



## CALLOVIAN AMMONITES FROM NORTHEASTERN IRAN

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**ABSTRACT** – The present paper includes the description of the Callovian ammonite fauna from the Dalichai Formation, eastern Alborz, Northeastern Iran. The following families are reported: Oppeliidae, Tilitidae, Macrocephalitidae, Pachyceratidae, Reineckeidae, Perisphinctidae and Aspidoceratidae. Some of the taxa are recorded for the first time from Iran. Altogether, 211 specimens of ammonites belonging to 43 species, 21 genera, and seven families are described. Among the families, Phylloceratidae is the most abundant, followed by Perisphinctidae and Reineckeidae. Pachyceratidae is the least common family. The ammonites represent six zones, *i.e.* Bullatus, Gracilis, Anceps, Coronatum, Athleta and Lamberti. Paleobiogeographically, the ammonite fauna is closely related to that of the sub-Mediterranean Province of the northwestern Tethys.

**Keywords:** Jurassic, Callovian, ammonites, taxonomy, Dalichai Formation, paleobiogeography.

**RESUMO** – O presente trabalho inclui as descrições sistemáticas da fauna de amonites do Calloviano da Formação Dalichai a leste de Alborz, no Nordeste do Irã. São reportadas as seguintes famílias: Oppeliidae, Tilitidae, Macrocephalitidae, Pachyceratidae, Reineckeidae, Perisphinctidae e Aspidoceratidae. Alguns dos táxons são registrados pela primeira vez no Irã. No total, 211 espécimes de amonites pertencentes a 43 espécies, 21 gêneros e sete famílias são descritos. Entre as famílias, Phylloceratidae é a mais abundante, seguida por Perisphinctidae e Reineckeidae. Pachyceratidae é a família menos comum. As amonites representam seis zonas, a seguir, Bullatus, Gracilis, Anceps, Coronatum, Athleta e Lamberti. Paleobiograficamente a fauna de amonites está intimamente relacionada com a da Província sub-mediterrânea do noroeste de Tétis.

**Palavras-chave:** Jurássico, Calloviano, amonites, taxonomia, Formação Dalichai, paleobiogeografia.

## INTRODUCTION

The Middle and Upper Jurassic sedimentary successions of the Alborz Mountains in Northeastern Iran comprise two formations: Dalichai and Lar. The Callovian sedimentary succession belongs to the Dalichai Formation. The Dalichai Formation consists of alternations of greenish marl and light-grey to bluish-grey limestone. The Middle and Upper Jurassic rocks constitute a more or less continuous sequence, being confined by two tectonic events; one at the base, in the uppermost part of the Shemshak Formation (Bajocian), the Mid-Cimmerian Event (Seyed-Emami & Alavi-Naini, 1990; Fürsich *et al.*, 2009), the other one at the top (Early Cretaceous), the so-called Late-Cimmerian Event (Sengör, 1990). The lowermost unit constitutes the uppermost member of a siliciclastic and partly continental depositional sequence known as Shemshak Formation. It contains a fairly abundant ammonite fauna ranging in age from Aalenian to early Bajocian. This formation begins with transgressive sediments of late Bajocian age. The upper Bajocian to Tithonian rocks are predominantly carbonates, which represent a platform, slope and basin system (Majidifard, 2003, 2008). The Dalichai Formation is rich in ammonites, which have been described by Assereto *et al.* (1968), Seyed-

Emami *et al.* (1989, 1991, 1995, 2013), Seyed-Emami & Schairer (2011), Schairer *et al.* (1992), Majidifard, (2003), and Dietze *et al.* (2014). The Golbini section of the Dalichai Formation is located 16 km north of Jajarm near the Golbini farm (quadrangle map of Kuh-e-Khurkhd, 1:250,000; coordinates 37°05'13"N, 56°44'41"E, Figure 1). The Tooy section is situated 4 km north of Tooy village (49 km west of Esferayen and 93 km SW of Bojnourd; quadrangle map of Bojnourd, 1:250,000; coordinates 37°09'14"N, 57°09'13"E; Figure 1). Based on ammonites, the Dalichai Formation ranges from the Upper Bajocian to Lower Tithonian. The top of the Dalichai Formation is diachronous at the studied sections. Thus, the age of the top of the formation is early Tithonian at the Golbini section and middle Kimmeridgian at the Tooy section.

## Stratigraphy of sections

The type section of the Dalichai Formation (right bank of Dalichai River, 700 m below Pole e Ferdowsi (bridge) along the Tehran – Firuzkuh road, 113 km east of Tehran) consists of 107 m of light-grey to bluish-grey limestone with thin intercalations of marl. According to Steiger (1966), the thickness of the formation is about 50 to 120 m (average: 100 m, reaching more than 300 m in the eastern Alborz). The

lower boundary of the Dalichai Formation is an unconformity due to the Mid-Cimmerian tectonic event (Seyed-Emami & Alavi-Naini, 1990; Fürsich *et al.*, 2009). In many areas, however, the upper boundary is gradational. In a few areas it is continuous but sharp, and followed by the Lar Formation (Seyed-Emami, 1975).

The ammonites described here come from a 96 m thick unit at Golbini, and an 80 m thick unit at Tooy. The lithology of the Callovian sedimentary successions consists of an alternation of marls and limestone characteristic of the Dalichai Formation (Figure 2). The Dalichai Formation at the Golbini section was measured north of Golbini with a total thickness of 454 m. It ranges from the upper Bajocian to the lower Tithonian and can be subdivided, from bottom to top, into three members (Majidifard, 2008; Figure 2). It overlies diachronously and with a sharp contact the Shemshak Formation. Its boundary to the overlying ridge-forming Lar Formation is gradational.

**Member 1.** 105 m thick, consists of green-grey silty marls with small amounts of secondary gypsum. Pink limestones (floatstone) occur 84 m above the base of the member in beds varying from 20 to 60 cm in thickness. The fossils comprise siliceous sponges, bryozoans, *Terebella lapilloides* Münster, 1833, bivalves (?*Anisocardia* sp.), gastropods, (*Obornella* sp.), echinoderm debris, belemnites, microbial crusts, *Tubiphytes*, and ammonites (*Strenoceras* sp., *Sphaeroceras tuttum* Buckman, 1921, *Garantiana (Orthogarantiana) cf. densicostata* (Quenstedt, 1886), *Oxycerites yeovilensis* (Rollier, 1911). *Oxycerites cf. oxus* (Buckman, 1926) *Bullatimorphites* sp., *Morphoceras multiforme* Arkell, 1951, *M. macrescens* (Buckman, 1923), *M. egrediens* Wetzel, 1937, and *Ebrayiceras cf. sulcatum* (Zieten, 1830). The ammonite fauna indicates the upper Bajocian (Niortense–Garantiana zones) to lower Bathonian Zigzag Zone.

**Member 2.** It has a thickness of 211 m and consists of alternations of greyish-green marls, well-bedded greyish to yellow marly limestones and limestones (packstone). At some levels, the marly limestones and limestones contain abundant chert-nodules and the trace fossil *Zoophycos*. This member contains, apart from a few fossils such as bivalves (filaments, *Protocardia*), brachiopods (terebatulids), gastropods, echinoderm debris, belemnites, *Neuropora* sp., ostracods, radiolarians, sponge spicules, benthic foraminifers (*Lenticulina* sp., *Ammobaculites coprolithoformis* (Schwager, 1867), *Spirillina* Ehrenberg, 1843 rotaliids, nodosariids, miliolids), a rich ammonite fauna, indicative of the upper Bathonian (Retrocostatum Zone), lower Callovian (Gracilis Zone), middle Callovian (Anceps and Coronatum zones), upper Callovian (Lamberti Zone), and middle Oxfordian (Transversarium Zone).

**Member 3.** 138 m thick and consists of alternations of medium-bedded, grey to pinkish limestones (mudstone to packstone) with cherts, green-grey marls, and rare limestones (grainstone) with sharp erosional bases in beds varying from 30 to 80 cm in thickness. The macro- and microfauna is represented by bivalves (fragments), echinoderm debris, belemnites, ostracods, radiolarians, sponge spicules,

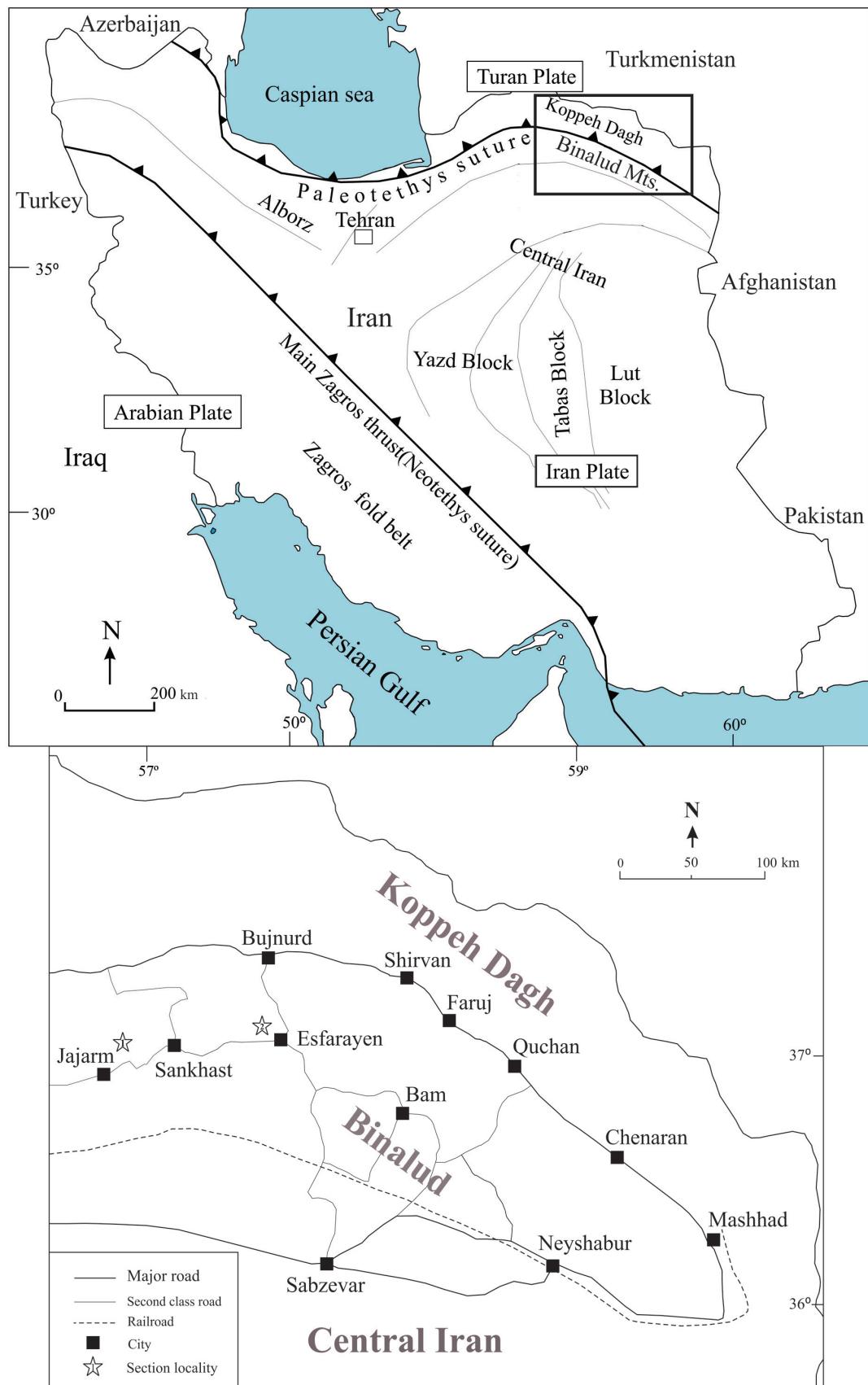
benthic foraminifers (*Lenticulina* sp., *Globuligerina* sp., *Ammobaculites* sp., rotaliids, nodosariids and miliolids). In the upper part, the member contains microbial crusts, *Terebella* Linnaeus, 1767, *Tubiphytes* Maslov, 1956 and numerous ammonites indicative of the middle Oxfordian (*Bifurcatus* Zone), upper Oxfordian (*Bimammatum* Zone) and lower Kimmeridgian (*Platynota* Zone) and lower Tithonian (*Richteri* Zone).

At the Tooy section, the Dalichai Formation is 561 m thick, ranging from the Upper Bajocian to Kimmeridgian. It can be subdivided, from bottom to top, into three members (Majidifard, 2008, Figure 2):

**Member 1.** 73 m thick and consists of green silty marls with belemnites and ammonites. It contains sponges, brachiopods, gastropods, echinoid spines, belemnites, benthic foraminifers (*Nauiloculina* sp., *Lenticulina* sp., nodosariids), ostracods and the ammonites *Spiroceras orbignyi* (Baugier & Sauze, 1843) (*Garantiana* Zone), *Spiroceras annulatum* (Deshayes, 1831) (Niortense and *Garantiana* zones), *Sphaeroceras tuttum* Buckman, 1921 (*Garantiana* and *Parkinsoni* zones), *Garantiana (Pseudogarantiana) dichotoma* Bentz, 1928 (*Garantiana* Zone), and *Parkinsonia parkinsoni* (Sowerby, 1823) (*Parkinsoni* Zone), *Bullatimorphites (Kheraiceras) bullatus* (d'Orbigny, 1846) (lower to ?middle Bathonian), *Cadomites (Polylectites) dorni* (Roche, 1939) (lower Bathonian), *Homoeoplanulites (Homoeoplanulites) cf. bugesiacus* (Dominjon, 1969) (*Discus* Zone), *Homoeoplanulites (Parachoffatia) arkelli* Mangold, 1970a (*Discus* Zone), and *Homoeoplanulites* sp.

**Member 2.** Thickness of 299 m, consists of alternations of well-bedded greyish-green marls, greyish to yellow marly limestones (mudstone to packstone) and medium-bedded, grey limestones (mudstone to packstone) with chert nodules at some levels. Trace fossils include *Zoophycos* and *Thalassinoides*. The faunal content comprises bivalves (fragments, inoceramids, *Entolium* sp.), brachiopods (terebatulids, rhynchonellids), gastropods (*Obornella* sp.), *Plagioecia* sp., belemnites, nautiloids, ostracods, sponge spicules, radiolarians, echinoderm debris, benthic foraminifers (*Globuligerina* sp., *Lenticulina* sp., *Ammobaculites coprolithoformis* (Schwager, 1867), *Spirillina*, nodosariids, rotaliids, ophtalmiids, miliolids, textulariids), *Laevaptychus*, and abundant and diverse ammonites indicative of the Callovian (*Macrocephalus*, *Patina*, *Anceps* and *Athleta* zones) and Oxfordian (*Cordatum*, *Bifurcatus*, *Planula* and *Transversarium* zones).

**Member 3.** 189-m-thick, consists of green silty marl, alternating thin- to thick-bedded greenish-grey, well sorted, fine-grained sandstones and siltstone, alternating medium-bedded, cream-coloured to yellow limestones (wackestone) and marls, alternating thin- to thick-bedded greenish-grey, well sorted, fine-grained sandstones and siltstones and alternations of medium-bedded, cream-coloured to yellow limestones (wackestone) and marls. The sandstone beds occur between 0–26 and 98–138 m above the base of the member. The sandstone beds are bioturbated; trace



**Figure 1.** The position of the sections of the Middle and Upper Jurassic Dalichai Formation at Golbini (eastern Alborz) and Tooy (Binalud mountains), northeastern Iran.

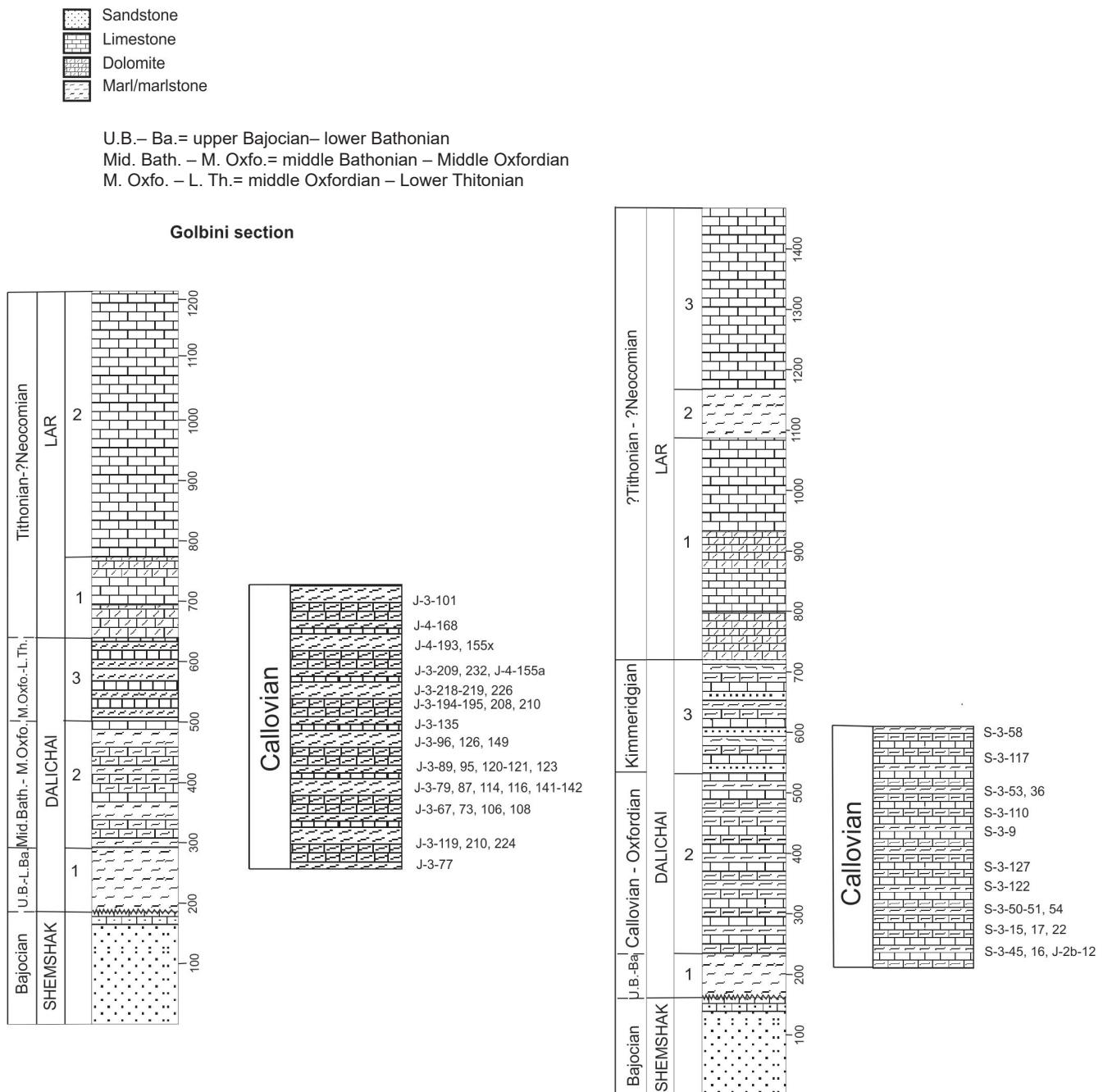


Figure 2. Stratigraphic logs of the Dalichai Formation at the two sections investigated.

fossils include *Zoophycos* and *Rhizocorallium*. Limestone (wackestone) in the lower part contains bivalves, belemnites and the ammonites *Taramelliceras cf. kiderleni* Berckhemer & Hoelder, 1959, *Sutneria eumela* (d'Orbigny, 1847), *Sutneria lorioli* Zeiss, 1979 (Eudoxus Zone), and *Physodoceras* sp. which indicate the Kimmeridgian Eudoxus Zone.

## MATERIAL AND METHODS

As far as permitted by the preservation of the specimens, measurements of the following parameters are given: diameter

(D) in mm, umbilical width (U), whorl height (H), whorl width (W), the latter all in % of diameter; numbers of primary ribs per whorl (PR) and secondary ribs (SR). [M] = macroconch; [m] = microconch.

All specimens are figured in natural size, except otherwise indicated. The figured specimens are located at the Bayerische Staatssammlung für Paläontologie und Historische Geologie, Munich, Germany (prefix GZN2011I); the other letter-number combination indicates the locality (J = Golbini section; S = Tooy section) and the position in the section.

## SYSTEMATIC PALEONTOLOGY

Superfamily PHYLLOCERATOIDEA Zittel, 1884

Family PHYLLOCERATIDAE Zittel, 1884

Subfamily CALLIPHYLLOCERATINAE Spath, 1927

*Calliphylloceras* Spath, 1927

*Calliphylloceras* sp.  
(Figures 3B–B', F)

**Material.** 18 specimens from Golbini (GZN2011I-J-4, 180-193, 240-243) and eight specimens from Tooy (GZN2011I-S-3, 25, 27, 29-31, 36-37, 43, 73), maximum diameter 58 mm and minimum 23 mm.

### Dimensions (in mm).

Specimen	D	U%	H%	W%
GZN2011I-S-3-36 (incomplete phragmocone)	58	11	57	29
GZN2011I-J-4-186 (incomplete phragmocone)	51	16	51	39
GZN2011I-J-4-191 (incomplete phragmocone)	49	18	51	39
GZN2011I-J-4-193 (incomplete body chamber)	35	16	56	39
GZN2011I-J-4-183 (incomplete body chamber)	31	19	45	35
GZN2011I-J-4-192 (incomplete body chamber)	24	21	54	42
GZN2011I-J-4-185 (incomplete phragmocone)	23	17	57	43

**Description.** Specimen (J-4-183, 193) with incomplete body chamber and other specimens with incomplete phragmocones, maximum diameter 58 mm and minimum 23 mm, involute phylloceratids with a smooth shell and steep, deep umbilicus. Suture line typically phylloceratid. Usually with five sigmoidal narrow constrictions on the last visible whorl. The constrictions start from the umbilical shoulder and terminate at the rounded venter.

**Stratigraphic distribution:** *Calliphylloceras* has a worldwide distribution, from the Hettangian to the Middle Albian. The present specimens come from the Callovian.

*Holcophylloceras* Spath, 1927

*Holcophylloceras indicum* (Lemoine, 1910)  
(Figure 3G)

1910 *Phylloceras mediterraneum* Neumayr indica – Lemoine, p. 3, pl. 1, fig. 1.

1976 *Holcophylloceras indicum* sp. nov. – Joly, p. 239, pl. 22, figs. 2–3, 5 pl. 23, fig. 1, pl. 25, figs. 3–5, pl. 26, figs. 2, 5, pl. 27, figs. 1–2, 4–5.

**Material.** One specimen with diameter 80 mm and one fragment from Golbini (GZN2011I-J-4, 155a, 155b).

### Dimensions (in mm).

Specimen	D	U%	H%	W%
GZN2011I-J-4-155a (incomplete phragmocone)	80	12	56	28

**Description.** A specimen with incomplete phragmocone, involute shell with five distinct and sigmoidal constrictions, which are narrow and shallow on the last visible whorl. Constrictions starting from the umbilical shoulder and terminating on the venter. Fine ribbing starts on the outer three-fourth of the flank and crosses the rounded venter.

**Remarks.** Based on the fine ribbing on the outer part of the whorl and the shape of the constrictions, the specimens closely match *Holcophylloceras indicum*.

Stratigraphic distribution: *Holcophylloceras* occurs worldwide from the Bajocian to the Aptian. The present specimens come from the middle Callovian, and the species is recorded for the first time from Iran.

*Ptychophylloceras* Spath, 1927

*Ptychophylloceras* sp.  
(Figure 3D–D')

**Material.** 28 specimens from Golbini (GZN2011I-J-4, 35, 102-105, 158-178, 266-267) and six specimens from Tooy (GZN2011I-S-3, 32-35, 40, 42, 57, 72), maximum diameter 85 mm, minimum 24 mm and generally 40 to 51 mm.

### Dimensions (in mm).

Specimens	D	U%	H%	W%
GZN2011I-S-3-33 (incomplete phragmocone)	85	12	60	36
GZN2011I-S-3-32 (incomplete phragmocone)	70	19	49	43
GZN2011I-J-4-168 (incomplete phragmocone)	56	15	55	37
GZN2011I-J-4-166 (incomplete phragmocone)	51	16	45	39
GZN2011I-J-4-159 (incomplete phragmocone)	50	16	52	26
GZN2011I-J-4-165 (incomplete phragmocone)	47	19	53	25
GZN2011I-J-4-172 (incomplete phragmocone)	47	17	51	42
GZN2011I-S-3-40 (incomplete phragmocone)	46	15	52	30

GZN2011I-J-4-169 (incomplete phragmocone)	46	17	50	39
GZN2011I-J-4-170 (incomplete phragmocone)	40	17	52	37
GZN2011I-J-4-171 (incomplete phragmocone)	30	17	53	36
GZN2011I-J-4-177 (incomplete phragmocone)	26	19	54	42
GZN2011I-J-4-176 (incomplete phragmocone)	24	12	54	46

**Description.** Specimens with incomplete phragmocones, Shell involute, with rounded-quadratus whorl section, umbilicus deep. The narrow and shallow constrictions start out as concave near the umbilical shoulder and turn convex in a ventral direction. In some of the specimens (*e.g.* S-2-32) strong ridges are developed on the venter, in other specimens (*e.g.* S-2-33) broadly rounded venter are crossed by periodic fine labial ridges.

**Stratigraphic distribution.** The present specimens come from the Callovian.

#### Sowerbyceras Parona & Bonarelli, 1895

##### Sowerbyceras sp. (Figure 3A)

**Material.** 57 specimens from Golbini (GZN2011I-J-155x, 247a-e, 248a-g, 249a-k, 250a-g, 251a-l, 252a-i, 253a-l, 254-256, 280), 20 specimens from Tooy (GZN2011I-S-74, 142-160), maximum diameter 71 mm and minimum 28 mm.

##### Dimensions (in mm).

Specimens	D	U%	H%	W%
GZN2011I-J-5-248a (incomplete phragmocone)	71	18	48	25
GZN2011I-J-5-247a (incomplete phragmocone)	70	20	43	27
GZN2011I-J-5-249 (incomplete phragmocone)	60	27	47	30
GZN2011I-J-5-250a (incomplete phragmocone)	54	30	41	31
GZN2011I-J-5-248a (incomplete phragmocone)	52	21	50	42
GZN2011I-J-4-155x (incomplete phragmocone)	28	32	42	39

**Description.** Shell moderately evolute with quadratus whorl cross-section. Umbilicus deep with the steep wall. Constrictions deep, wide, and sigmoidal starting at the umbilical shoulder and crossing prorsiradiate over the venter. **Stratigraphic distribution.** Worldwide in the Oxfordian-Kimmeridgian. The present specimens come from the Callovian.

#### Nannolytoceras Buckman, 1905

##### Nannolytoceras sp. (Figure 3H)

**Material.** One specimen with incomplete phragmocone from Tooy (GZN2011I-S-3, 9).

**Description.** Shell fairly wide with transverse elliptical to nearly quadratus whorl cross-section, umbilicus shallow. Shell surface smooth except for about three constrictions per whorl, which vary from oblique to prorsiradiate. The periodic constrictions are visible on both the internal mould and on the shell.

**Stratigraphic distribution.** The present specimen comes from the middle Callovian. According to Hoffmann (2010), the genus occurs in the Bajocian to the middle Bathonian of Europe (France, Hungary) and North Africa. The youngest representative comes from the middle Callovian of Crimea (Arkell *et al.*, 1957; Stremoukhoff, 1923; Besnosov, 1958).

#### Superfamily HAPLOCERATACEAE Zittel, 1884

Family OPPELIIDAE Bonarelli, 1894

Subfamily HECTICOERATINAE Spath, 1925

#### Hecticoceras Bonarelli, 1893

##### Subgenus Lunuloceras Bonarelli, 1893

#### Hecticoceras (Lunuloceras) aff. pseudopunctatum

(Lahusen, 1883)

(Figure 3J–J')

1883 *Harpoceras pseudopunctatum* – Lahusen, p. 73, pl. 11, figs. 10–12.

1939 *Hecticoceras pseudopunctatum* – Lahusen – Kuhn, p. 457, ix, v, fig. 9.

1956 *Hecticoceras (Lunuloceras) pseudopunctatum* (Lahusen) – Zeiss, p. 38, pl. 1, figs. 3–4.

1975 *Lunuloceras (Lunuloceras) pseudopunctatum* (Lahusen) – Lominadze, p. 75, pl. 7, figs. 6–9.

1961 *Hecticoceras (Lunuloceras) pseudopunctatum* (Lahusen) – Rangheard, p. 148, pl. 2, fig. 5–5a.

aff. 1984 *Hecticoceras (Lunuloceras) pseudopunctatum* (Lahusen, 1883) – Conze *et al.*, p. 180, pl. 1, fig. 8.

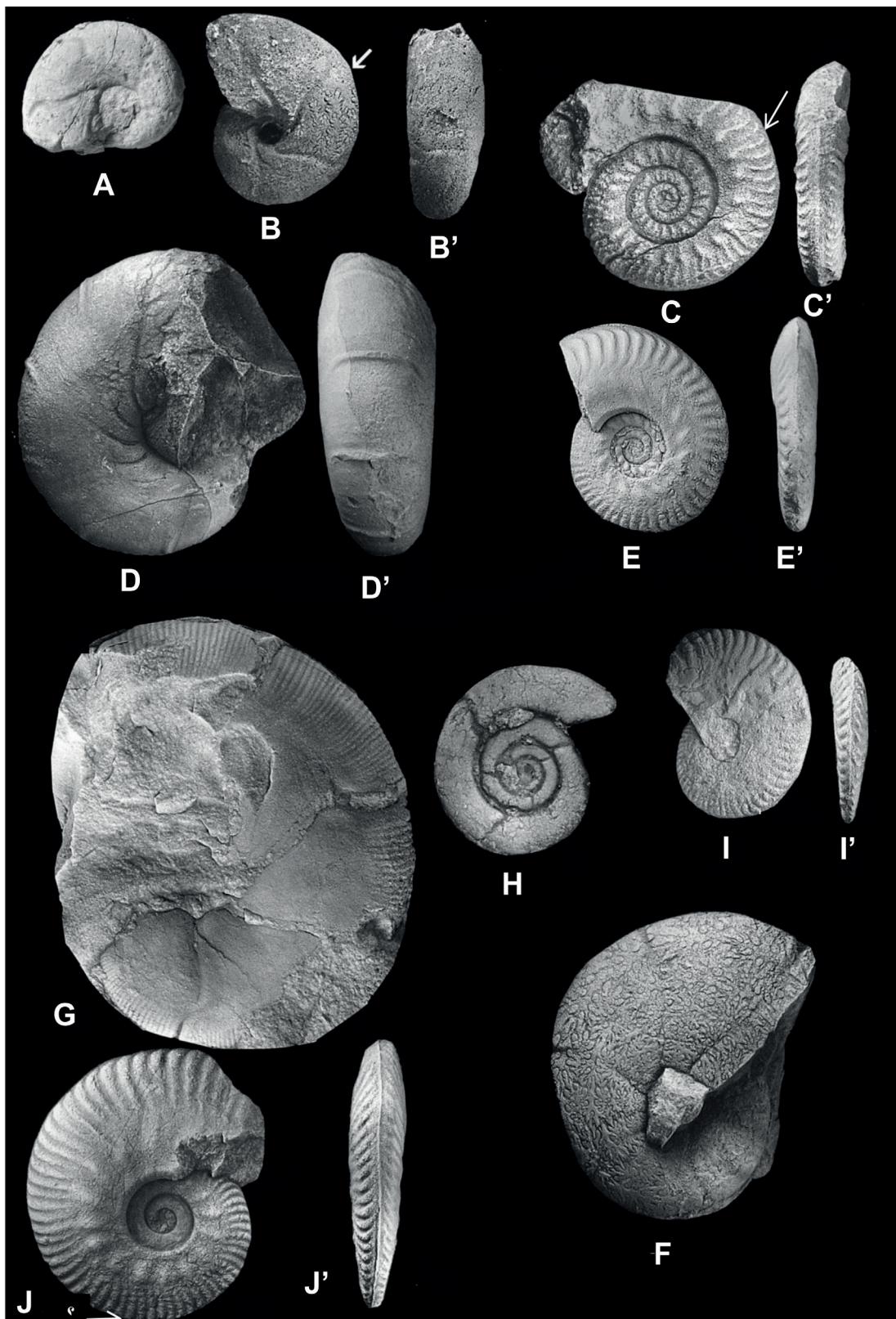
1985 *Lunuloceras (Lunuloceras) pseudopunctatum* (Lahusen) – Schlegelmilch, p. 42, pl. 8, fig. 6.

1991 *Hecticoceras (Lunuloceras) aff. pseudopunctatum* (Lahusen) – Schairer *et al.*, p. 65, pl. 1, fig. 3.

2000 *Lunuloceras (Lunuloceras) pseudopunctatum* (Lahusen) – Schairer *et al.*, p. 55, fig. 13a–b.

**Material.** Eight specimens from Golbini (GZN2011I-J-3, 79-86), maximum diameter 79 mm and minimum 37 mm, generally 45 to 57 mm.

##### Dimensions (in mm).



**Figure 3.** A, *Sowerbyceras* sp. (GZN2011I-J-4-155x), Golbini section. B–B', *Calliphylloceras* sp., specimen GZN2011I-J-4-193, a phragmocone with incomplete body chamber, Golbini section. C–C', *Hecticoceras (Putealiceras) schalchi* (Zeiss) (GZN2011I-J-3-67), a phragmocone with incomplete body chamber, Golbini section, Anceps Zone. D–D', *Ptychophylloceras* sp. (GZN2011I-J-4-168), Golbini section. E–E', *Hecticoceras (Zieteniceras) evolutum* (Lee) (GZN2011I-J-3-95) with incomplete phragmocone, Golbini section, middle Callovian. F, *Calliphylloceras* sp., specimen GZN2011I-S-3-36 with incomplete phragmocone, Tooy section. G, *Holcophylloceras indicum* (Lemoine) (GZN2011I-J-4-155a), Golbini section. H, *Nannolytoceras* sp. (GZN2011I-S-3-9), Tooy section; x1.5. I–I', *Hecticoceras (Lunuloceras) cf. lunuloides* (Kilian) (GZN2011I-J-3-87 with incomplete phragmocone, Golbini section, Anceps Zone. J–J', *Hecticoceras (Lunuloceras) aff. pseudopunctatum* (Lahusen) (GZN2011I-J-3-79), a phragmocone with incomplete body chamber, Golbini section, Callovian. Dimensions in the text.

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-j-3-83 (incomplete phragmocone)	79	27	47	19	-	30
GZN2011I-J-3-84 (incomplete phragmocone)	57	24	45	21	7	25
GZN2011I-J-3-82 (incomplete phragmocone)	53	34	39	17	7	-
GZN2011I-J-3-81 (incomplete phragmocone)	53	25	46	13	-	26
GZN2011I-J-3-79 (incomplete body chamber)	50	25	48	22	8	31
GZN2011I-J-3-80 (incomplete phragmocone)	49	24	51	15	7	25
GZN2011I-J-3-86 (incomplete phragmocone)	45	30	44	15	-	22

**Description.** A specimen with incomplete body chamber (J-3-79) and other specimens with incomplete phragmocones, shell with ovate whorl cross-section. Umbilicus deep with the steep umbilical wall. Primary ribs slightly bullate, distant and prorsiradiate, terminating at prominent nodes near mid-flank. The strong, prorsiradiate, bundled secondary ribs mainly bifurcate with some intercalatory ribs, which end at the distinct and narrow keel on the venter.

**Remarks.** The specimens differ from the specimen of Lahusen (1883), in having stronger nodes. They are similar to the material studied by Schairer *et al.* (1991) but differ from specimens described by Zeiss (1956), in having stronger ribs and nodes. The present specimens differ from specimens studied by Schlegelmilch (1985), in having slightly stronger ribs, from the specimens figured Conze *et al.* (1984) in having fainter ribs, and from the specimens studied by Rangheard (1961) in having blunter ribs. Most likely, they represent varieties of a single species.

**Stratigraphic distribution.** According to Zeiss (1959), the species ranges from the Callovian to the lower Oxfordian. The present specimens come from the Callovian.

#### *Hecticoceras (Lunuloceras) cf. lunuloides* (Kilian 1899) (Figure 3I–I')

- 1899 *Harpoceras lunuloides* Kilian – Kilian, p. 118.  
cf. 1959 *Hecticoceras (Lunuloceras) compressum* (F.A. Quenstedt 1849) – Zeiss, p. 30.  
cf. 1984 *Hecticoceras (Lunuloceras) lunuloides* Kilian 1899 – Conze *et al.*, p. 179, pl. 1, fig. 14.  
1991 *Hecticoceras (Lunuloceras) cf. lunuloides* (Kilian 1899) – Schairer *et al.*, p. 51, pl. 1, fig. 4.  
1992 *Hecticoceras (Lunuloceras) lunuloides* (Kilian 1899) – Schairer & Zeiss, p. 231, pl. 1, fig. 4.

**Material.** Two specimens from Golbini (GZN2011I-J-3, 87-88), the first (J-3-87) is small (D = 34 mm); the second (J-3-88) is larger (D = 40 mm).

#### Dimensions (in mm).

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-88 (incomplete phragmocone)	40	25	46	16	-	28
GZN2011I-J-3-87 (incomplete phragmocone)	34	23	48	17	-	24

**Description.** Specimens with incomplete phragmocone, shell compressed, involute, with trigonal whorl cross-section. Umbilicus shallow with steep umbilical wall and rounded shoulder. On the anterior part of the last whorl a faint rib starts at the umbilical margin and divides about mid-flank into two ribs. The secondary ribs end at a narrow keel and are slightly rursiradiate. Ribbing on the posterior part of the last whorl fine and dense, on the anterior part coarse and distant. The umbilical part of the whorl side is smooth other than fine, irregular striae. In contrast to the holotype, the ventral ribs are present only on the ventral third of the whorl side.

**Remarks.** The specimen figured by Quenstedt (1849, pl. 8, fig. 3) differs from the present specimens in having fine, dense ribs and a trigonal whorl section. The present material closely resembles the specimen figured by Schairer *et al.* (1991, pl. 1, fig. 4). The specimens differ from the specimen of Conze *et al.* (1984), in having stronger nodes. The specimen figured by Andal *et al.* (1968) as *Hecticoceras (Lunuloceras) cf. Lunula* (Reinecke) is very similar. Most likely, they represent varieties of a single species.

**Stratigraphic distribution.** According to Niederhöfer in Schairer *et al.* (1991), *Hecticoceras (Lunuloceras) lunuloides* occurs in the middle Callovian, Anceps Zone.

#### Subgenus *Brightia* Rollier, 1922

##### *Hecticoceras (Brightia) solinophorum* Bonarelli, 1893 (Figure 4B–B')

1893 *Hecticoceras (Lunuloceras) nodosum* Bonar. var. *solinophorum* n. – Bonarelli, p. 94.

1991 *Hecticoceras (Brightia) aff. solinophorum* Bonarelli – Schairer *et al.*, p. 50, pl. 1, fig. 2.

**Material.** Two specimens from Golbini (GZN2011I-J-3, 96-97), the first (J-3-96) is small (D = 31 mm); the second (J-3-97) is larger (D = 42 mm).

#### Dimensions (in mm).

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-97 (incomplete phragmocone)	42	34	40	15	-	18
GZN2011I-J-3-96 (incomplete phragmocone)	31	43	40	17	-	-

**Description.** Specimens with incomplete phragmocones, moderately evolute, flanks flat, venter narrow, whorl cross-section high-ovate, umbilicus shallow, with the steep wall. The strong, falcate and prorsiradiate primaries begin about

mid-flank and terminate at a narrow and trigonal keel on the venter. Ribs on inner whorls smooth. Towards the aperture primaries are strong and distant.

**Remarks.** The present specimens differ from the specimens studied by Quenstedt (1858) in having stronger ribs, and from the specimens figured by Schairer *et al.* (1991) in having fainter ribs. Most likely, they represent varieties of a single species.

**Stratigraphic distribution.** The present specimens come from the middle Callovian, while according to Zeiss (1959), the species ranges from the middle Callovian to the lower Oxfordian.

#### Subgenus *Putealiceras* Buckman, 1922

*Hecticoceras (Putealiceras) metomphalum* (Bonarelli, 1893)  
(Figure 4A–A')

- 1893 *Hecticoceras (Lunuloceras) metomphalum* sp. nov. – Bonarelli, p. 90.  
 1911 *Hecticoceras metomphalum* Bonar. var. *multicostata* nob. – Tsytovitch, p. 62, pl. 5, figs. 13–14.  
 1939 *Hecticoceras metomphalum* Bonarelli – Kuhn, p. 455, pl. 5, fig. 2.  
 1956 *Hecticoceras (Rossiensiceras) metomphalum* (Bonarelli) – Zeiss, p. 107, pl. 2, fig. 7.  
 1975 *Putealiceras (Putealiceras) metomphalum multicostatum* (Tsytovitch) – Lominadze, p. 37, pl. 2, figs. 6–7.  
 1976 *Hecticoceras (Brightia) metomphalum* Bonarelli – Rocha, p. 115, pl. 2, fig. 21.  
 1984 *Hecticoceras (Rossiensiceras) metomphalum* (Bonarelli) – Conze *et al.*, p. 176, pl. 1, figs. 3–5.  
 1985 *Hecticoceras (Putealiceras) metomphalum* Bonarelli – Schlegelmilch, p. 42, pl. 8, fig. 3.  
 2013 *Hecticoceras (Rossiensiceras) gr metomphalum* Bonarelli – Seyed-Emami *et al.*, p. 50, fig. 5f.

**Material.** Five specimens and one fragment from Golbini (GZN2011I-J-3, 73–78, 78a, 79); one specimen from Tooy (GZN2011I-S-3, 108), maximum diameter 51 mm and minimum 33 mm, generally 42 to 51 mm.

#### Dimensions (in mm).

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-j-3-73 (incomplete phragmocone)	51	33	41	17	10	26
GZN2011I-J-3-79 (incomplete phragmocone)	48	35	40	19	11	26
GZN2011I-J-3-74 (incomplete phragmocone)	42	33	40	21	10	29
GZN2011I-J-3-78 (incomplete phragmocone)	33	36	36	18	-	-

**Description.** Specimens with incomplete phragmocones. This taxon has a rather large intraspecific morphological variability, ranging from compressed and involute forms up

to evolute and heavily ornamented forms. Whorl cross-section high-ovate, umbilicus deep, with the steep wall. Primary ribs beginning close to the umbilical shoulder, terminating on the flank about one-third up at prominent lateral tubercles. Secondaries strong, prorsiradiate, slightly falcate and moderately bifurcating with some intercalatory ribs. They end at the fine keel on the venter.

**Remarks.** Several authors proposed subdivisions at the subspecies level (Zeiss, 1956), introducing *Hecticoceras (Lunuloceras) metomphalum multicostatum* Tsytovitch (1911) for compressed forms with numerous external ribs, or *Hecticoceras (Lunuloceras) metomphalum acuticosta* Tsytovitch (1911) for the forms with strong internal ribs. Compared to the holotype, the specimens are more evolute. The specimen clearly belongs to *Hecticoceras (Putealiceras) metomphalum*, which shows a great variability with regard to ribbing pattern and umbilical width. The tubercles and ribs present in the specimens are distinctly more densely spaced and more numerous than in *Hecticoceras (Rossiensiceras) metomphalum* Bonarelli, 1893. According to the ornamentation, the present specimens most closely resembles the subspecies *Hecticoceras (Rossiensiceras) metomphalum multicostata* Tsytovitch, 1911 (Tsytovitch, 1911: pl. 5, fig. 12; Zeiss, 1956: pl. 2, fig. 7) and *Hecticoceras (Rossiensiceras) metomphalum suevum* Bonarelli in Tsytovitch, 1911 (Tsytovitch, 1911: pl. 5, figs. 7, 8, 10). However, the later is much more evolute. It may be noted that the subgenus *Rossiensiceras* Gerard & Contaut, 1936 is considered synonymous to *Putealiceras* by Arkell (1956) and Schlegelmilch (1985).

**Stratigraphic distribution.** According to Tsytovitch (1911), the species occurs in the middle Callovian (Anceps Zone) and middle Callovian Jason Zone (Zeiss, 1956, 1959; Thierry *et al.*, 1997).

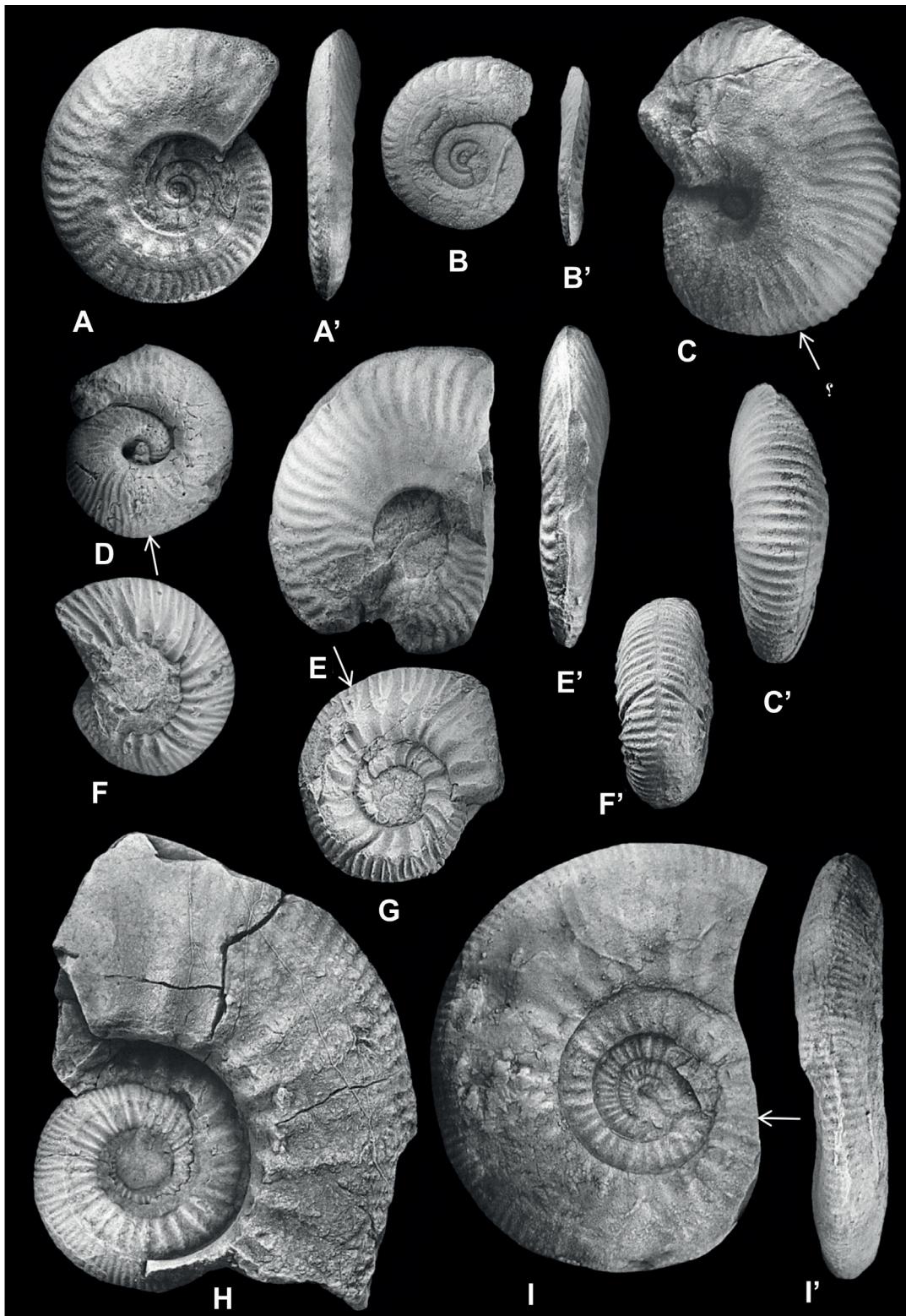
#### *Hecticoceras (Putealiceras) schalchi* Zeiss, 1956 (Figure 3C–C')

- 1956 *Hecticoceras (Putealiceras) schalchi* sp. nov. – Zeiss, p. 67, pl. 3, fig. 4.  
 1961 *Hecticoceras (Putealiceras) schalehi* Zeiss – Rangheard, p. 160, pl. 4, fig. 3.  
 1975 *Putealiceras (Zieteniceras) schalchi* Zeiss – Lominadze, p. 63, pl. 6, figs. 5–6.

**Material.** Five specimens and one fragment from Golbini (GZN2011I-J-3, 67–72), maximum diameter 43 mm and minimum 25 mm, generally 30 to 33 mm.

#### Dimensions (in mm).

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-67 (incomplete body chamber)	43	45	34		10	26
GZN2011I-J-3-69 (incomplete phragmocone)	33	35	42	21	8	
GZN2011I-J-3-68 (incomplete phragmocone)	31	35	42		8	25



**Figure 4.** **A–A'**, *Hecticoceras (Putealiceras) metomphalum* (Bonarelli), (GZN2011I-J-3-73) with incomplete phragmocone, Golbini section, Anceps Zone. **B–B'**, *Hecticoceras (Brightia) solinophorum* (Bonarelli) (GZN2011I-J-3-96) with incomplete phragmocone, Golbini section, middle Callovian. **C–C'**, *Pachyceras lalandei* (d'Orbigny) (GZN2011I-J-4-101) a phragmocone with incomplete body chamber, Golbini section, Lamberti Zone. **D**, *Bullatimorphites (Bomburites) cf. microstoma* (d'Orbigny) (GZN2011I-S-3-45), a phragmocone with incomplete body chamber, Tooy section, Bullatus Zone. **E–E'**, *Hecticoceras zieteni* (Detsytovitch) (GZN2011I-J-3-89) with incomplete phragmocone, Golbini section, Anceps Zone. **F–F'**, specimen GZN2011I-S-3-122 with incomplete phragmocone, Tooy section; **G**, specimen GZN2011I-J-3-106, a phragmocone with incomplete body chamber from the Golbini section, x1.5. **H**, *Choffatia (Choffatia) sakuntala* (Spath), (GZN2011I S-3-51), a phragmocone of a macroconch [M], Tooy section, Gracilis Zone. **I–I'**, *Choffatia (Grossouvreria) kontkiewiczi* (Siemiradzki) (GZN2011I-J-3-210), a incomplete body chamber of a macroconch [M], Golbini section, Coronatum Zone. Dimensions in the text.

GZN2011I-J-3-72 (incomplete phragmocone)	30	40	37	20	7	20
GZN2011I-J-3-71 (incomplete phragmocone)	25	40	34	22	10	25

**Description.** A specimen with incomplete body chamber (J-3-67), and specimens (J-3-68-69, 72, 71) with incomplete phragmocones, whorl cross-section ovate, umbilicus shallow with steep wall, flanks flat, venter fairly narrow. Radiate primary ribs beginning at the umbilical margin and ending at about one-third of flank height at prominent, conical lateral tubercles. From there, they mainly bifurcate with some intercalators. Concave secondary ribs terminating at a narrow and distinct keel on the venter. Secondary ribs denser than primaries. Ribs on inner whorls finer than those on outer whorls. Secondary on outer whorls coarse, strong and bullate than primary ribs. Towards the aperture secondary are strong and distant bullate than primary ribs. Ribbing on outer whorls stronger, coarser, and more distant than on inner whorls. Ribbing denser at the posterior part of the last whorl.

**Remarks.** The present specimens resemble the holotype (Zeiss, 1956), and the material figured by Rangheard (1961). The specimen figured by Lominadze (1975), differs from the present specimens in having finer ribs.

**Stratigraphic distribution.** According to Tsytovitch (1911), the species occurs in the middle Callovian (Anceps Zone), and is recorded for the first time from Iran.

#### Subgenus *Zieteniceras* Zeiss, 1956

##### *Hecticoceras (Zieteniceras) zieteni* Tsytovitch, 1911 (Figure 4E–E')

1911 *Hecticoceras zieteni* sp. nov. – Tsytovitch, p. 25, pl. 1, fig. 2.

1956 *Hecticoceras (Zieteniceras) zieteni* (Tsytovitch) – Zeiss, p. 105, pl. 1, fig. 17.

1961 *Hecticoceras (Zieteniceras) zieteni* Tsytovitch – Rangheard, p. 141, pl. 1, fig. 7.

1975 *Putealiceras (Zieteniceras) zieteni* (Tsytovitch) – Lominadze, p. 52, pl. 4, figs. 5, 7, pl. 5, fig. 1.

1985 *Hecticoceras (Zieteniceras) zieteni* Tsytovitch – Schlegelmilch, p. 162, pl. 6, fig. 5.

2009 *Hecticoceras (Prohecticoceras) gr. zieteni* (Tsytovitch, 1911) – Schlögl et al., p. 63, pl. 5, fig. 15.

**Material.** Two specimens and one fragment from Golbini (GZN2011I-J-3, 89-91) the first (J-3-91) is small ( $D = 49$  mm); the second (J-3-89) is larger ( $D = 53$  mm).

#### Dimensions (in mm).

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-89 (incomplete phragmocone)	53	28	46	23	11	
GZN2011I-J-3-91 (incomplete phragmocone)	49	34	42	24	11	24

**Description.** Specimens with incomplete phragmocones, moderately involute, venter fairly narrow, whorl cross-section high-ovate, flank relatively flat and ribbing relatively coarse, relatively large and keel venter, and falcoid ribbing, umbilicus deep with steep wall and rounded shoulder. The strong, radiate to slightly prorsiradiate primary ribs begin at the umbilical margin and divide about mid-flank into two secondary ribs which, together with some intercalated ribs. They end at the distinct keel on the venter. Towards the aperture, distant ribs, stronger and whorl height increasing.

**Remarks.** The present material is very similar to the holotype, but differs from the specimens studied by Lominadze (1975, especially the figured in pl. 5, fig. 1), in having coarser and sharper ribs. This species shows, however, a large intraspecific variability encompassing also forms similar to the described specimen.

**Stratigraphic distribution.** The specimens from Iran occur in the Callovian Anceps Zone. The species was established by Tsytovitch (1911), based on material from the middle Callovian Anceps Zone. It has also been recorded from the middle Callovian Coronatum Zone and the Macrocephalus/ Anceps zones (Lemoine, 1932) and is recorded for the first time from Iran.

##### *Hecticoceras (Zieteniceras) evolutum* Lee, 1905 (Figure 3E–E')

1905 *Hecticoceras evolutus* – Lee, p. 21, pl. 1, fig. 6.

1911 *Hecticoceras evolutum* Lee – Tsytovitch, p. 21, pl. 2, fig. 9.

1956 *Hecticoceras (Zieteniceras) evolutum* Lee – Zeiss, p. 105, pl. 1, fig. 19.

1985 *Hecticoceras (Zieteniceras) evolutum* Lee – Schlegelmilch, p. 163, pl. 6, fig. 7.

**Material.** Three specimens and one fragment from Golbini (GZN2011I-J-3, 93-95), the first (J-3-95) is small ( $D = 40$  mm); the second (J-3-93) is medium ( $D = 43$  mm); the third (J-3-94) is larger sized ( $D = 49$  mm).

#### Dimensions (in mm).

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-94 (incomplete phragmocone)	49	32	42	23	8	22
GZN2011I-J-3-93 (incomplete phragmocone)	43	38	42	23	9	24
GZN2011I-J-3-95 (incomplete phragmocone)	40	32	43	22	8	23

**Description.** Specimens with incomplete phragmocones, flanks flat, venter narrow, moderately involute, whorl cross-section high-ovate, umbilicus shallow with steep wall and rounded shoulder. Primaries bullate and prorsiradiate, beginning at the umbilical margin and dividing about mid-flank into two to three rursiradiate secondaries which,

together with some intercalated ribs, end at the fine keel on the venter. Secondary ribs denser than primary ones. Towards the aperture, ribs distant, stronger and whorl height increasing. Ribs on inner whorls finer than those on outer whorls. Secondary ribs stronger and distinct than primaries.

**Remarks.** The present specimens are very similar to the holotype, but differ from the specimen figured by Zeiss (1959) in having coarser and stronger primary ribs, and from the specimens figured by Schlegelmilch (1985) in having bullate primaries ribs.

**Stratigraphic distribution.** Middle Callovian (Zeiss, 1959); the species is recorded for the first time from Iran.

Superfamily STEPHANOCERATOIDEA Neumayr, 1875

Family TULITIDAE Buckman, 1921

*Bullatimorphites* Buckman, 1921

Subgenus *Bomburites* Arkell, 1952

*Bullatimorphites (Bomburites)* cf. *microstoma*  
(d'Orbigny, 1846)  
(Figure 4D)

cf. 1846 *Ammonites microstoma* – d'Orbigny, p. 413, pl. 129, figs. 3–4.

cf. 1887 *Ammonites microstoma* (d'Orbigny) – Quenstedt, p. 661, pl. 78, figs. 3, 4, 6.

cf. 1958 *Bullatimorphites ? (Bomburites) microstoma* (d'Orbigny) – Westermann, p. 66, pl. 22, fig. 3.

cf. 1971 *Bullatimorphites (Bomburites) microstoma* (d'Orbigny) – Hahn, pl. 9, fig. 8.

cf. 1985 *Bullatimorphites (Bomburites) microstoma* (d'Orbigny) – Schlegelmilch, p. 135, pl. 52, fig. 8.

**Material.** One specimen from Tooy with diameter 35 mm (GZN2011I-S-3, 45).

#### Dimensions (in mm).

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-S-3-45 (incomplete body chamber)	35	28	37	43	14	

**Description.** A specimen with incomplete body chamber, mostly in poor state of preservation. Inner and middle whorls with narrow umbilicus, the last whorl, which is the body chamber, is eccentrically coiled, with widely opening umbilicus. The features of the aperture cannot be seen because there is no completely preserved specimen in the material. Shell involute, inflated, venter broad, umbilical wall vertical. Primary ribs starting at the umbilical margin. Secondary ribs irregular, some starting around the umbilical margin, others halfway or two-thirds up the flank. In addition, some ribs are single, yet others sinuous which, together with some intercalated ribs, continue towards the venter. Secondary ribs stronger and denser than primaries. Ribs on the inner part in the last visible whorl prorsiradiate and on the outer part moderately rectiradiate.

**Remarks.** The present specimen resembles a specimen of *Bullatimorphites (Bomburites) suevicus* illustrated in Hahn (1971, pl. 8, fig. 8), but differs in having sinuous and regular ribs. The specimen figured in Hahn (1971, pl. 9, fig. 8) has stronger primary ribs. Westermann (1958, pl. 22, fig. 3)'s specimen differs by the shape of its umbilicus, and the figured in Quenstedt (1887, pl. 78, figs. 3–4, 6), display some sinuous ribs.

**Stratigraphic distribution.** Lower Callovian, Bullatus Zone (Hahn, 1971); the species is recorded for the first time from Iran.

Subgenus *Kheraiceras* Spath, 1924

*Bullatimorphites (Kheraiceras)* sp.  
(Figure 5B–B')

**Material.** One fragment from Golbini (GZN2011I-J-3, 37).

**Description and remarks.** A specimen with incomplete phragmocone, shell fat and inflated, broadly convex venter. Involute globular sphaerocone with very small umbilicus and suboval whorl section with rounded shoulder. Venter with rectiradiate, strong, distant and coarse ribs. Since only the ventral area is visible, a specific identification is not possible. The specimen resembles, however, *Kheraiceras* cf. *K. bullatum* as figured by Seyed-Emami *et al.* (1991, pl. 4, fig. 1). Its coarse ribs and broad venter are also similar to *Bullatimorphites (Kheraiceras) hannoveranus* Dietl (1994, pl. 1, fig. 2).

**Stratigraphic distribution.** The specimen comes from the lower Callovian.

Family MACROCEPHALITIDAE Buckman, 1922

*Macrocephalites* Zittel, 1884

Subgenus *Macrocephalites* Zittel, 1884

*Macrocephalites (Macrocephalites) jacquoti*  
(Douville, 1912)  
(Figure 5C–C')

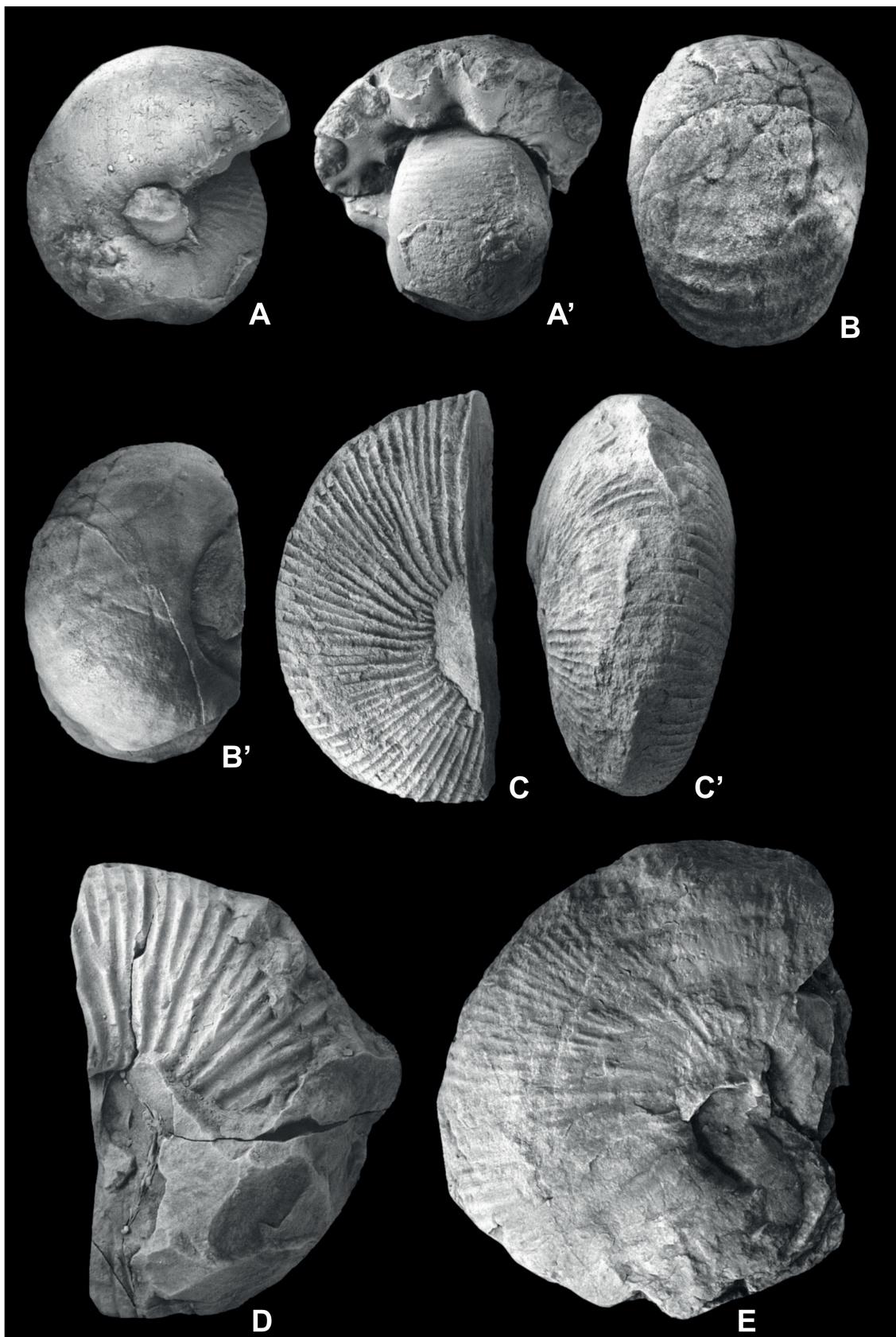
1994 *Macrocephalites (Macrocephalites) jacquoti* (Douville 1912) – Dietl, p. 13, pl. 2, fig. 4, pl. 4, figs. 1–3, pl. 5, fig. 1.

1998 *Macrocephalites (Macrocephalites) jacquoti* (Douville 1912) – Dietl & Gygi, pl. 3.

2009 *Macrocephalites jacquoti* Douville – Mitta, p. 52, pl. 7, figs. 1–3.

**Material.** 3 fragments from Golbini (GZN2011I-J-3, 38–40), and 1 fragment from Tooy (GZN2011I-S-3-16).

**Description.** A specimen with incomplete phragmocone, shell inflated and large-sized, umbilicus narrow and moderately narrow, with a vertical wall and a rounded shoulder, whorl cross-section oval, venter rounded and broad. The prorsiradiate primaries divide at about one-third of the height of the flank into two and seldom into three prorsiradiate



**Figure 5.** **A-A'**, *Kheraiceras* cf. *bullatum* (d'Orbigny) (GZN2011I-S-2b-12) with incomplete phragmocone, Tooy section, Lower Callovian. **B-B'**, *Bullatimorphites* (*Kheraiceras*) sp. (GZN2011I-J-3-37) with incomplete phragmocone, Golbini section, Lower Callovian. **C-C'**, *Macrocephalites* (*Macrocephalus*) *jacquoti* (Douvillé) (GZN2011I-S-3-16) with incomplete phragmocone, Tooy section, Bullatus (*Macrocephalus*) Zone. **D**, *Macrocephalites* (*Kamptokephalites*) cf. *kamptus* (Buckman) (GZN2011I-S-3-15) with incomplete phragmocone, Tooy section, Lower Callovian. **E**, *Macrocephalites* cf. *subtrapezinus* (Waagen) (GZN2011I-S-3-17) with incomplete phragmocone, Tooy section, Lower Callovian. Dimensions in the text.

secondaries, which cross the venter. The ribs are strong and dense. Primary and secondary ribs equally coarse. To wards the aperture, whorl height increasing.

**Remarks.** The specimen can be compared with the holotype of Douvillé (1912), and with the specimens reported by Dietl (1994) and Dietl & Gygi (1998), and differ from the specimen of Mitta (2009), in having a broader venter.

**Stratigraphic distribution.** Lower Callovian, Bullatus Zone (Dietl, 1994); the species is recorded for the first time from Iran.

#### Subgenus *Kamptocephalites* Buckman, 1922

##### *Macrocephalites (Kamptocephalites) kamptus* (Buckman, 1922) (Figure 5D)

1922 *Kamptocephalites kamptus* sp. nov. – Buckman, pl. 347.  
1954 *Macrocephalites (Kamptocephalites) cf. kamptus*  
Buckman – Jeannet, p. 256, pl. 25, fig. 3.

2012 *Macrocephalites (Kamptocephalites) cf. kamptus*  
Buckman – Dietl et al., p. 12, pl. 6, fig. c.

**Material.** One fragment from Tooy (GZN2011I-S-3-15).

**Description and remarks.** A specimen with incomplete phragmocone, whorl cross-section elliptical. Large-sized, umbilicus narrow, with a vertical wall and a rounded shoulder. Primaries starting at the umbilical margin and dividing near mid-flank into two or three secondaries, terminate at the rounded venter. The ribs are strong, coarse, blunt, distant, and rectiradiate. Primary and secondary ribs equally coarse. To wards the aperture, whorl height increasing.

**Remarks.** The fragment can be compared with the holotype of Buckman (1922), and differ from the specimen of Dietl et al. (2012), in having stronger ribs. The present specimen is similar to *Macrocephalites (Kamptocephalites) lamellosus* Thierry (1978, 399, pl. 34, fig. 1) but differs in having strong, distant ribs.

**Stratigraphic distribution.** Lower Callovian (Jeannet, 1954); the species is recorded for the first time from Iran.

##### *Macrocephalites (Kamptocephalites) cf. subtrapezinus* (Waagen, 1875) (Figure 5E)

1875 *Stephanoceras subtrapezinus* – Waagen, p. 137, pl. 33, fig. 4.

1978 *Macrocephalites subtrapezinus* Waagen – Thierry, p. 155, pl. 2, fig. 1, pl. 4, fig. 2.

**Material.** One fragment from Tooy (GZN2011I-S-3-17).

**Description.** A specimen with incomplete phragmocone, large-sized, umbilicus narrow, with a rounded shoulder, the distant, coarse and prorsiradiate primaries start at the umbilical margin and at around one-third of the height of the flank they divide into two or three dense and prorsiradiate secondaries

with some intercalatory ribs. To wards the aperture, whorl height increasing. Secondary ribs denser than primaries but equally moderately coarse.

**Remarks.** The present fragment resemble the holotype (Waagen, 1875), and differ from the specimen of Thierry (1978) in having finer ribs and whorl height increasing.

**Stratigraphic distribution.** According to Thierry (1978), *Macrocephalites subtrapezinus* appears in the lower Callovian; the species is recorded for the first time from Iran.

#### *Dolikephalites* Buckman, 1923

##### *Macrocephalites (Dolikephalites) cf. perseverans* Kuhn, 1939 (Figure 6A–A'')

cf. 1954 *Macrocephalites (Indocephalites) perseverans* (Model) – Jeannet, pl. 24, fig. 5, pl. 25, fig. 4.  
cf. 1985 *Macrocephalites (Dolikephalites) perseverans* Kuhn, – Schlegelmilch, pl. 39, fig. 3.

**Material.** One specimen from Tooy with diameter 57 mm (GZN2011I-S-3-22).

#### Dimensions (in mm).

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-S-3-22 (incomplete body chamber)	57	28	43	78	17	37

**Description.** A specimen with incomplete body chamber, shell medium, fat and inflated, with very broad venter and oval whorl cross-section. Involute globular sphaerocone with moderately narrow umbilicus with rounded shoulder. Venter with rectiradiate, strong, and coarse ribs. Ribbing strong and coarse. The slightly concave and prorsiradiate primaries begin at around mid-flank and divide into two and occasionally three prorsiradiate secondaries, which cross in a slightly convex manner over the venter. Secondary ribs denser than primaries but equally moderately coarse.

**Remarks.** The specimen can be compared with the holotype of Kuhn (1939, 480, pl. 3, fig. 7) but differs in being smaller. It differ from the specimen of Jeannet (1954) in having slightly stronger ribs, and differ from the specimen of Schlegelmilch (1985) in having a broader venter.

**Stratigraphic distribution.** Lower Callovian Kuhn (1939); the species is recorded for the first time from Iran.

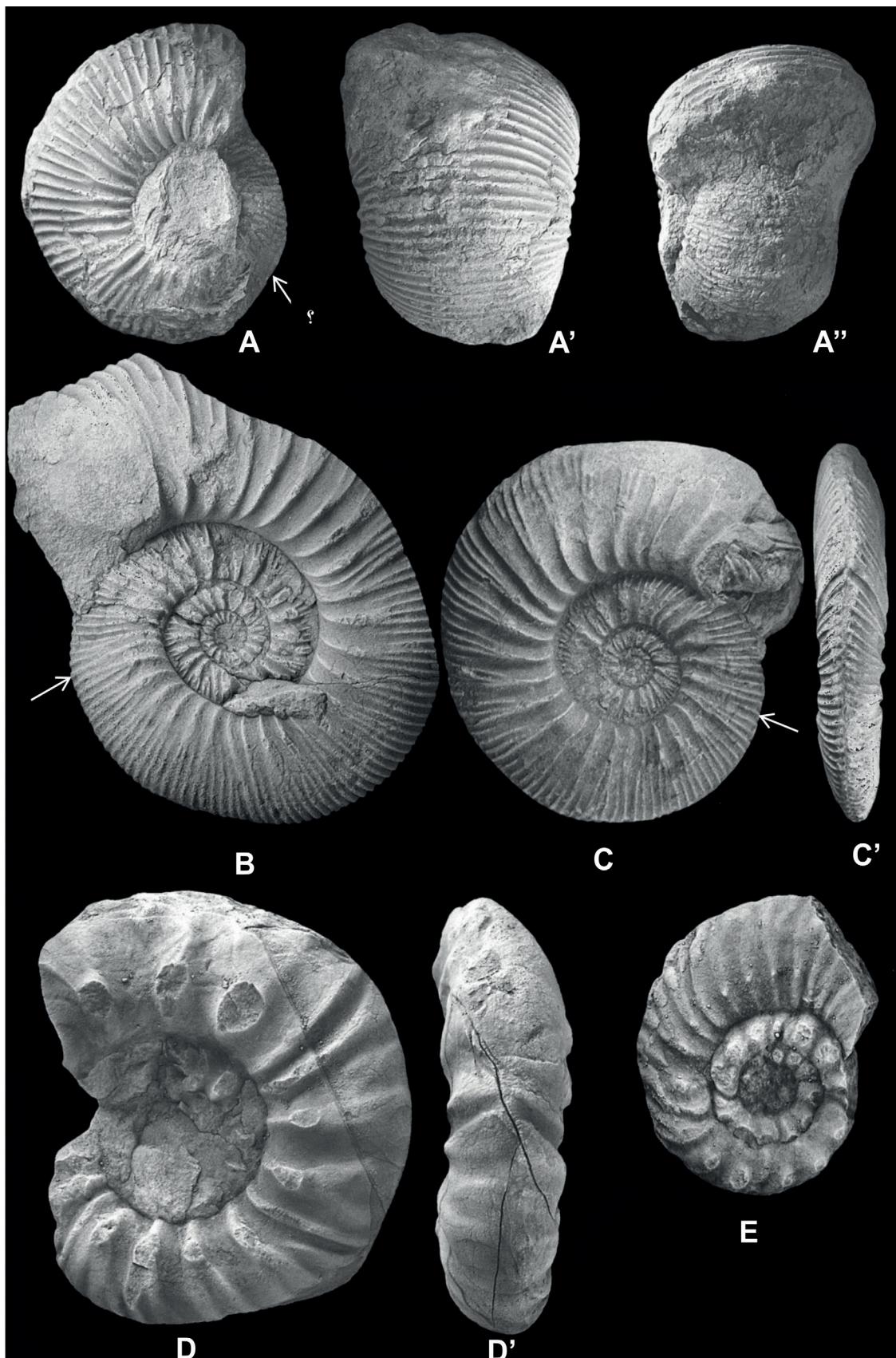
#### Family PACHYCERATIDAE Buckman, 1918

##### *Pachyceras* Bayle, 1878

##### *Pachyceras lalandei* (d'Orbigny, 1848) (Figure 4C–C')

1848 *Ammonites lalandeana* sp. nov. – d'Orbigny, p. 477, pl. 175, figs. 1–3.

1912 *Pachyceras lalandei* (d'Orbigny) – Douvillé, p. 44, pl. 8, figs. 1–2.



**Figure 6.** A–A'', *Macrocephalites (Dolikephalites) cf. perseverans* (Kuhn) (GZN2011I-S-3-22) a phragmocone with incomplete body chamber, Tooy section, Lower Callovian. B, C–C', *Reineckeia (Tyrannites)* sp., Golbini section, middle Callovian; B, specimen GZN2011I-J-3-142. C–C', specimen GZN2011I-J-3-141 with a phragmocone and nearly complete body chamber. D–D', cf. *Reineckeia* sp. (GZN2011I-J-3-121) with incomplete phragmocone, Golbini section, middle Callovian. E, cf. *Reineckeia* sp. (GZN2011I-J-3-123) with incomplete phragmocone, Golbini section, middle Callovian. Dimensions in the text.

**Material.** One specimen from Golbini with diameter 56 mm (GZN2011I-J-4-101).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-4-101 (incomplete body chamber)	56	12	56	35	-	30

**Description.** A specimen with incomplete body chamber, shell involute and moderately inflated, venter fairly narrow, umbilicus narrow and deep with steep wall and rounded shoulder. The distinct primaries ribs begin at about one-third of flank height and split into two secondaries halfway or two-thirds up the flank. They cross the venter as strong, coarse, and slightly prorsiradiate ribs. Secondary ribs denser than primaries but equally moderately coarse. Towards the aperture, whorl height increasing.

**Remarks.** The specimen can be compared with the holotype of d'Orbigny (1848), but differs from the specimen of Douvillé (1912), in being smaller and having slightly weaker primaries.

**Stratigraphic distribution.** According to Douvillé (1912), *Pachyceras lalandei* occurs in the upper Callovian, Lamberti Zone; the species is recorded for the first time from Iran.

Superfamily PERISPHINCTOIDEA Steinmann, 1890  
Family REINECKEIIDAE Hyatt, 1900

*Rehmannia* Schirardin, 1956

Subgenus *Loczyceras* Bourquin, 1968

*Rehmannia (Loczyceras) segestana* (Gemmellaro, 1872)  
(Figure 8A–A')

1872 *Perisphinctes segestana* sp. nov. – Gemmellaro, p. 246, pl. 13, figs. 1–3.

1984 *Rehmannia (Loczyceras) segestana* (Gemmellaro) – Cariou, p. 72, pl. 7, figs. 3–4, pl. 8, fig. 1.

**Material.** Six specimens and two fragments from Golbini (GZN2011I-J-3-126–132a), maximum diameter 59 mm and generally 51 to 53 mm.

**Dimensions (in mm).**

Specimens	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-J-3-126 (incomplete phragmocone)	57	41	37	24	20	15	42
GZN2011I-J-3-131 (incomplete phragmocone)	59	41	36	20	17	12	35
GZN2011I-J-3-130 (incomplete phragmocone)	51	45	37	25	24	18	-
GZN2011I-J-3-127 (incomplete phragmocone)	53	45	32	23	19	18	-
GZN2011I-J-3-129 (incomplete phragmocone)	53	40	32	26	18	12	34

**Description.** Specimens with incomplete phragmocones, shell evolute with nearly ellipsoidal whorl cross-section. Umbilicus shallow, with steep wall, flanks flat, venter fairly narrow. Ribbing relatively coarse and distant. The bullate and radiate primary ribs end at prominent and pyramidal lateral tubercles at one-third of flank height, from where they bifurcate or trifurcate with some intercalatory ribs. The rectiradiate secondary ribs terminate at a ventral furrow. The secondary ribs are fainter and denser than the primaries. Some of the primary ribs do not divide. Primaries on outer whorls bullate.

**Remarks.** The present specimens resemble the holotype (Gemmellaro, 1872), and the material figured by Cariou (1984). However, the holotype exhibits nearly prorsiradiate ribs.

**Stratigraphic distribution:** middle Callovian (Anceps Zone), Stuebeli Subzone and Bannense horizon (Cariou, 1984); the species is recorded for the first time from Iran.

*Rehmannia (Loczyceras) sequanica* (Bourquin, 1968)  
(Figure 8B–B')

1968 *Rehmannia (Loczyceras) sequanica* – Bourquin, pl. 24, fig. 3.

1984 *Rehmannia (Loczyceras) sequanica* nov. subsp. – Cariou, p. 172, pl. 24, figs. 4–5.

**Material.** Six specimens and one fragment from Golbini (GZN2011I-J-3-133–140), maximum diameter 61 mm and generally 56 to 61 mm.

**Dimensions (in mm).**

Specimens	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-J-3-139 (incomplete body chamber)	60	43	38	29	19	15	42
GZN2011I-J-3-135 (incomplete body chamber)	61	41	38	25	16	13	39
GZN2011I-J-3-134 (incomplete body chamber)	57	42	35	23	16	11	36
GZN2011I-J-3-138 (incomplete body chamber)	56	41	37	25	19	13	38

**Description.** Specimens with incomplete body chambers, shell evolute, flanks flat, venter fairly narrow, whorl cross-section nearly rectangular. Umbilicus shallow, with the steep wall. The bullate and radiate primary ribs end at faint lateral tubercles at around one-third of flank height, from where they bifurcate to quadrifurcate with some intercalatory ribs. The rectiradiate secondary ribs terminate at a ventral furrow. Secondary ribs fainter and denser than the primaries. Some of the primary ribs do not divide. Ribbing denser at the posterior part of the last whorl.

**Remarks.** *Rehmannia (Loczyceras) sequanica* is similar to *R. (Loczyceras) segestana* (Gemmellaro), but differs in having fainter and thinner ribs and tubercles and in possessing quadrifurcating secondaries.

**Stratigraphic distribution.** Middle Callovian (Coronatum

Zone), Baylei Subzone (Cariou, 1984), the species is recorded for the first time from Iran.

*Rehmannia (Loczyceras) cf. hungarica* (Till, 1907)  
(Figure 7A–A')

cf. 1907 *Reineckia hungarica* sp. nov. – Till, p. 125.  
cf. 1910 *Reineckia hungarica* Till – Till, p. 10, pl. 1 (5), fig. 1.  
1984 *Rehmannia (Loczyceras) cf. hungarica* (Till) – Cariou, p. 79, pl. 8, fig. 9.  
cf. 1986 *Rehmannia (Loczyceras) cf. hungarica* (Till) – Sequeiros et al., p. 78, pl. 1, figs. 4–5.

**Material.** One specimen with diameter 108 mm and one fragment from Golbini (GZN2011I-J-3-114-115).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-J-3-114 (incomplete body chamber)	105	42	34	18	14	9	51

**Description.** An adult specimen with incomplete body chamber, shell large with oval whorl cross-section, flanks flat, venter fairly narrow, umbilicus deep with steep wall. Bullate, distant and prorsiradiate primary ribs ending mostly at conical and sharp tubercles at around one-third of flank height. The slightly prorsiradiate secondaries bifurcate or trifurcate with some intercalatory ribs, ending at a smooth ventral band. Some of the primary ribs do not divide; they are also more distant than the secondaries. On the outer part of the last whorl the ribs are irregular. Ribbing denser at the posterior part of the last whorl.

**Remarks.** The specimens is similar to the material studied by Cariou (1984), but differ from specimens described by Sequeiros et al. (1986) in having distant ribs and and whorl height increasing.

**Stratigraphic distribution.** Middle Callovian Anceps Zone (Cariou, 1984), the species is recorded for the first time from Iran.

*Rehmannia (Loczyceras) intermedia* (Bourquin 1968)  
(Figure 8C–C')

1968 *Reineckia intermedia* nov. sp. – Bourquin, p. 100, pl. 23, fig. 6, pl. 2, fig. 12, pl. 22, fig. 10.

1984 *Rehmannia (Loczyceras) intermedia* (Bourquin) – Cariou, p. 144, pl. 19, figs. 1–4.

**Material.** One specimen with diameter 62 mm and two fragments from Golbini (GZN2011I-J-3-116–118).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-J-3-116 (incomplete body chamber)	60	39	37	27	14	10	41

**Description.** A specimen with incomplete body chamber, flanks flat, whorl cross-section broad-ovate to rectangular,

umbilicus shallow with the steep wall. The bullate, distant and prorsiradiate primary ribs end mostly at pyramidal and sharp tubercles at around one-third of flank height. The prorsiradiate secondaries are trifurcate, quadrifurcate, seldom quinquefurcate, ending at a ventral furrow. There are also some single intercalatory ribs. The secondary ribs are denser than the primary ones. Ribbing denser at the posterior part of the last whorl.

**Remarks.** The present specimen differ from the holotype with respect to their bullate ribs and sharp tubercles.

**Stratigraphic distribution:** Middle Callovian Anceps Zone (Cariou, 1984); the species is recorded for the first time from Iran.

*Reineckeia (Reineckeia)* Bayle, 1878

Subgenus *Tyrannites* Cariou, 1984

*Reineckeia (Tyrannites)* sp.  
(Figures 6B, C–C')

**Material.** Two specimens and five fragments from Golbini (GZN2011I-J-3-142–141), the first (J-3-141) is small (D = 72 mm); the second (J-3-142) is larger (D = 92 mm).

**Dimensions (in mm).**

Specimens	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-J-3-142 (nearly complete body chamber)	92	40	36	27	19	14	45
GZN2011I-J-3-141 (nearly complete body chamber)	72	40	35	18	16	15	51

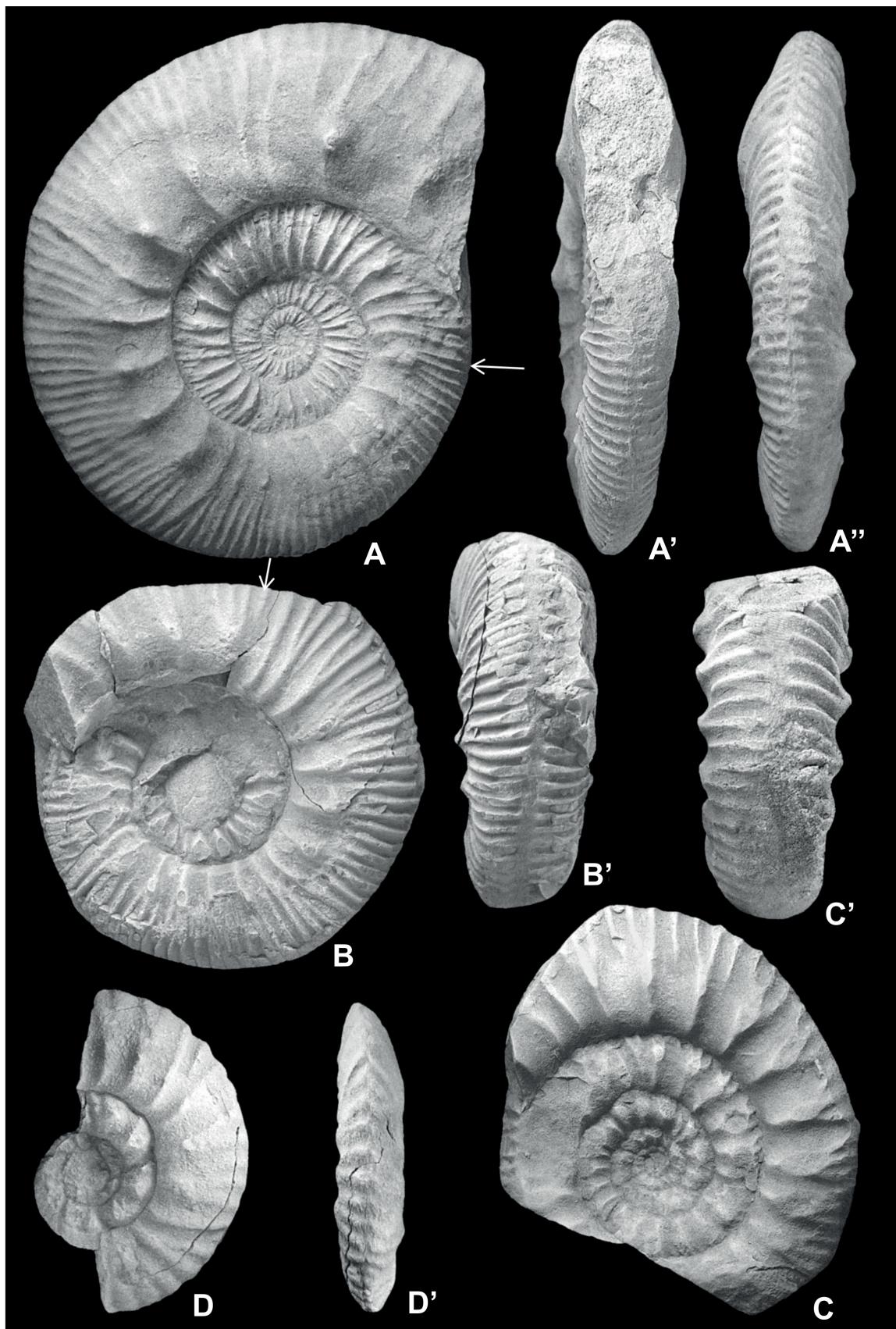
**Description.** Adult specimens with nearly complete body chambers, flanks flat, venter fairly narrow, umbilicus shallow with the steep wall. Ribbing relatively coarse, strong and distant. Primary ribs on the inner flank slightly bullate, terminating at around one-third of flank height in small and weak tubercles. From there they bifurcate to quadrifurcate in a prorsiradiate fashion (specimen J-5-142) or bifurcate or trifurcate in a prorsiradiate fashion (specimen J-5-141). Secondaries with intercalatory ribs and ending at the ventral furrow. Secondaries denser and finer than primaries. Ribbing on outer whorls stronger, coarser, and more distant than on inner whorls. Towards the aperture primaries are strong and distant and whorl height increasing.

**Remarks.** The specimens differ from *Reineckeia (Tyrannites) convex* (Cariou, 1984) in having stronger, blunter and more rectiradiate ribs.

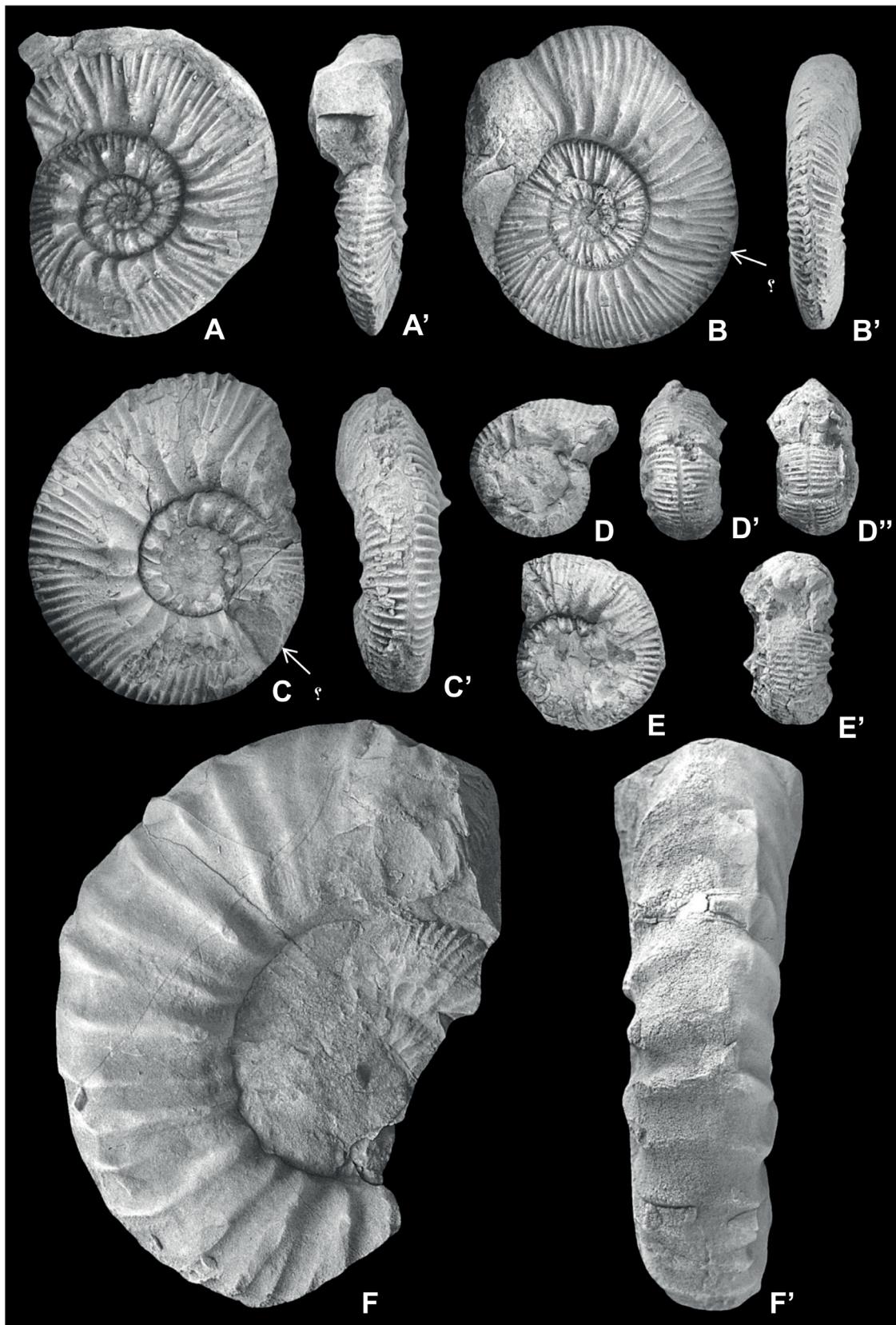
**Stratigraphic distribution.** The present specimens come from the middle Callovian (Cariou, 1984), and the taxon is for the first time from Iran.

*Reineckeia (Tyrannites) convex* Cariou, 1984  
(Figure 7B–B')

1984 *Reineckeia (Tyrannites) convex* sp. nov. – Cariou, p. 197, pl. 28, figs. 3–4, pl. 29, figs. 1–4.



**Figure 7.** **A–A'**, *Rehmannia (Loczyceras) cf. hungarica* (Till) (GZN2011I-J-3-114), a phragmocone with incomplete body chamber, Golbini section, Anceps Zone. **B–B'**, *Reineckeia (Tyrannites) convex* (Cariou) (GZN2011I-J-3-119), a phragmocone with incomplete body chamber, Golbini section, Gracilis Zone. **C–C'**, *Reineckeia (Reineckeia) cf. fehlmanni* (Jeannet) (GZN2011I-J-3-108) with incomplete phragmocone, Golbini section, Middle Callovian. **D–D'**, *Reineckeia* sp. (GZN2011I-J-3-149) with incomplete phragmocone, Golbini section, Callovian. Dimensions in the text.



**Figure 8.** A–A', *Rehmannia (Loczyceras) segestana* (Gemmellaro) (GZN2011I-J-3-126) with incomplete phragmocone, Golbini section, Anceps Zone. B–B', *Rehmannia (Loczyceras) sequanica* (Cariou) (GZN2011I-J-3-135), a phragmocone with incomplete body chamber, Golbini section, Coronatum Zone. C–C', *Rehmannia (Loczyceras) intermedia* (Bourquin) (GZN2011I-J-3-116), a phragmocone with incomplete body chamber, Golbini section, Anceps Zone. D–D'', *Reineckeia (Reineckeia) nodosa* (Tilli) (GZN2011I-S-3-120) with incomplete phragmocone, Tooy section, Athleta Zone. E–E', *Reineckeia (Reineckeia)* aff. *Polycosta* (Kuhn) (GZN2011I-S-3-127) with incomplete phragmocone, Tooy section, Anceps Zone. F–F', cf. *Reineckeia* sp. (GZN2011I-J-3-120) with incomplete phragmocone, Golbini section, middle Callovian. Dimensions in the text.

**Material.** One specimen from Golbini with diameter 78 mm (GZN2011I-J-3-119).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-J-3-119 (incomplete body chamber)	78	38	35	32	15	11	37

**Description.** A specimen with incomplete body chamber, umbilicus is deep with steep umbilical wall and rectangular whorl cross-section and venter rounded to broad. The bullate and distant primary ribs end mostly at conical and sharp tubercles at around one-third of flank height. The rectiradiate secondaries are bifurcating or trifurcating with single intercalatory ribs, all ending at a ventral furrow. The secondary ribs are denser than the primaries. Rarely, primary ribs do not divide.

**Remarks.** The blunt, coarse and strong ribs distinguish this species from other species.

**Stratigraphic distribution.** Lower Callovian Gracilis Zone, Pictava Subzone and horizon (Cariou, 1984), the species is recorded for the first time from Iran.

Subgenus *Reineckeia* Bayle, 1878

*Reineckeia* (*Reineckeia*) cf. *fehlmanni* Jeannet, 1951  
(Figure 7C–C')

cf. 1951 *Reineckeia fehlmanni* sp. nov. – Jeannet, p. 134, pl. 53, figs. 316–317.

cf. 1984 *Reineckeia* (*Reineckeia*) *fehlmanni* Jeannet – Cariou, p. 278, pl. 42, figs. 1–3.

cf. 1986 *Reineckeia* (*Reineckeia*) *fehlmanni* Jeannet – Sequeiros *et al.*, p. 79, pl. 2, fig. 3.

**Material.** Three fragments from Golbini (GZN2011I-J-3-108-113).

**Description.** Specimens with incomplete phragmocones, whorl cross-section rectangular, venter broad, and umbilicus shallow, low with steep wall. Nearly the entire bullate and distant primary ribs end at pyramidal, sharp tubercles at around one-third of flank height. Bullate secondaries bifurcate or trifurcate with single intercalatory ribs, ending at a smooth ventral band. Ribs on the inner part in the last visible whorl rectiradiate and on the outer part prorsiradiate.

**Remarks.** The fragments described here differ from the holotype with respect to their bullate and long ribs and sharp, big tubercles. Moreover, the ribs are first rectiradiate and then prorsiradiate, while in the specimens described by Cariou (1984, pl. 42), and Jeannet (1951, pl. 53) the ribs are usually rectiradiate. The specimen differ from the reported by Sequeiros *et al.* (1986) in having long ribs, fainter, smaller tubercles and whorl height increasing.

**Stratigraphic distribution.** Middle Callovian (Cariou, 1984); the species is recorded for the first time from Iran.

*Reineckeia* (*Reineckeia*) *anceps* (Reinecke, 1818)  
(Figures 4F–F', G)

1818 *Nautilus anceps* – Reinecke, p. 82, pl. 7, fig. 61.

1939 *Reineckeia anceps* Reinecke – Kuhn, p. 491, pl. 2, fig. 2.

1951 *Reineckeia anceps* Reinecke – Jeannet, p. 127, pl. 48, figs. 2–3.

1984 *Reineckeia* (*Reineckia*) *anceps* (Reinecke) – Cariou, p. 220, pl. 33, figs. 4–5, pl. 34, figs. 1–2, 5, pl. 35, figs. 1, 4–5.

1988 *Reineckeia* (*Reineckia*) *anceps* (Reinecke) – Cariou & Krishna, p. 160, pl. 2, figs. 2–3, pl. 3, fig. 1.

1995 *Reineckeia* (*Reineckia*) sp. ex gr. *R* (*R.*) *anceps* (Reinecke) – Seyed-Emami *et al.*, p. 43, pl. 2, fig. 1.

2002 *Reineckeia* (*Reineckia*) *anceps* (Reinecke) – Seyed-Emami *et al.*, p. 185, figs. 2–4.

**Material.** One specimen and one fragment from Golbini (GZN2011I-J-3-106-107) and one specimens and three fragments from Tooy (GZN2011I-S-3-122a-f), the first (J-3-106) is small (D = 27 mm); the second (S-3-122) is larger (D = 37 mm).

**Dimensions (in mm).**

Specimens	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-S-3-122 (incomplete phragmocone)	37	34	47	47	19	12	31
GZN2011I-J-3-106 (incomplete body chamber)	27	44	33	48	18	12	30

**Description.** A specimen with incomplete body chamber (J-3-106), and a specimen with incomplete phragmocone (J-3-122), moderately evolute, coronate *Reineckeia* with broad-oval to broad-rectangular whorl cross-section. Umbilicus shallow, low umbilical wall near-vertical with a distinct rounded shoulder. Ribbing relatively coarse. Slightly bullate and somewhat prorsiradiate primary ribs end at prominent and pyramidal lateral tubercles at one-third of the flank height, from where they trifurcate in a somewhat prorsiradiate manner. Seldom they quadrifurcate with some intercalatory ribs. The slightly incurved secondary ribs terminate at a smooth ventral band. Four prorsiradiate constrictions per whorl.

**Remarks.** With respect to the prominent conical tubercles and rather strict trifurcate secondaries, our specimens match well the inner whorls of *Reineckeia* (*Reineckeia*) *anceps* as figured by Cariou (1984, pl. 34, fig. 5; 1994, pl. 61, figs. 1–3), Jeannet (1951, pl. 48, figs. 2–3), and Kuhn (1939, pl. 2, figs. 2, 11, 15).

**Stratigraphic distribution.** Middle Callovian Anceps Zone (Cariou, 1984).

*Reineckeia* (*Reineckeia*) aff. *polycosta* Kuhn, 1939  
(Figure 8E–E')

aff. 1939 *Reineckeia polycosta* sp. nov. – Kuhn, p. 483, pl. II, fig. 24.

aff. 1984 *Reineckeia* (*Reineckeia*) cf. *polycosta* Kuhn – Cariou, p. 281, pl. 42, fig. 4.

**Material.** One specimen from Tooy with diameter 33 mm (GZN2011I-S-3-127).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-S-3-127 (incomplete phragmocone)	33	42	36	42	-	34

**Description.** A specimen with incomplete phragmocone, venter rounded and broad, broad-oval whorl cross-section, umbilicus shallow with a vertical wall. Bullate rectiradiate primary ribs ending at prominent, conical, and sharp lateral tubercles near the umbilical margin, from where they form trifurcate, seldom quadrifurcate and quinquefurcate bundles. Rectiradiate secondary ribs terminating at a ventral furrow. Four deep, prorsiradiate constrictions on the last visible whorl.

**Remarks.** The present specimen closely resembles the holotype figured by Kuhn (1939, pl. 2, fig. 24) but differ in the secondaries being rectiradiate, whereas in the holotype they are prorsiradiate. The specimen differ from the Cariou (1984) one in having sharper tubercles.

**Stratigraphic distribution.** Middle Callovian Anceps Zone (Cariou, 1984); the species is recorded for the first time from Iran.

*Reineckeia (Reineckeia) nodosa* Till, 1907  
(Figure 8D–D”)

1907 *Reineckeia nodosa* n. sp. – Till, p. 124.

1939 *Reineckeia nodosa* Till – Kuhn, p. 34, pl. II, fig. 14.

1975 *Reineckeia (Reineckeia) nodosa* Till – Hillebrandt & Gröschke, pl. 6, fig. 13

1984 *Reineckeia (Reineckeia) nodosa* Till – Cariou, p. 246, pl. 37, figs. 5–6.

2013 *Reineckeia (Reineckeia) nodosa* Till – Seyed-Emami et al., p. 55, 8k–1.

**Material.** Two specimens from Tooy with diameter 27 mm (GZN2011I-S-3-120-121).

**Dimensions (in mm).**

Specimens	D	U%	H%	W%	N	PR/2	SR/2
GZN2011I-S-3-120 (incomplete phragmocone)	27	44	33	55	11	6	25
GZN2011I-S-3-121 (incomplete phragmocone)	27	48	30	44	11	6	-

**Description.** Specimens with incomplete phragmocones, whorl cross-section oval, venter rounded and broad. Bullate, distant and prorsiradiate primary ribs ending at prominent and sharp tubercles at around mid-flank, from where they usually form quadrifurcate bundles. Prorsiradiate secondary ribs terminating at a ventral furrow. Three deep, prorsiradiate constrictions on the last visible whorl. Secondary ribs finer and denser than primaries.

**Remarks.** The present specimens resemble the holotype (Kuhn, 1939, pl. 2, fig. 14), and the material figured by Cariou (1984, pl. 37, figs. 5–6). However, the holotype exhibits nearly prorsiradiate ribs. *Reineckeia nodosa* differs from *R. (Reineckia) anceps* by its strong and coarse tubercles.

**Stratigraphic distribution.** Upper Callovian Athleta Zone, Collotiformis Subzone (Hillebrandt & Gröschke, 1975). *Reineckeia nodosa* ranges according to Cariou (1984) from late middle Callovian (upper Coronatum Zone) to early upper Callovian (Collotiformis Subzone).

cf. *Reineckeia* sp.  
(Figures 6D–D’, E; 8F–F’)

**Material.** Three incomplete specimens (GZN2011I-J-3-120, 121, 123), specimen J-3-120 with incomplete phragmocone and body chamber, specimens J-3-121, 123 with incomplete phragmocones.

**Description.** The specimens are the fragment of a large quadrate phragmocone, shell large, with a rectangular-oval whorl cross-section and a broad venter. Umbilicus shallow, with a steep wall. Ribbing coarse and very strong. Rectiradiate, bullate, distant and somewhat prorsiradiate primary ribs ending at prominent and pyramidal lateral tubercles at one-third of the flank height. From there the bullate secondaries bifurcate with single intercalatory ribs, crossing somewhat prorsiradiate over the venter. Prorsiradiate constrictions on the last visible whorl. Secondary ribs denser than primaries but equally moderately coarse. Towards the aperture, primaries distant and whorl height increasing. Ribbing on the last visible whorl (large specimen GZN2011I-J-3-120 is nearly fully grown) stronger and more distant than on earlier whorls (e.g. Figure 8F–F’).

**Stratigraphic distribution.** The present specimens come from the lower Callovian.

Family PERISPHINCTIDAE Steinmann, 1890  
Subfamily PROPLANULITINAE Buckman, 1921

*Hubertoceras* Spath, 1930

cf. *Hubertoceras* sp.  
(Figure 9A)

**Material.** One specimen from Tooy (GZN2011I-S-3-110).

**Description.** A specimen with incomplete body chamber, flanks flat, venter fairly narrow, whorl cross-section rounded, umbilicus shallow with vertical wall. Primaries strong and rectiradiate, dividing into two secondaries (some of the ribs do not divide) near mid-flank and crossing the venter. Ribbing denser at the posterior part of the last whorl. Ribs on inner whorls finer and denser than those on outer whorls. Primary and secondary ribs equally coarse.

**Stratigraphic distribution.** *Hubertoceras* has been recorded from the middle Callovian (Spath, 1930).

Subfamily PSEUDOPERISPHINCTINAE Schindewolf, 1925

*Loboplanulites* Buckman, 1925

*Loboplanulites* cf. *L. collociaris* (Quenstedt, 1887)  
(Figure 9E–E’)

cf. 1887 *Ammonites triplicatus colliciaris* sp. nov. – Quenstedt, p. 680, pl. 80, fig. 1.

**Material.** One fragment from Tooy (GZN2011I-S-3-54), [m].

**Description.** A crushed microconch specimen with incomplete phragmocone, shell moderately inflated, whorl cross-section nearly subrounded, umbilicus shallow. Strong, blunt primaries dividing at around two-thirds of the flank height into two slightly rursiradiate secondaries (some of the ribs do not divide) and crossing the venter. Primary and secondary ribs are equally coarse.

**Remarks.** The fragment described here differ from the holotype with respect to their slightly strong bullate ribs.

**Stratigraphic distribution.** The present fragment comes from the lower Callovian; the species is recorded for the first time from Iran.

*Choffatia* Siemiradzki, 1898

Subgenus *Choffatia* Siemiradzki, 1898

*Choffatia* (*Choffatia*) *sakuntala* Spath, 1931  
(Figures 4H, 9F)

1931 *Choffatia* (*Choffatia*) *sakuntala* sp. nov. – Spath, p. 351, pl. 48, fig. 4.

1970b *Choffatia* (*Choffatia*) *sakuntala* Spath – Mangold, p. 152, pl. 12, fig. 1, pl. 13, fig. 3.

**Material.** Two fragments from Tooy (GZN2011I-S-3-50-51), [M].

**Description.** Crushed specimens with incomplete phragmocones and body chambers, macroconchs, whorl cross-section ovate, venter broad, umbilicus moderately wide and deep, umbilical wall vertical. Ribbing on outer whorls stronger, coarser, and more distant than on inner whorls. Strong, coarse, distant primaries dividing at around three-fourth of flank height into two or three secondaries which, together with some intercalated ribs, cross the venter. Secondaries denser and fainter than the primaries. Towards the aperture, primaries distant and whorl height increasing.

**Remarks.** The fragments resemble the holotype (Spath, 1931, pl. 48, fig. 4), and the material figured by Mangold (1970b, pl. 13, fig. 3). The present specimens are considered to be macroconchs.

**Stratigraphic distribution.** Lower Callovian Gracilis Zone (Mangold, 1970b); the species is recorded for the first time from Iran.

*Choffatia kontkiewiczi* (Siemiradzki, 1894)  
(Figures 4I–I'; 9B, C–C', D–D')

1894 *Perisphinctes kontkiewiczi* sp. nov. – Siemiradzki, p. 513, pl. 38, figs. 3–4.

1931 *Grossouvreria* aff. *kontkiewiczi* (Siemiradzki) – Spath, p. 368, pl. 60, fig. 2, pl. 63, fig. 7.

1985 *Choffatia* (*Grossouvreria*) *kontkiewiczi* (Siemiradzki) – Schlegelmilch, p. 130, pl. 49, fig. 10.

2009 *Choffatia* (*Grossouvreria*) ex. gr. *kontkiewiczi* Siemiradzki – Schlögl et al., p. 69, fig. 7(11).

**Material.** 22 specimens and five fragments from Golbini (GZN2011I-J-3-194-200, 204-208, 210, 233), maximum diameter 79 mm and minimum 21 mm, generally 30 to 39 mm.

**Dimensions (in mm).**

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-210 (macroconchs, incomplete body chamber)	79	43	33	20	13	-
GZN2011I-J-3-195 (microconchs, incomplete body chamber)	36	45	34	17	15	-
GZN2011I-J-3-194 (microconchs, incomplete phragmocone)	38	49	35	22	18	41
GZN2011I-J-3-208 (microconchs, incomplete body chamber)	33	47	34	21	16	-
GZN2011I-J-3-196 (microconchs, incomplete body chamber)	30	47	30	27	17	-
GZN2011I-J-3-197 (incomplete phragmocone)	23	43	35	30	16	-
GZN2011I-J-3-199 (incomplete phragmocone)	21	48	29	27	18	-
GZN2011I-J-3-198 (incomplete phragmocone)	21	48	33	29	18	-
GZN2011I-J-3-200 (incomplete phragmocone)	15	49	35	33	15	-

**Description.** Macroconchs (J-3-210), including with incomplete body chamber and specimens (J-3-194-195, 208) microconchs with incomplete body chambers and other specimens (J-3-197-199, 200) with incomplete phragmocones, whorl cross-section subrounded, umbilicus shallow, umbilical wall nearly vertical. Blunt, strong, and slightly parabolic primaries dividing mainly at around three-fourth of the flank height into two or three secondaries which, together with some intercalated ribs, cross rursiradiate over the venter. Some of the primary ribs have a common origin close to the umbilical margin. Ribbing on inner whorls denser and more prorsiradiate than on outer whorls. Towards the aperture, primaries distant and whorl height increasing.

**Remarks.** Mangold (1970b, p.175) distinguished this species from others by its distinctly parabolic ribs. Morphological characters place these specimens between *C. (G.) kontkiewiczi kontkiewiczi* Siemiradzki (1894), *C. (G.) kontkiewiczi composita* Pfaehler-Erath (1938) and *C. (G.) kontkiewiczi incomposita* Pfaehler-Erath (1938).

**Stratigraphic distribution.** Upper part of the middle Callovian Coronatum Zone, Obductum Subzone (Mangold, 1970b); the species is recorded for the first time from Iran.

*Grossouvria* Siemiradzki, 1898*Grossouvria* sp.  
(Figure 10A–A')

**Material.** One specimen from Tooy with diameter 33 mm (GZN2011I-S-3-53).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-S-3-53 (incomplete phragmocone)	33	42	35	33	23	46

**Description and remarks.** A specimen with incomplete phragmocone, whorl cross-section rounded, umbilicus shallow with vertical wall, venter broad. Primaries dense and slightly prorsiradiate, starting at the umbilical margin, dividing into two secondaries near mid-flank, and crossing the venter. Primary and secondary ribs equally coarse, but the ribs on the inner whorls denser than those on the outer whorls. Three prorsiradiate and fairly deep constrictions on the last visible whorl.

**Stratigraphic distribution.** The present specimens come from the middle Callovian.

*Binatisphinctes* Buckman, 1921  
Subgenus *Okaites* Sasonov, 1961*Binatisphinctes* (*Okaites*) cf. *mosquensis* (Fischer, 1843)  
(Figure 10H)

cf. 1843 *Ammonites mosquensis* nov. sp. – Fischer, p. 110, pl. 3, figs. 4–7.

cf. 1898 *Perisphinctes mosquesis* Fischer – Siemiradzki, p. 104, pl. 21, fig. 13.

cf. 1970b *Binatisphinctes* (*Okaites*) cf. *mosquensis* (Fischer in Siemiradzki) – Mangold, p. 204, pl. 10, fig. 4.

cf. 1987 *Binatisphinctes* (*Okaites*) *mosquensis* Fischer – Meledina, p. 74, pl. 20, fig. 6, pl. 22, fig. 3, pl. 23, fig. 2.

**Material.** Two fragments from Golbini (GZN2011I-J-3-232, 225), the first (J-3-225) is small (D = 49 mm); the second (J-3-232) is larger (D = 57 mm).

**Dimensions (in mm).**

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-232 (incomplete phragmocone)	57	49	33	18	17	-
GZN2011I-J-3-225 (incomplete phragmocone)	49	45	35	20	16	-

**Description.** Specimens with incomplete phragmocones, whorl cross-section oval, umbilicus shallow with steep wall. Ribs irregular. Coarse, fine and rectiradiate primaries starting at the umbilical margin, dividing mainly into two rursiradiate ribs at around two-thirds of flank height, and crossing the venter. Some of the ribs do not divide. Secondary ribs finer

and denser than primaries. Ribbing on the last visible whorl increasingly distant.

**Remarks.** The present material is similar to the specimens described by Siemiradzki (1898, p. 104) and Meledina (1987, p. 74) but differs in having a narrow venter and in being of large size. The specimens can also be compared with Mangold (1970b) material.

**Stratigraphic distribution.** Upper part of the middle Callovian, Coronatum Zone and Obductum Subzone (Mangold, 1970b); the species is recorded for the first time from Iran.

*Indosphinctes* Spath, 1930Subgenus *Elatmites* Shevyrev, 1960*Indosphinctes* (*Elatmites*) cf. *revili* Mangold, 1970  
(Figure 10C)

cf. 1970b *Indosphinctes* (*Elatmites*) *revili* sp. nov. – Mangold, p. 111, pl. 7, fig. 2.

cf. 1985 *Indosphinctes* (*Elatmites*) *revili* Mangold – Schlegelmilch, p. 126, pl. 48, fig. 1.

**Material.** One fragment from Golbini with diameter 79 mm (GZN2011I-J-3-224).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-224 (incomplete body chamber)	64	43	33	15	12	70

**Description.** A specimen with incomplete body chamber, whorl cross-section high-ovate, flanks flat, venter fairly narrow, umbilicus shallow with the steep wall. Ribbing on inner whorls denser and more regular than on outer whorls. Primaries strong, coarse, distant and bullate up to about mid-flank but gradually fainting and splitting at around two-thirds of flank height into fine and dense secondaries which, together with some intercalated ribs, continue across the venter. One constriction is seen on the last visible whorl.

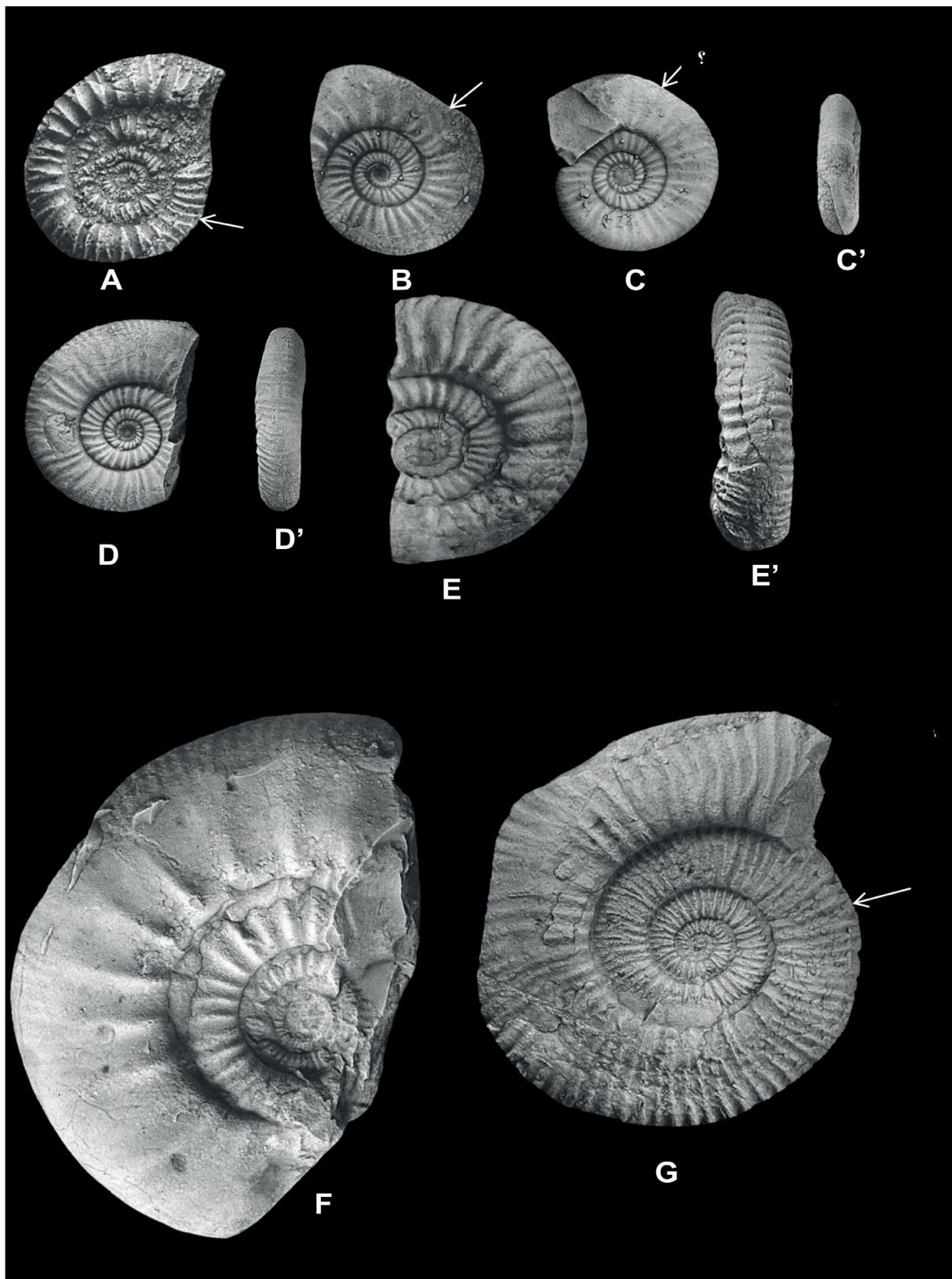
**Remarks.** The present fragment resembles the holotype of Mangold (1970b, pl. 7, fig. 2) but differs in being smaller and having slightly weaker primaries.

**Stratigraphic distribution.** Lower Callovian Gracilis Zone (Mangold, 1970b); the species is recorded for the first time from Iran.

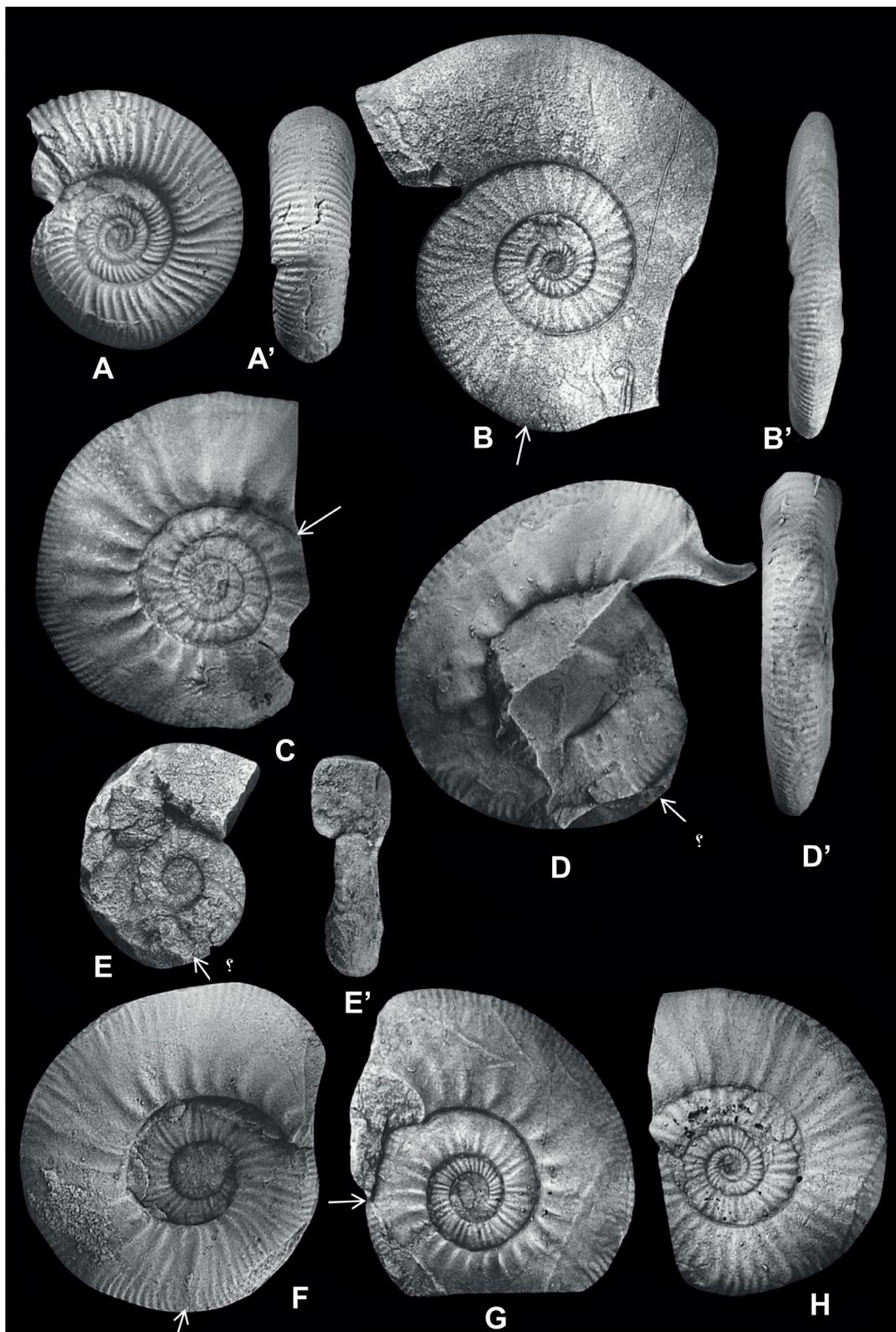
*Indosphinctes* (*Elatmites*) sp.  
(Figure 10B–B')

**Material.** One fragment from Golbini (GZN2011I-J-209).

**Description.** A crushed specimen with incomplete body chamber, flanks flat, venter narrow, umbilical wall steep. Ribbing denser and slightly prorsiradiate on inner whorls and irregular. Primaries distinct up to around one-third of flank height, then gradually fainting and dividing around two-thirds of flank height into secondaries which, together with some



**Figure 9.** A, cf. *Hubertoceras* sp. (GZN2011I-S-3-110), a phragmocone with incomplete body chamber, Tooy section, Middle Callovian. B, C-C', D-D', *Choffatia (Grossouvreria) kontkiewiczi* (Siemiradzki), phragmocone of a microconch [m], Golbini section, Coronatum Zone. B, specimen GZN2011I-J-3-195, a phragmocone with incomplete body chamber; C-C', specimen GZN2011I J-3-208, a phragmocone with incomplete body chamber; D-D', specimen GZN2011I-J-3-194 with incomplete phragmocone. E-E', *Loboplanulites* cf. *collociaris* (Quenstedt) (GZN2011I-S-3-54) with incomplete phragmocone, Tooy section, lower Callovian, phragmocone of a microconch [m], x1.5. F, *Choffatia (Choffatia) sakuntala* (Spath), phragmocone of a macroconch [M], (GZN2011I-S-3-50), Tooy section, Gracilis Zone. G, *Parawedekindia callomonii* (Sapunov) (GZN2011I-S-3-58), a phragmocone with incomplete body chamber, Tooy section, upper Callovian. Dimensions in the text.



**Figure 10.** **A–A'**, *Grossouvia* sp. (GZN2011I-S-3-53) with incomplete phragmocone, Tooy section, Middle Callovian, x1.5. **B–B'**, *Indosphinctes* (*Elatmites*) sp. (GZN2011I-J-3-209), a phragmocone with incomplete body chamber, Golbini section, Middle Callovian. **C**, *Indosphinctes* (*Elatmites*) cf. *revili* (Mangold) (GZN2011I-J-3-224), a phragmocone with incomplete body chamber, Golbini section, Gracilis Zone. **D–D'**, **F–G**, *Flabellisphinctes* (*Flabellia*) *tsytovitchae* (Mangold), Golbini section, Coronatum Zone. **D–D'**, specimen GZN2011I J-3-226, a phragmocone with complete body chamber and lappet [m]. **F**, specimen GZN2011I-J-3-218, a phragmocone of a microconch with incomplete body chamber [m]. **G**, specimen GZN2011I-J-3-219, a phragmocone of a microconch with nearly complete body chamber [m]. **E–E'**, *Peltoceras* sp. (GZN2011I-S-3-117), a phragmocone of a microconch with incomplete body chamber, Tooy section, Upper Callovian. **H**, *Binatisphinctes* (*Okaites*) cf. *mosquensis* (Siemiradzki) (GZN2011I-J-3-232) with incomplete phragmocone, Golbini section, Coronatum Zone. Dimensions in the text.

intercalated ribs, continue towards the venter. Primary and secondary ribs equally coarse. Towards the aperture, primaries distant and whorl height increasing.

**Remarks.** *Indosphinctes* was proposed by Spath (1930) for a group of perisphinctids from the Callovian of Cutch and India.

**Stratigraphic distribution.** The subgenus is known from the middle Callovian (Mangold, 1970b).

*Flabellisphinctes* Mangold, 1970

Subgenus *Flabellia* Mangold, 1970

*Flabellisphinctes (Flabellia) tsyrovitchae* Mangold, 1970

[m]

(Figures 10D–D', F–G)

1938 *Grossouvria curvicosta* (Oppel) var. *variabilis* (Lahusen) – Pfahl-Erath, p. 10, pl. 1, fig. 7.

1970b *Flabellisphinctes (Flabellia) tuberosus* sp. nov. – Mangold, p. 196, pl. 15, fig. 3, pl. 16, figs. 3–4.

1970b *Flabellisphinctes (Flabellia) tsyrovitchae* sp. nov. – Mangold, p. 195, pl. 16, figs. 7–8.

2009 *Flabellisphinctes (Flabellia) tsyrovitchae* Mangold – Schlögl et al., p. 69, fig. 7(1).

**Material.** Seven specimens and three fragments from Golbini (GZN2011I-J-3-218-228), maximum diameter 72 mm and minimum 47 mm, generally 63 to 69 mm.

#### Dimensions (in mm).

Specimens	D	U%	H%	W%	PR/2	SR/2
GZN2011I-J-3-226 (microconch with lappet)	69	41	31	20	9	51
GZN2011I-J-3-218 (microconch, incomplete body chamber)	63	40	33	23	13	52
GZN2011I-J-3-219 (microconch, nearly complete body chamber)	65	41	35	14	11	-
GZN2011I-J-3-223 (microconch, incomplete body chamber)	72	35	37	22	10	-
GZN2011I-J-3-227 (microconch, incomplete body chamber)	69	42	29	20	10	-
GZN2011I-J-3-221 (incomplete phragmocone)	51	43	33	16	13	-
GZN2011I-J-3-228 (incomplete phragmocone)	47	40	34	15	9	-

**Description.** An adult microconch with complete body chamber and aperture (J-3-226), an adult specimen and microconch with nearly complete body chamber (J-3-219), specimens (J-3-218, 223, 227) with incomplete body chambers, and specimens (J-3-221, 228) with incomplete

phragmocone, whorl cross-section oval, flanks flat, umbilicus shallow with the steep wall. Primaries on outer whorls coarse, strong and bullate mainly up to one-fourth of flank height and rarely up to mid-flank, then gradually vanishing. Primary ribs starting at the umbilical margin, dividing into fine and dense secondary ribs with some intercalated ribs at around three-fourth of flank height, and thereafter crossing the venter. Towards the aperture primaries are strong and distant.

**Remarks.** Mangold (1970b) introduced *Flabellisphinctes (Flabellia) tuberosus* and *F. (Flabellia) tsyrovitchae*, mentioning as a distinguishing feature between the two species the more evolute nature and stronger ribs at the umbilical margin of the former. However, this difference is very small, and it appears more appropriate to regard the two as variants of one species, i.e. *Flabellisphinctes (Flabellia) tsyrovitchae*. Specimen GZN2011I-J-5-226 exhibits on the last whorl a constriction with lappet and, therefore, is a microconch. *Flabellisphinctes (Flabellia) tsyrovitchae* differs from *F. (Flabellia) lineatus* Mangold (1970), in being more evolute and having strong ribs at the umbilical margin.

**Stratigraphic distribution.** Upper part of middle Callovian, Coronatum Zone and Obductum Subzone (Mangold, 1970b), the species is recorded for the first time from Iran.

Family ASPIDOCERATIDAE Zittel, 1895  
Subfamily PELTOCERATINAE Spath, 1924

*Parawedekindia* Schindewolf, 1925

*Parawedekindia callomoni* Sapunov, 1979  
(Figure 9G)

1979 *Parawedekindia callomoni* sp. nov. – Sapunov, p. 154, pl. 47, fig. 5.

**Material.** One specimen from Tooy with diameter 82 mm (GZN2011I-S-3-58).

#### Dimensions (in mm).

Specimen	D	U%	H%	W%	PR/2	SR/2
GZN2011I-S-3-58 (incomplete body chamber)	80	45	34		21	35

**Description.** A specimen with incomplete body chamber, whorl cross-section oval, umbilicus shallow with a vertical wall. Primary ribs strong, coarse and rursiradiate, dividing near umbilical margin into two convex secondaries that cross straight over the venter. Ribs on inner whorls finer and denser than those on outer whorls. Primary and secondary ribs equally coarse.

**Remarks.** The present species is easily distinguished from other species of the genus by its fine and dense ribs on the inner whorls. The specimen is slightly smaller than the holotype of Sapunov (1979, pl. 47, fig. 5).

**Stratigraphic distribution.** According to Sapunov (1979), *Parawedekindia callomoni* occurs in the ?lower or ?middle Oxfordian. However, the present specimen comes from the Upper Callovian; the species is recorded for the first time from Iran.

*Peltoceras* Waagen, 1871

*Peltoceras* sp.  
(Figure 10E–E')

**Material.** One specimen from Tooy with diameter 42 mm (GZN2011I-S-3-117).

**Dimensions (in mm).**

Specimen	D	U%	H%	W%
GZN2011I-S-3-117 (incomplete body chamber)	42	37	35	35

**Description.** A specimen with incomplete body chamber, the poorly preserved specimen has a distinctly rectangular whorl cross-section and a broad venter. There are spines at the venter shoulder. The inner whorls are depressed and carry fine ribs.

**Stratigraphic distribution.** The present specimens come from the upper Callovian.

### BIOSTRATIGRAPHIC AND PALEOBIOGEOGRAPHIC REMARKS

The Callovian sedimentary succession in the Dalichai Formation is widely distributed and superbly exposed in the Alborz Mts., and contains an abundant fauna of Callovian ammonites. The latest Bathonian and early Callovian time interval is characterized by the presence of *Macrocephalites* and *Bullatomorphites*. In other words, the early Callovian (Bullatus and Gracilis zones) is indicated by the presence of *Bullatomorphites* (*Bomburites*) cf. *microstoma* and *Macrocephalites* (*Macrocephalites*) *jacquoti* for the Bullatus Zone and *Reineckeia* (*Tyrannites*) *convex*, *Choffatia* (*Choffatia*) *sakuntala*, and *Indosphinctes* (*Elatmites*) cf. *revili* for the Gracilis Zone.

The Bathonian–Callovian boundary is defined at the base of the *Bullatus* (*jacquoti*) Biohorizon. Infrazonational biostratigraphic units of the Bathonian–Callovian boundary interval established in the section are of the wide geographic distribution and high correlation potential in the Panboreal Superrealm, i.e., in European Russia, northern Caucasus, West Europe, East Greenland and in the Tethyan Super-realm, the adjacent European areas inclusive (*Jacquoti* Biohorizon) Kiselev *et al.* (2007).

The middle Callovian Anceps and Coronatum zones are documented, apart from *Choffatia kontkiewiczi*, *Binatisphinctes* cf. *mosquensis*, and *Flabellisphinctes* (*Flabellia*) *tsytovitiae*, in particular by some species of *Hecticoceras*, *Rehmannia*, and *Reineckeia* [e.g. *Hecticoceras* (*Lunuloceras*) cf. *lunuloides*, *H.* (*Putealiceras*) *metomphalum*, *Rehmannia* (*Loczyceras*) cf. *hungarica*, and *R.* (*Loczyceras*) *sequanica*]. The Middle Callovian contains numerous and diverse Ammonitina, composed mainly of Hecticoceratinæ and Reineckeiidæ. First, the presence of the subgenus *Flabellia* indicates the Coronatum Zone of upper middle Callovian Mangold (1970a). Second, *C.* (*G.*) *kontkiewiczi* *kontkiewiczi* is also typical of this zone, more precisely of the Baylei Subzone (although it appears already in the uppermost

Anceps Zone) (Schlögl *et al.*, 2009). The stratigraphic ranges of hecticoceratid ammonites based on studies of Zeiss (1956), Lemine (1932), and Elmi (1967) mainly indicate a time span from the Anceps Zone up to the Athleta zones.

The latest Callovian and early Oxfordian represent one of the most dynamic intervals in the history of Jurassic Ammonoidea, and is characterized by one of the highest levels of mixing of Boreal, Submediterranean and even Mediterranean faunas (Page *et al.*, 2009). The late Callovian is indicated by the presence of *Reineckeia* (*Reineckeia*) *nodosa*, indicative of the Athleta Zone, and of *Pachyceras lalandei* of the Lamberti Zone.

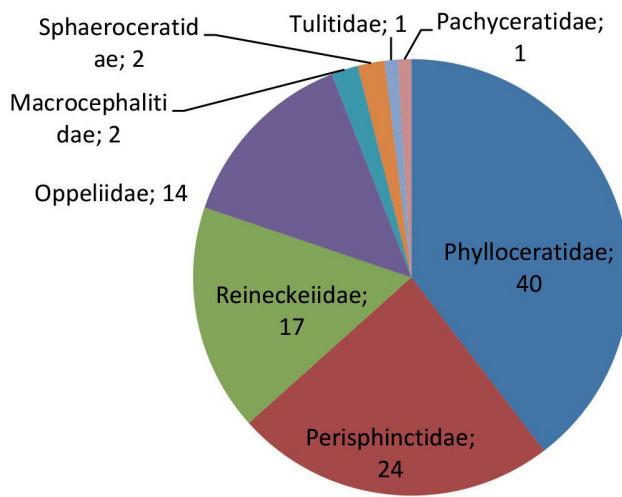
Quantitative and qualitative distributions show that Reineckeidiæ and Hecticoceratinæ include the 17% and 14% respectively of the whole Callovian age ammonite fauna, the most abundant being in the Anceps Zone. Reineckeidiæ and Hecticoceratinæ accord with the biostratigraphic Subtethyan Province distribution (Sequeiros *et al.*, 1986). Reineckeidiæ and Oppeliidae are more abundant in the middle Callovian (Anceps Zone) than in the lower and upper Callovian in this area.

Paleobiogeographically, the Callovian ammonite fauna of the Dalichai Formation has a typical Northwest-Tethyan character, and belong to the Submediterranean faunal province (Seyed-Emami *et al.*, 2013), and are largely dominated by Phylloceratidae ammonites. These pelagic taxa that preferred open oceanic conditions are accompanied consistently by Perisphinctidae, Reineckeidiæ, Oppeliidae (Hecticoceratinæ), Macrocephalitidae, Tulinidae, Aspidoceratidae (*Parawedekindia*, *Peltoceras*).

On the other hand, this is supported by the occurrence of Submediterranean ammonites such as *Macrocephalites*, *Pachyceras*, and some cosmopolitan taxa such as *Hecticoceras* and *Reineckeia*. Furthermore, according to Page (2008), Schrögl *et al.* (2009) and Seyed-Emami & Schairer (2011), the typical Mediterranean Reineckeidiæ appears in large numbers and high diversity in the Alborz. Moreover, paleogeographic reconstructions place the Iranian platform at latitude of 30°N during the Jurassic, which is equivalent to European areas situated at the southern margin of Eurasia (e.g. Enay & Cariou, 1997).

### FINAL REMARKS

The most abundant ammonite families within the investigated sections of the Dalichai Formation are Phylloceratidae (40%), Perisphinctidae (24%), Reineckeidiæ (17%), Oppeliidae (14%), Sphaeroceratidae (2%), Macrocephalitidae (2%), Tulinidae (1%), and Pachyceratidae (1%) (Figure 11). During the early Callovian, the number of ammonite taxa decreased, which can be related to a sea-level fall. In the middle Callovian, the families Phylloceratidae, Oppeliidae, and Reineckeidiæ are most abundant. Besides numerous taxa of these families, also Perisphinctidae occur. This pattern agrees well with the Jurassic global sea-level curve (e.g. Hallam, 2001), which indicates a major eustatic sea-level rise during the middle Callovian. In the



**Figure 11.** Relative abundances of Callovian ammonite families at the studied sections.

late Callovian, in contrast, the diversity and number of the ammonite families Reineckeidae (*Reineckea nodosa*, two specimens), Pachyceratidae (*Pachyceras*, 1 specimen), Aspidoceratidae (*Parawedekindia*, one specimen; *Peltoceras*, one specimen) is reduced, indicating again a sea-level fall (e.g. Seyed-Emami *et al.*, 2013).

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