearly complete internal mould from Parikhan (west Shahrud, col. Shafeizad): SNSB-BSPG 2013 XXIV 62 and a strongly eroded, incomplete specimen with a portion of the body chamber from Talu (col. Behfar): SNSB-BSPG 2013 XXIV 56.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV62 (end of PH)	38	31	31	ca 40

Description: SNSB-BSPG 2013 XXIV 62: The phragmocone is ellipticone, inflated and nearly sphaerocone with a tight umbilicus. About ¾ of the last whorl belongs to the body chamber. The beginning of the body chamber, at a diameter of ca 22 mm, is indicated by a distinct eggression and simultaneous contraction of the whorl. At the beginning of the peristome there is a deep prorsiradiate constriction, delimited by a distinct bulge. A small part of the lappet is preserved at the end of the peristome. The ribbing is similar to *B.* (*B.*) *microstoma*. On the phragmocone it is fine and prorsiradiate, single or bifurcating irregularly within the inner flank. On the body chamber the ribs become slightly coarser and more widely spaced. The ribs cross the arched venter without interruption.

Discussion: The specimen from Parikhan unites both properties of *B.* (*B.*) *microstoma*, as well as *B.* (*B.*) *suevicus*, so that it could be assigned to both taxa. Compared to the lectotype of *B. (B.) suevicus*, designated by Hahn (1971: p. 107) and illustrated by Arkell (1954, fig. 36 left) and Schlegelmilch (1985: pl. 52, fig. 7) it is somewhat smaller and less inflated. In this respect it resembles *B. (B.) uhligi* (Popovici-Hatzeg), see Martin & Mangold (2015, p. 57).

Another similar taxon is *Bullatimorphites weigelti* Kuhn (1939, pl. 7, fig. 3), refigured by Schlegelmilch (1985, pl. 52, fig. 3).

Age: Our specimen was collected loosely from the locality Parikhan (west Shahrud) by M. Shafeizad (Seyed-Emami et al. 2013, fig. 3b). Fernandez-Lopez (2001) reported the taxon from the Upper Bathonian (Retrocostatum Zone). *Bullatimorphites* (*B.*) *suevicus* is usually recorded from the uppermost Bathonian.

Family Reineckeiidae Hyatt, 1900

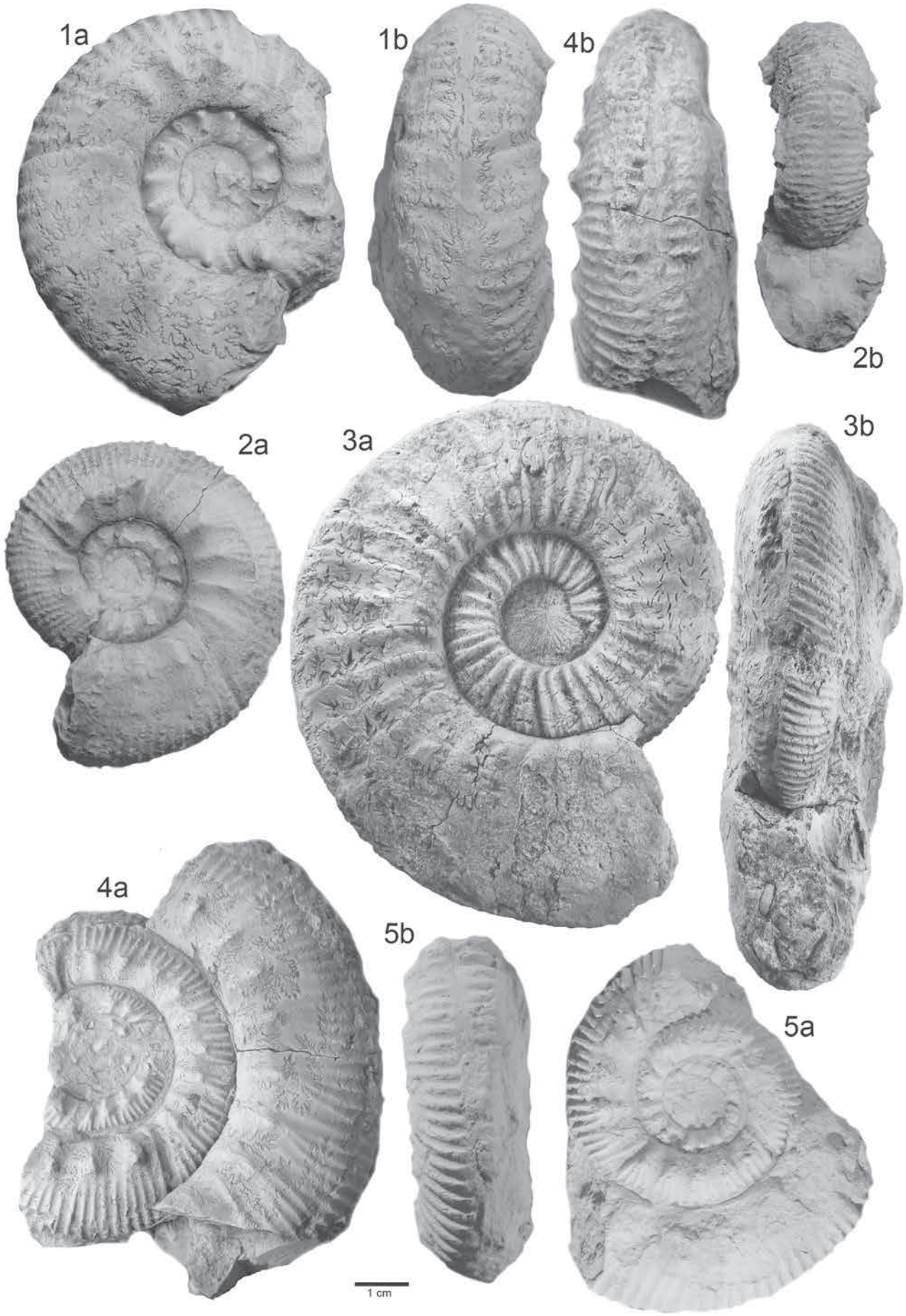
Remarks on Reineckeiidae from Talu: In Talu, Reineckeiidae are most abundant next to the Perisphinctidae as is usual within the Dalichai Formation in North Iran. Of more than hundred specimens, only few examples are considered here, because of nomenclatural problems regarding this ammonite family.

Genus *Reineckeia* Bayle, 1878

Reineckeia (*Reineckeia*) gr. *stuebeli*
(Steinmann, 1881) (M)
Pl. 4, Figs 4a, b, 5a, b

1984 *Reineckeia* (*Reineckeia) stuebeli* Steinmann, 1881 – Cariou, p. 264, pl. 40, figs 1–4a–c, 5, pl. 41, figs 2a–b, 3, 6a–b; textfigs 131–132, 146–149, 152, 159–160 (with synonymy).

Plate 4: (1) *Reineckeia* (*Reineckeia*) ex gr. *anceps* (Reinecke, 1818); Red Bed III, Talu, SNSB-BSPG 2013 XXIV 60. **(2)** *Reineckeia* sp.; Red Bed III, Talu, SNSB-BSPG 2013 XXIV 61. **(3)** *Alborzites binaludensis* Seyed-Emami (2013); Red Bed III, Talu, SNSB-BSPG 2013 XXXIV 57. **(4, 5)** *Reineckeia* (*Reineckeia*) gr. *stuebeli* (Steinmann, 1881) [M]; Red Bed III, Talu. **(4)** SNSB-BSPG 2013 XXIV 58. **(5)** SNSB-BSPG 2013 XXIV 59.


1a
1b
4b
2b
2a
3a
3b
4a
5b
5a
1 cm

Material: Two on one side preserved phragmocones from Talu: SNSB-BSPG 2013 XXIV 58, 59.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV 58	65	47	31	38
BSPG 2013 XXIV 59	65	52	29	-

Description: Specimen SNSB-BSPG 2013 XXIV 58 is a fragment of a larger, fully septated and very evolute Reineckeiidae. In the inner whorls the whorl section is broad trapezoid-oval, but becomes later ovate and slightly higher than wide. The umbilicus is wide and shallow with rounded umbilical margin and steep umbilical wall. The ribbing consists of short, distant, nearly radiate and fairly coarse primary ribs, which start at the seam and end shortly above the umbilicus into fairly strong and sharp (spinose) tubercles. There are 11 tubercles on a half whorl at a diameter of 65 mm. Mostly four slightly prorsiradiate secondary ribs radiate from the tubercles with occasionally intercalated ribs. The ribs end vertically at a distinct ventral furrow. At a diameter of 65 mm there are two deep, prorsiradiate constrictions per half whorl.

Discussion: Regarding the wide umbilicus and the pattern of ribbing our specimens can be fairly well compared to the macroconch forms of *R. stuebeli* (Steinmann, 1881) as reported by Cariou (1984, p. 264,), especially the specimens illustrated on plate 40. A rather similar taxon is *Rehmannia* (*Loczyceras*) *reissi* (Steinmann) in Cariou & Krishna (1988, p. 156, pl. 1, fig. 1) from the Anceps Zone of Cutch, India.

Age: After Cariou (1984: p. 278) and Crariou (1994: p. 150) *R. suebeli* is a frequent taxon in the lower Middle Callovian (Anceps Zone) of Europe, being also known from the South Tethyan Realm (North Africa, India (Cutch) and Madagaskar). At Talu, the specimens come from Red Bed III.

Reineckeia (*Reineckeia)* ex gr. *anceps*
(Reinecke, 1818)
Pl. 4, Fig. 1a, b

1984 *Reineckeia (Reineckeia*) *anceps anceps* (Reinecke) – Cariou, p. 220, pl. 33, figs 4, 5a– b; pl. 34, figs 1, 2, 5a–b; pl. 35, figs 1, 4, 5a–b; textfigs 123, 126, 137, 155, 156 (with synonymy).
1988 *Reineckeia* (*Reineckeia*) *anceps* (Reinecke 1818) – Cariou & Krishna, p. 160, pl. 2, figs 2a–b; pl. 3, figs 1a–b (with synonymy).
2002 *Reineckeia* (*Reineckeia*) *anceps* (Reinecke, 1818) – Seyed-Emami et al., p. 185, figs 2–2–4.

Material: One phragmocone from Talu: SNSB-BSPG 2013 XXIV 60.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV 60	75	41	37	-

Description: A fully septated, fairly evolute and rather depressed *Reineckeia* with a diameter of 76 mm. The whorl section is, at the end of the last preserved whorl, rounded to oval and nearly as high as wide. The ribbing on the inner whorl consists of short, radiate, distant and coarse primaries, beginning at the seam. These end alternately into coarse, conical and spinose tubercles. Towards the last preserved whorl, the tubercles weaken. On the last portion of the whorl the ribbing consists of coarse and distant primaries, which often trifurcate above the mid-flank. Only one constriction can be recognized on the last whorl.

Discussion: The holotype of *R. anceps* (Reinecke 1818, p. 82, pl. 7, fig. 61) is lost and so far no neotype is established. Therefore, there is a lot of confusion regarding this taxon. Considering the numerous topotypes the taxon has to be re-studied. After E. Mönnig (pers. com. 2016) “the holotye comes from a little creek E of Uetzing in Franconia and probably from the upper Jason Zone (Dietl & Mönnig, in press). Similar species are also known from the upper Jason Zone of Swabia (Dietl 2013)“. Our specimen can be well compared to depressed morphotypes of the *R. anceps* group as reported by Cariou (1984), especially to *R. anceps elmii* Bourquin, 1968 in Cariou (pl. 37, fig. 2a, b). Concerning the broad whorl section and the coarse ribbing it shows also similarity with *Reineckeia* (*R.*) *nodosa* (Till, 1907).

Age: After Dietl (2013) *Reineckeia anceps* occurs in the upper part of the Jason Zone, which corresponds to the Upper Anceps Zone (Tyranniformis Subzone) in the Submediterranean Province. Our specimen comes from Red Bed III at Talu.

Reineckeia sp.
Pl. 4, Fig. 2a, b

Material: One phragmocone from Talu: SNSB-BSPG 2013 XXIV 61.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXIV 61	60	38	38	38

Description: Fairly evolute and slightly depressed *Reineckeia* with a rounded to oval whorl section. The ribbing consists of slightly proverse and distant primaries which end within the inner third of the flank into conical (spinose?) tubercles. Three or four rather fine, dense and partly polygrate secondaries bundle from the tubercles. Two or three intercalated ribs occur irregularly. There are three prorsiradiate and rather deep constrictions on the last whorl.

Age: early Middle Callovian, Red Bed III.

Genus *Alborzites* Schairer,
Seyed-Emami & Zeiss, 1991

Alborzites binaludensis Seyed-Emami, 2013
Pl. 4 Fig. 3a, b

2013 *Alborzites binaludensis* Seyed-Emami nov. sp. – Seyed-Emami et al., p. 57, figs 8e–h, m–o.
2014 *Alborzites binaludensis* Seyed Emami, 2012 – Parent et al., p. 11, pl. 5, figs 3–4, pl. 6, fig. 3, pl. 8, fig. 4, pl. 20, fig. 3.

Material: One fully septated and one-sided preserved specimen from Red Bed III at Talu: SNSB-BSPG 2013 XXXIV 57.

Dimensions:	*D*	*U*	*H*	*W*
BSPG 2013 XXXIV 57	90	38	36	-

Description: The present specimen is a fully septated phragmocone with a diameter of 90 mm. For a detailed description see Seyed-Emami et al. (2013, p. 57).

Discussion: Hitherto only few specimens of the new genus *Alborzites* have been found in eastern Alborz. However, apparently it is not a rare taxon. Parent et al. (2014) reported several specimens from the Binalud Mountains (East Alborz).

Age: Red Bed III, early Middle Callovian.

4. Discussion

The Dalichai Formation (Late Bajocian–Oxfordian) is a sequence of greyish limestone and marlstone, being widely distributed along the Alborz Range and its eastern continuation Binalud Mountains. It contains locally a rather rich ammonite fauna, being often concentrated in few condensed beds. The studied ammonites come mostly from the upper part of the Dalichai Formation at Talu, north of Damghan. At Talu the ammonites are mostly accumulated within three few meter thick beds of condensed, red, nodular limestones and marls (Red Beds I–III). The red nodular limestone beds are the most prominent features within the Dalichai Formation along the eastern Alborz and Binalud Mountains (Seyed-Emami et al. 2013), representing condensation horizons being deposited on pelagic swells of a swell-trough system (Sandoval 2016, p. 245). This facies is widespread in the Alpine-Mediterranean Jurassic (e.g. Elmi 1981; Farinacci et al. 1981a, b; Martire 1988, 1989; Böhm et al. 1999; Rais et al. 2007; Jenkyns 1974, 2009; Baraboshkin et al. 2010; Sandoval 2016).

Within the red beds the ammonites are preserved mostly as one-sided internal moulds with iron impregnation and crusts without shell. This indicates strong dissolution, presence of oceanic currents and probably deeper-water environments. The deeper environmental deposition of the Dalichai Formation is also indicated by sedimentary structures such as slumpings, trace fossils, the great number of Phylloceratidae and the relatively great numbers of Lytoceratidae (Behfar et al. 2012).

At Talu, the bulk of the ammonite fauna consists of Perisphinctidae (ca 30%), Phylloceratidae (ca 20%) and Reineckeidae (ca 18%) as is usual for the Dalichai Formation (Seyed-Emami et al. 2013). The relativey high number of Lytoceratinae (ca 4%) and Macrocephalitidae (ca 6.5%) is especially remarkable, as they are rather rare elements within the Dalichai Formation. On the other hand, the nearly complete absence of Reineckeiidae and Macrocephalitidae in the section near Kelariz nearby Talu is remarkable (Seyed-Emami et al., 2015), although both sections are separated by a few kilometres only. Usually Reineckeiidae are amongst the most frequent ammonite taxa within the Dalichai Formation.

Paleobiogeographically the ammonite fauna of the Dalichai Formation is typically north-west Tethyan, with relations to the subboreal/submediterranean provinces (Seyed-Emami et al. 2013; Dietze et al. 2014).

5. Age of the Red Bed III

Red Bed III lies about two meters above the beds with Macrocephalitinae which belong to the Bullatus and Prahecquense zones of the Lower Callovian (Seyed-Emami et al. 2015). Consequently, regarding the stratigraphic position and the faunal composition, the age of the Red Bed III is late Early to Middle Callovian (Gracilis to Coronatum chrones). At Talu the first Macrocephalitinae appear in the Bullatus Zone, in which the Reineckeiidae are still absent. The first Reineckeiidae appear in the Gracilis Zone. It is remarkable that in southeast Spain the first Macrocephalitidae also appear in the Bullatus Zone, in which the Reineckeiidae are still absent and the first Reineckeiidae appear in the Gracilis Zone (Sandoval, 2016, p. 240).

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6. References

Alavi-Naini M, Salehi Rad F. 1975. Geological map of Damghan, 1: 100000. Geological Survey of Iran, Sheet Nr. 6862.

Arkell WJ. 1951–1958. A Monograph of English Bathonian Ammonites. Palaeontological Society London, parts 1–8, 264 p.

Baraboshkin EY, Rogov MA, Mileev VS. 2010. On the Characteristics of Ammonitico Rosso Facies in Callovian (Middle Jurassic) Sediments near Planerskoe (East Crimea). Moscow University Geology Bulletin 65 (4), 223–228.

Behfar N. 2009. Stratigraphy and paleontology of the Dalichai Formation in northeast of Damghan on the base of ammonites (East Alborz), Unpublihed MSc. Thesis, Geological Survey of Iran, Research Institute for Earth Sciences, 330 p. [in Farsi].

Behfar N, Seyed-Emami K, Majidifard M, Behfar A. 2012 Lithostratigraphy and biostratigraphy of the Dalichai Fomation at Talu (Northeast Damghan, Alborz), based on ammonites. Geosciences 21 (81), 249–262 [in Farsi].

Besnosov NV, Mitta VV. 2000. Jurassic geology and ammonites of Great Balkan (Western Turkmenistan). Bulletin CF VNIGNI 5, 1–115.

Bonarelli G. 1894. *Hecticoceras*, novum genus Ammonidarum. Bolletino Della Società Malacologia Italiana 18, 73–108.

Böhm F, Ebli O, Krystyn L, Lobitzer H, Rakus M, Siblik M. 1999. Fauna, stratigraphy and depositional environment of the Hettangian-Sinemurian (Early Jurassic) of Adnet (Salzburg, Austria). Abhandlungen der Geologischen Bundesanstalt 56, 143–271.

Bourquin J. 1968. Les Reineckéidés. Annales Scientifiques de L' Université de Besancon, 3e Série, Géologie, fasc. 4, 1–169.

Buckman SS. 1909–1930. Yorkshire Type Ammonites, 7 volumes, London (Wheldon & Wesley).

Callomon JH. 1984. A review oft he biostratigraphy of the post-Lower Bajocian Jurassic ammonites of western and northern North America. In GEG Westermann (Ed.): Jurassic-Createceous biochronology and plaleogeography of North America. Geological Association of Canada Special Paper 47, 143-147.

Cariou E. 1984. Les Reineckeiidae (Ammonitina, Callovien) de la Tethys occidentale. Dimorphisme et évolution. Étude à partir des gisements du centre-ouest de la France. Documents des Laboratoires de Géologie Lyon H. S. 8 (1+2), 1–599.

Cariou E, Krishna J. 1988. The Tethyan Reineckeinae of Kachchh and Jaisalmer (West India): systematic, biostratigraphic and biogeographic implications. Palaeontographica A 203 (4–6), 149–170.

Cariou E. 1994. Céphalopodes jurassiques. In: JC Fischer, (Ed), Révision critique de la Paléontologie française, Alcide d'Orbigny, Vol. I. Paris, Masson, 1–338;

Collignon M. 1958. Atlas des fossils caractéristiques des Madagascar. Service géologique de Tananarive 2, Bathonian–Callovian.

Dietl G. 1994. Der *hochstetteri*-Horizont - ein Ammonitenfaunen-Horizont (Discus-Zone, Ober-Bathonium, Dogger) aus dem schwäbischen Jura. Stuttgarter Beiträge zur Naturkunde B202, 1–39.

Dietl G. 2013. Der Braunjura am Fuß der Schwäbischen Alb. Fossilien, Sonderheft 2013, 3-46.

Dietze V, Schweigert G, Callomon J, Dietl G, Kapitzke M. 2007. Der Mitteljura des Ipf-Gebietes (östliche Schwäbische Alb, Süddeutschland). Korrelation der Süddeutschen Ammoniten-Faunenhorizonte von Ober-Bajocium bis Unter-Callovium mit Südengland und Frankreich. Zitteliana A 47, 105–125.

Dietze V, Seyed-Emami K, Raoufian A. 2014. *Morphoceras* Douvillé, 1880 und *Ebrayiceras* Buckman, 1920 from the Dalichai Formation (Lower Bathonian) north and northeast of Damghan (Northeast Alborz, Iran). Zitteliana A 53, 15–22.

Elmi S. 1981. Classification typologique et genetique des Ammonitico-Rosso et des facies noduleux ou grumeleux: essai de synthese. In: A Farrinacci, S Elmi, S. (Eds), Rosso Ammonitico Symposium Proceedings, Tecnoscienza, Roma, 233–249.

Farinacci A, Malantrucco G, Mariotti N, Nicosia U. 1981a. Ammonitico Rosso facies in the framework of the Martani Mountains paleoenvironmental evolution during Jurassic. In: A Farrinacci, S Elmi (Eds), Rosso Ammonitico Symposium Proceedings, Tecnoscienza Roma, 311–334.

Farinacci A, Mariotti N, Nicosia U, Pallini G, Schiavinotto F. 1981b. Jurassic sediments in the UmbroMarchean Apennines: an alternative model. In: A Farrinacci, S Elmi (Eds), Rosso Ammonitico Symposium Proceedings, Tecnoscienza Roma, 335–398.

Fernández-López S. 2001. Upper Bathonian ammonites of the Catalan Basin (Tivissa and Cap Salou, Spain). Hantkeniana 3, 25–39.

Fortwengler D, Marchand D, Bonnot A, Jardat R, Raynaud D. 2012. Proposal for the Thuoux section as a candidate for the GSSP of the base of the Oxfordian stage. Carnets de Géologie (Notebooks on Geology), Brest, CG2012-A06: 117–136.

Fürsich FT, Wilmsen M, Seyed-Emami K, Majidifard MR. 2009. Lithostratigraphy of the Upper Triassic-Middle Jurassic Shemshak Group of Northern Iran. Geological Society London, Special Publications 312, 129–160.

Galácz A, Szente I. 2008. A revision of ammonites and bivalves collected by the Déchy Caucasus expeditions (1885–1902). Hantkeniana 6, 109–125.

Hahn W. 1971. Die Tulitidae S. Buckman, Sphaeroceratidae S. Buckman und Clydoniceratidae S. Buckman (Ammonoidea) des Bathoniums (Brauner Jura ε) im südwestdeutschen Jura. Jahrbuch des geologischen Landesamts Baden-Würtemberg 13, 55–122.

Imlay RW. 1953. Callovian (Jurassic) ammonites from the United States and Alaska. Part 1. Western Interior United States. Geological Survey Professional Paper 249-A, 1-39.

Jeannet A. 1951. Stratigraphie und Paläontologie des oolithischen Eisenerzlagers von Herznach und seiner Umgebung. Beiträge zur Geologie der Schweiz. Geotechnische Serie, Lieferung 13, 5, 1–240.

Jenkyns HC. 1974. Origin of red nodular limestone (Ammonitico Rosso, Knollenkalke) in the Mediterranean Jurassic: a diagenetic model. Special Publication of International Association of Sedimentologists 1, 249– 271.

Jenkyns HC. 2009. Origin of Red Nodular limestones (Ammonitico Rosso, Knollenkalke) in the Mediterranean Jurassic: A diagenetic model. In: KJ Hsü, HC Jenkyns (Eds), Oxford, U.K, Blackwell Publishing Ltd, doi: 10.1002/9781444855.ch 11.

Joly B. 1976. Les Phylloceratidae malagaches au Jurassique. Généralités sur quelques Phylloceratidae et quelques Juraphyllitidae. Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon 67, 1–471.

Kopik J. 1974. Genus *Cadomites* Munier-Chalmas (Ammonitina) in the upper Bajocian and Bathonian of the Cracow-Wieluń Jurassic range and the Gōry SŚwietokrzyskie Mountains. Instytut Geologiczny Biuletyn 276, 7–53.

Krystyn L. 1972. Die Oberbajocium und Bathonium der Klas-Schichten des Steinbruchs Neumühle bei Wien. Annalen des Naturhistorischen Museums in Wien 76, 195–310.

Kuhn O. 1939. Die Ammoniten des fränkischen Calloviums. Nova Acta Leopoldina, Neue Folge 6(43), 451–532.

Lemoine F. 1932. Essai sur l'évolution du genre *Hecticoceras* dans le Callovien de la chaîne du Mont-du-chat. Traveaux Laboratoire Géologie Lyon Fascicule Science Lyon 19(16), 1–527.

Martin A, Mangold C. 2015. Le genre *Bullatimorphites* du Bathonien moyen et supérieur du Maconnaise (Saone-et-Loire, France). Strata 52(2),119 p.

Majidifard MR. 2003. Biostratigraphy, lithostratigraphy, ammonite taxonomy and microfacies analysis of the Middle and Upper Jurassic of Northeastern Iran. Ph. D. Thesis, Julius-Maximilians Universität Würzburg, Germany, 201 p., https://webcache.googleusercontent.com/search?q=cache:CRuB_RPldPcJ:https://opu.bibliothek.uni-wuerzburg.de/

Mangold C, Rioult M. 1997. Ammonites (Bathonien). In: E Cariou, P Hantzpergue (Eds), Biostratigraphie du Jurassique Ouest-Européenet méditerranéen: zonations parallèles et distribution des invertébrés et microfossiles. Bulletin des Centres de Re-

cherche Elf Exploration-Production 17, 55–62.
Martire L. 1988. Eta dinamica deposizionale e possibile organizzazione sequenziale del Rosso Ammonitico dell'Altopiano di Asiago (VI). Bollettino Società Geologica Italiana 11, 231–236.
Martire L. 1989. Analisi biostratigrafica e sedimentologica del Rosso Ammonitico Veronese dell'Altopiano di Asiago (VI). Ph.D. Thesis, University of Torino, 166 p.
Mönnig E. 1995. Der Macrocephalen-Oolith von Hildesheim. Mitteilungen aus dem Roemer-Museum Hildesheim, Abhandlungen, Neue Folge 5, 1–77.
Parent H, Raoufian A, Seyed-Emami K, Ashouri AR, Majidifard MR. 2014. The Bajocian-Kimmeridgian ammonite fauna of the Dalichai Formation in the Se Binalud Mountains, Iran. Reports of the Instituto de Fisiografia y Geologia 1, 1–58.
Pavia G, Cresta S (Eds). 2002. Revision of Jurassic ammonites of the Gemmellaro collections. Quaderni del Museo G. G. Gemmellaro di Palermo 6, 1–408.
Pavia G, Fernández-López SR, Mangold C. 2008. Ammonoid succession at the Bajocian-Bathonian transition in the Bas Auran area, Digne district, Southeast France. Rivista Italiana di Paleontologia e Stratigrafia 114, 287–311.
Rais P, Lois-Schmid B, Bernasconi SM, Weissert H. 2007. Palaeoceanographic and palaeoclimatic reorganization around the Middle-Late Jurassic transition. Palaeogeography, Palaeoclimatology, Palaeoecology 251, 527–546.
Raoufian A, Seyed-Emami K, Ashouri AR, Majidifard MR, Joly B. 2011. Middle and Late Jurassic Phylloceratidae from the Binalud Mountains (Northeast Iran). Sedimentary Facies, Scientific Semiannual Journal of Ferdowsi University Mashhad 3(2), 68–81 [in Farsi].
Raoufian A. 2014. Investigations on the Middle and Upper Jurassic strata along the Binalud Range, based on Stratigraphy, Paleontology (ammonite fauna) and Sedimentary Environment. Ph.D. Thesis Ferdowsi University of Mashhad, Iran. 380 p. [in Farsi].
Raoufian A, Joly B, Seyed-Emami K, Ashouri AR, Majidifard MR, Ameri H. 2014. Phylloceratoidea du Jurassique moyen et supérieur du Nord-Est del'Iran (Monts Binalud). Annales de Paléontologie 100 (2014), 311–325.
Sandoval J. 1983. Bioestratigraphia y Paleontologia (Stephanocerataceae y Perisphinctaceae) del Bajociense y Bathonense en las Cordilleras Beticas. - Thesis Doctoral - Universidad de Grenada, 613 p.
Sandoval J. 2016. Ammonite assemblages and chronostratigraphy of the uppermost Bajocian–Callovian (Middle Jurassic) of the Murcia Region (Betic Cordillera, south-eastern Spain). Proceedings of the Geologists' Association 127(2), 230–236.
Schairer G, Seyed-Emami K, Fürsich FT, Senowbari-Daryan B, Aghanabati SA, Majidifard MR. 2000. Stratigraphy, facies analysis and ammonite fauna of the Qal'eh Dokhtar Formation (Middle-Upper Jurassic) at the type locality west of Boshrouyeh (east-Central Iran). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 260(1), 35–66.
Schairer G, Seyed-Emami K, Zeiss A. 1991. Ammoniten aus der oberen Dalichai-Formation (Callov) östlich von Semnan (SE-Alborz, Iran). Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie 31: 47–67.
Schlegelmilch R. 1985. Die Ammoniten des Süddeutschen Doggers. Stuttgart, G. Fischer, 284 p.
Schlögl J, Mangold C, Tomašových A, Golej M. 2009. Early and Middle Callovian ammonites from the Pieniny Belt (Western Carpathians) in hiatal successions: unique biostratigraphic evidence from sediment-filled fissure deposits. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 252(1), 55–79.
Seyed-Emami K, Schairer, G, Bolourchi MH. 1985. Ammoniten aus der unteren Dalichy Formation (ob. Bajocium–unt. Bathonium) der Umgebung von Abe-Garm (Avaj, NW Iran). Zitteliana 12, 57–85.
Seyed-Emami K, Schairer G, Alavi-Naini M. 1989. Ammoniten aus der unteren Dalichai-Formation (Unterbathon) östlich von Semnan (SE-Alborz, Iran). Münchner Geowissenschaftliche Abhandlungen A 15, 79–91.
Seyed-Emami K, Schairer G, Aghanabti A, Fazl M. 1991. Ammoniten aus dem Bathon von Zentraliran (Tabas-Naiband Region). Münchner Geowissenschaftliche Abhandlungen A19, 65–100.
Seyed-Emami K, Schairer G, Zeiss A. 1995. Ammoniten aus der Dalichai Formation (Mittlerer bis Oberer Jura) und der Lar-Formation (Oberer Jura) N Emamzadeh-Hashem (Zentralalborz, Nordiran). Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie 35, 39–52.
Seyed-Emami K, Schairer G, Fürsich FT, Senowbari-Daryan B, Majidifard MR. 1998. *Cadomites* aus der unteren Baghamshah-Formation (Oberbathon, Mittlere Jura) SW Tabas (Zentraliran). Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie 38, 111–119.
Seyed-Emami K, Schairer G, Aghanabati SA. 1998. *Bullatimorphites* aus Oberbathon (Mittlerer Jura), SW Tabas (Zentraliran Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie 38, 111–119.
Seyed-Emami K, Schairer G, Fürsich FT, Wilmsen M, Majidifard MR. 2002. Reineckeidae (Ammonoidea) from the Callovian (Middle Jurassic) of the Shotori Range (East Central Iran). Neues Jahrbuch Geologie Paläontologie Monatshefte 3, 184–192.
Seyed-Emami K, Schairer G. 2010. Late Jurassic (Oxfordian, Bimammatum Zone) ammonites from the eastern Alborz Mountains, Iran. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 257/3, 267–281.
Seyed-Emami K, Schairer G. 2011a. Late Jurassic (Oxfordian, Bifurcatus and Bimammatum zones) ammonites from the eastern Alborz Mountains, Iran. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 260/1, 11–20.
Seyed-Emami K, Schairer G. 2011b. New Middle and Upper Jurassic ammonites from the Binalud Mountains (Mashhad region, NE Iran). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 261/3, 373–380.
Seyed-Emami K, Schairer G, Raoufian A, Shafeizad M. 2013. Middle and Upper Jurassic ammonites from the Dalichai Formation east of Shahrud (East Alborz, North Iran). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 267/3, 43–66.
Seyed-Emami K, Raoufian A, Mönnig E. 2015. Macrocephalitinae (Ammonoidea, Middle Jurassic) from North and Central Iran. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 3, 257–279.
Shafeizad M, Seyed-Emami K. 2005. Lithostratigraphy and biostratigraphy of the Dalichai Formation west of Shahroud (Eastern Alborz). Geosciences, 12(55), 98–113 [in Farsi].
Thierry J, Mangold E, Cariou E. 1994. Céphalopodes jurassiques, In: J-C Fischer (Eds.), Révision critique de la Paléontologie française d'Alcide d'Orbigny I. Paris, Masson, 1–338;
Topchishvili M, Lominadze I, Tsereteli I, Tordia V, Nadareishvili G. 2006. Stratigraphy of the Jurassic deposits of Georgia. Georgian Academy of Siences A. Janelidze Geological Insitute Proceedings, New Series 122, 455 pp. [in Russian].
Tsereteli ID. 1968. Bathonian ammonites of the Georgia. Tbilisi: Metsniereba. 98 pp. [in Russian]
Tsytovitch X. 1911. *Hecticoceras* du Callovian de Chézerny. Mémoires de la Société Paléontologique Suisse 37, 1–84.
Westermann GEG, Callomon JH. 1988. The Macrocephalitinae and associated Bathonian and early Callovian (Jurassic) ammonoids of the Sula Islands and New Guinea. Palaeontographica A, 203(1-3), 1-90.
Zaton M. 2010. Bajocian-Bathonian (Middle Jurassic) ammonites from the Polish Jura. Part 1: Families Phylloceratidae, Nannolytoceratidae, Sonniniidae, Strigoceratidae, Oppeliidae and Lissoceratidae. Part 2: Families Stephanoceratidae, Perisphinctidae, Parkinsoniidae, Morphoceratidae and Tulitidae. Palaeontographica A292 (4–6), 65–213.
Zeiss A. 1956. *Hecticoceras* und *Reineckeia* im Mittel- und Ober-Callovien von Blumberg (Südbaden). Bayerische Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Klasse, Abhandlungen, Neue Folge 80, 1–98.