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Article

Late Jurassic (Oxfordian, Bimammatum Zone) ammonites from the eastern Alborz Mountains, Iran

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With 8 figures

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Abstract: From the Upper Jurassic Lar Formation northeast of Jajarm, eastern Alborz, 14 taxa of ammonoids are described. These belong to the following families: Phylloceratidae, Oppeliidae, Glochiceratidae, Perisphinctidae and Aspidoceratidae, most of them recorded for the first time from Iran. The ammonite fauna is Late Oxfordian, Bimammatum Zone, in age. Palaeobiogeographically, the Late Jurassic ammonite fauna of North Iran is closely related to those from epicontinental seas, bordering the northern margins of the western Tethys, intermediate to Mediterranean and Submediterranean provinces. The high percentage of Phylloceratina, occasionally exceeding 50 % of the fauna, indicates a relatively deep marine environment and to some extent closer relations to the Mediterranean Province.

Key words: Ammonites, Upper Jurassic, Oxfordian, Lar Formation, Alborz Mountains, Iran.

1. Introduction

The Upper Jurassic in the Alborz Mountains consists predominantly of light, medium- to thick-bedded, cliff-forming limestone and dolomite with thicknesses of several hundred meters. Towards the eastern Alborz and along the Koppeh Dagh Range (Basin) the thicknesses increase and also the lithology changes to some extent. Consequently, a separate unit, the Mozduran Formation, was defined for this area (Afshar-Harb 1994).

A rather complete and well-exposed section of Jurassic strata (Shemshak, Dalichai and Lar formations) crops out in the study area north of Kuh-e-Zoo (Kuh-e-Ozom) and on the southern flank of Kuh-e-Zirkamar (Kuh-e-Kurkhud Quadrangle), north of the small town Jajarm (Fig. 1). The lithological composition of the Middle and Upper Jurassic strata at these outcrops is somewhat intermediate between those found in the Eastern Alborz and the Koppeh Dagh Basin to the north (Fig. 2).

In the study area, the Upper Jurassic Lar Formation follows continuously on the Middle Jurassic marls and limestones of the Dalichai Formation and is overlain discontinuously by the red siliciclastics (siltstones, sandstones and conglomerates) of the Shurijeh Formation (?Neocomian) (Fig. 3). The Lar Formation is predominantly composed of light-grey to cream and occasionally pink, medium to thick-bedded and dense limestones with marl intercalations in the lower part. On the whole, a lower, softer member, consisting of thin- to medium-bedded limestones with marly intercalations and an upper member of thick-bedded and cliff-forming limestones can be distinguished (Fig. 4). Occasionally, some beds contain a rich ammonite fauna (Fig. 5).

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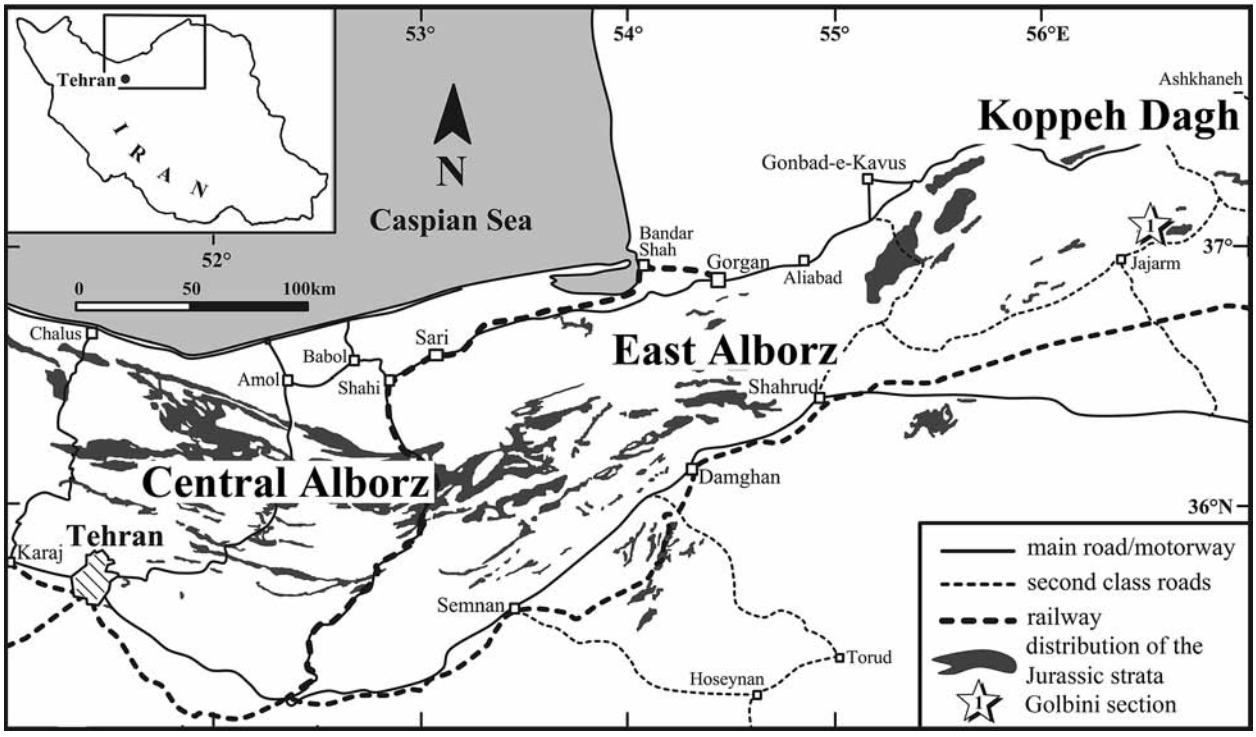

Fig. 1. Geographic map of North Iran (Alborz and Koppeh Dagh Mountain Range). The study section at Golbini, north of Jajarm is indicated by [1].

The studied ammonite fauna comes from the lower part of the Upper Jurassic strata (Lar Formation) northeast of Jajarm and has been collected during several visits to the area in 1997 and 2003 together with M. R. MAJIDIFARD, M. MOHAMMADI MONFARED, F. T. FÜRSICH, and M. WILMSEN. The exact site of the section is in a north-south directed valley north of Golbini, at the southern slope of the Reshteh-e-Zirkamar mountain range, ca. 16 km northeast of the small town Jajarm, with the coordinates: N 37° 05' 13", E 56° 44' 41". According to MAJIDIFARD (2003), the Lar Formation at this locality has a thickness of 414 m, ranging from the Oxfordian to the Tithonian. However, according to our subdivision, the Lar Formation has a thickness of ca. 500 m at the studied section (Fig. 3).

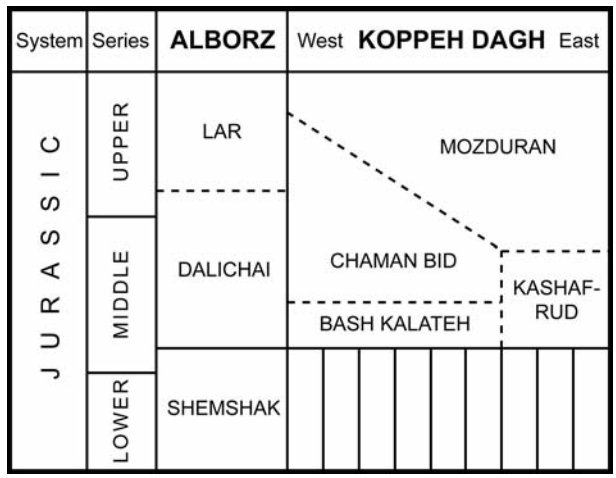

Fig. 2. Lithostratigraphic units (formations) of the Jurassic System in the Alborz and Koppeh Dagh basins.

2. Previous records of Oxfordian ammonites from North Iran (Alborz and Koppeh Dagh)

BOGDANOVITCH (1890) was the first researcher to report on Late Jurassic ammonites from eastern Alborz. From the Oxfordian, he recorded "*Perisphinctes* aff. *plicatilis* SOWERBY", later identified as *Orthosphinctes* (*Orthosphinctes*) *tiziani* (OPPEL) by ENAY (1966). Subsequently, the following Oxfordian ammonites were described from northern Iran:

DOUVILLÉ (1904): Oxfordian; Central Alborz:

Ochetoceras canaliculatum (BUCH)

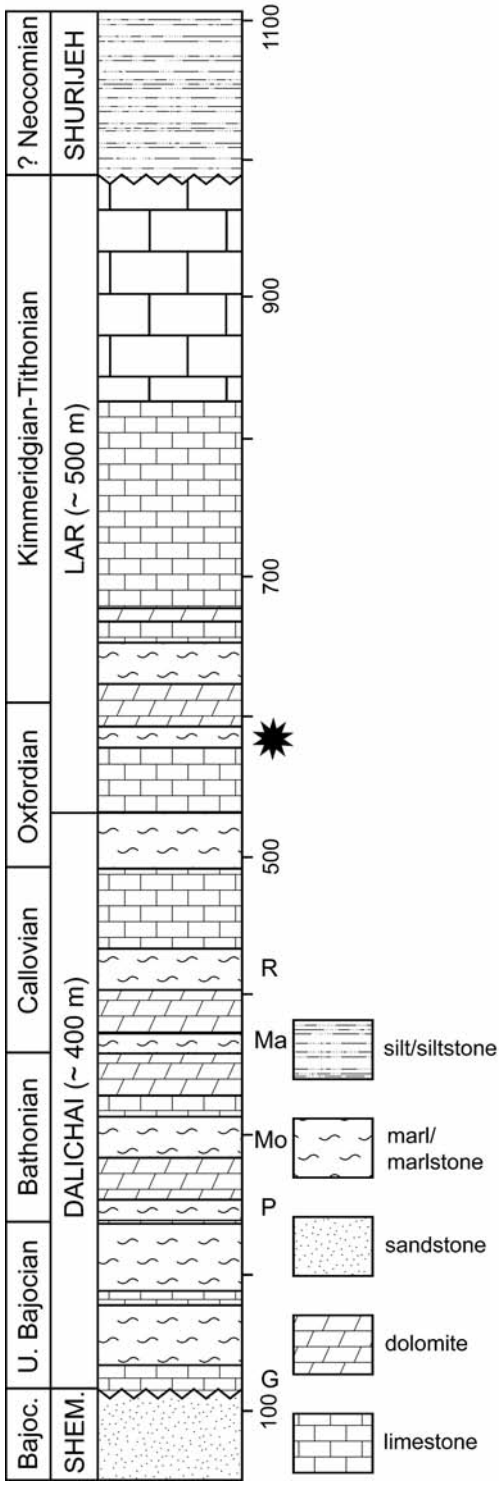

Fig. 3. Idealized stratigraphic log of the Lar Formation at Golbini; modified from MAJIDIFARD (2003).
G = *Garantiana*, P = *Parkinsonia*, Mo = *Morphoceras*, Ma = *Macrocephalites*, R = *Reineckeia*. The sampling horizon of the described ammonites is indicated by an asterisk (*).

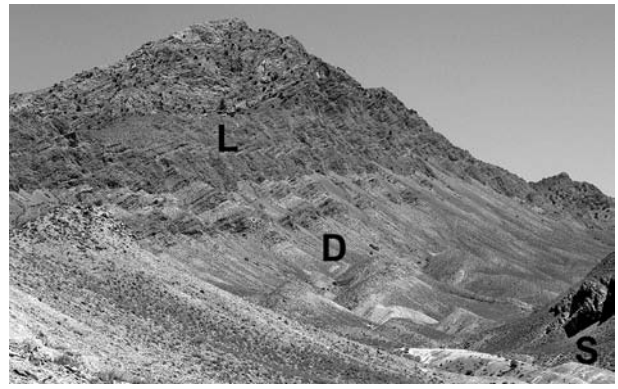

Fig. 4. View of the Kuh-e-Zirkamar mountain, north of Jajarm, north of Golbini (from south to north). The picture shows the Shemshak Formation (S) in the front, the Dalichai Formation (D) in the middle part, and the Lar Formation (L) in the background.

Fig. 5. The collection site of the ammonite fauna in the lower part of the Lar Formation.

Perisphinctes (Discosphinctes) aff. *lucingensis* FAVRE FISCHER (1915) studied the Jurassic fossils collected by STAHL (1897): Oxfordian; Central and East Alborz:

Taramelliceras cf. *culminis* (FONTANNES)
Taramelliceras flexuosum (BUCH)
Perisphinctes mogosensis CHOFFAT [corresponds to *Orthosphinctes* (*O.*) *fischeri* n. sp., according to FANTINI SESTINI & ASSERETO (1970)]
Perisphinctes rhodanicus DUMORTIER
Perisphinctes alterneplicatus WAAGEN [corresponds to *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ according to FANTINI SESTINI & ASSERETO (1970)]
Perisphinctes morgani FISCHER

Perisphinctes obliqueplicatus Fischer
Perisphinctes pleuricus Fischer
Euaspidoceras sp.

Fantini Sestini (1968): Lower Oxfordian; Central Alborz:
Sowerbyceras helios (Noetling)
Taramelliceras (*Proscaphites*) *globosum* (de Loriol)
Creniceras renggeri (Oppel)
Perisphinctes (*Properisphinctes*) *bernensis* de Loriol
P. (*Properisphinctes*) *filicostatus* Haas
P. (*Properisphinctes*) *trapezoidalis* Haas
P. (*Properisphinctes*) *vicinus* Haas

Fantini Sestini & Assereto (1970): Upper Oxfordian; Central Alborz:
Ochetoceras canaliculatum (Buch)
Taramelliceras (*Proscaphites*) cf. *anar* (Oppel)
Perisphinctes (*Perisphinctes*) sp.
Perisphinctes (*Otosphinctes*) sp.
Perisphinctes (*Dichotomoceras*) sp.
Orthosphinctes (*Orthosphinctes*) *fischeri* n. sp.
Orthosphinctes (*Orthosphinctes*) cf. *laufenensis* Siemiradzki
Orthosphinctes (*Orthosphinctes*) *polygyratus* (Reinecke)
Orthosphinctes (*O.*) *virgulatus* (Quenstedt)
Lithacoceras (*Larcheria*) sp.
L. (*Discosphinctes*) sp.
Euaspidoceras sp.

Alavi-Naini (1972): Oxfordian; Kuh-e-Sharaf northeast of Semnan, eastern Alborz:
Perisphinctes (*Dichotomosphinctes*) *luciae* de Riaz
Perisphinctes (*Dichotomosphinctes*) gr. *wartae* Bukowski
Perisphinctes (*Otosphinctes*) cf. *pulvinus* Enay
Orthosphinctes (*Orthosphinctes*) gr. *tiziani* Oppel
Orthosphinctes (*Orthosphinctes*) cf. *tiziani pseudoplicatilis* Siemiradzki

Mohammadi Monfared (1997): Oxfordian; Kuh-e-Sharaf, northeast of Semnan, eastern Alborz:
Sowerbyceras sp.
Perisphinctes spp.
Perisphinctes bernensis de Loriol
Perisphinctes (*Dichotomosphinctes*) sp.
Perisphinctes (*Dichotomoceras*) sp.
Perisphinctes (*Discosphinctes*) sp.
Epipeltoceras sp.
Euaspidoceras sp.

Seyed-Emami et al. (1998): Oxfordian; Lar and Mozduran formations, central/east Alborz and Koppeh Dagh Basin of northern Mashhad:
Taramelliceras (*Taramelliceras*) *costatum* (Quenstedt)
Taramelliceras (*Strebliticeras*) *externnodosum* (Dorn)
Mirosphinctes hiemeri (Oppel)
Epipeltoceras sp.
Euaspidoceras douvillei (Collot).

Schairer et al. (1999): Oxfordian; central Koppeh Dagh:
Subdiscosphinctes sp.
cf. *Dichotomosphinctes* sp.

Majidifard (2003): Oxfordian; eastern Alborz (Lar Formation at Golbini) and the Koppeh Dagh (Chaman Bid and Mozduran formations) (Phylloceratidae are not listed here):
Lissoceratoides sp.
Eochetoceras sp.
Ochetoceras marantianum (d'Orbigny)
Ochetoceras semifalcatum (d'Orbigny)
Taramelliceras (*Taramelliceras*) aff. c*ostatum* (Quenstedt)
Taramelliceras (*Proscaphites*) cf. *dentostriatum* (Quenstedt)
Taramelliceras (*Proscaphites*) *anar* (Oppel)
Taramelliceras (*Richeiceras*) sp.
Cardioceras (*Scarburgiceras*) *praecordatum* (Douvillé)
Geyssantia geyssanti Meléndez
Geyssantia sp.
Perisphinctes (*Dichotomosphinctes*) *buckmani* (Arkell)
Perisphinctes (*Dichotomosphinctes*) sp. A
Perisphinctes (*Dichotomosphinctes*) sp. B
Perisphinctes (*Dichotomoceras*) *bifurcatus* (Quenstedt)
Perisphinctes (*Dichotomoceras*) cf. *microplicatilis* (Quenstedt)
Perisphinctes (*Dichotomoceras*) cf. *bifurcatoides* Enay
Perisphinctes (*Dichotomoceras*) sp.
Larcheria schilli (Oppel)
Idoceras (*Subnebrodites*) *schroederi* Wegele
Passendorferia (*Enayites*) sp.
Subdiscosphinctes sp.
Parawedekindia stephanovi Sapunov
Epipeltoceras cf. *berrense* (Favre)
Pseudowaagenia tietzei Neumayr
Externnodites sp.
Euaspidoceras hypselum (Oppel)

3. Systematic palaeontology

The following measurements are provided: diameter (D) in mm; umbilical width (U), whorl height (H), whorl width (W), all in % of diameter; number of primary ribs per half whorl (UR/2), and number of secondary ribs (SR).

The herein studied ammonite fauna is deposited provisionally in the collections of the Bayerische Staatssammlung für Paläontologie und Geologie (BSPG) in Munich, Germany.

Order Ammonoidea Zittel, 1884
Suborder Phylloceratina Arkell, 1950
Family Phylloceratidae Zittel, 1884
Genus *Sowerbyceras* Parona & Bonarelli, 1895

Sowerbyceras tortisulcatum (d'Orbigny, 1841)
Fig. 6a, b

1994 *Sowerbyceras tortisulcatum* (d'Orbigny, 1841). – Atrops (in Fischer), p. 165, pl. 73, figs. 3a, b; 4a, b. [includes detailed remarks on taxonomy]
1997 *Sowerbyceras tortisulcatum* (d'Orbigny). – Schweigert & Callomon, p. 25, pl. 4, fig. 3.

Material: Three compressed and eroded specimens from Golbini: Gol. 1-3.

Dimensions:	D	U	H	W
Gol. 1	46	21	-	-

Description: All three specimens are crushed and strongly eroded internal moulds. These are smooth and relatively evolute Phylloceratidae, with flattened sides and sigmoid constrictions (3-4 per whorl), being flared on the venter. Umbilical border is rounded, umbilical wall oblique to steep.

Discussion: *Sowerbyceras* is a very frequent element in the Upper Jurassic of Alborz as well as at Golbini section, occasionally accounting for more than 50% of the fauna (Majidifard 2003).

Age: According to Atrops (1994: 165) the stratigraphic range of *S. tortisulcatum* is Oxfordian. Schweigert & Callomon (1997, pl. 4, fig. 3) figured a specimen of this species from the Upper Oxfordian Hauffianum Subzone, *bauhini* Horizon, of the Swabian Jurassic, Southern Germany.

Family Oppeliidae Bonarelli, 1894
Subfamily Taramelliceratinae Spath, 1928
Genus *Taramelliceras* Del Campana, 1904
Subgenus *Taramelliceras* Del Campana, 1904

Taramelliceras (*Taramelliceras*) *costatum* (Quenstedt, 1849)
Fig. 6c, d

* 1849 *Ammonites flexuosus costatus*. – Quenstedt, pl. 9, fig. 4.
1955 *Taramelliceras* (*Taramelliceras*) *costatum* (Quenstedt). – Hölder, p. 95, pl. 17, pl. 18, figs. 17-18; text-fig. 5/63-68.
1994 *Taramelliceras* (*T.*) *costatum* (Qu. 1849). – Schlegelmilch, p. 35, pl. 8, fig. 10.
1998 *Taramelliceras* (*Taramelliceras*) *costatum* (Quenstedt). – Seyed-Emami et al., p. 100, pl. 1, fig. 3.
? 2003 *Taramelliceras* (*Taramelliceras*) aff. *costatum* (Quenstedt, 1849). – Majidifard, p. 93, pl. 3, figs. 7-8.

Material: Four specimens from Golbini: Gol. 8-11.

Description: Gol. 9 (Fig. 6d) is a compressed but fairly well preserved specimen with a diameter of ca. 97 mm. It is involute, with high-ovate whorls in cross section. The greatest whorl cross section is positioned at about the mid-flank, from where it inclines towards the umbilicus. The ribbing is rather fine and dense, falcoid to biconcave, with strong marginal and less strong lateral clavi. Alternately, there are stronger ribs, beginning at the umbilicus and fainter intercalate ribs, beginning somewhat higher up on the flank. Irregularly, some ribs bifurcate at the lateral nodes on the mid-flank. Towards the marginal area the ribs become slightly broader and end ventrolaterally at small tubercles. Some ribs end at marginal clavi, where they are looped.

Discussion: Our specimens belong to the variety-group of *T.* (*T.*) *costatum* in Hölder (1955). The specimens Gol. 8 and Gol. 9 can be best compared to *T.* (*T.*) *costatum* forma *aurita* (Quenstedt) in Hölder (1955: 98, figs. 5/64, 5/66; pl. 17, figs. 9, 11). The ribbing on the inner whorls of the specimen Gol. 8 closely resembles the pattern seen in Gol. 9, but on the outer whorl the marginal clavi of Gol. 8 are stronger and more distant.

Subfamily Ochetoceratinae Spath, 1928
Genus *Glochiceras* Hyatt, 1900

Glochiceras sp.
Fig. 6e

Material: A single internal mould from Golbini: Gol. 4.

Description: The eroded and one-sided preserved specimen has a diameter of 22 mm. It is a full-grown specimen with a long and narrow lappet. Probably because of corrosion, no ribbing pattern can be observed. An extremely week lateral canal exists on the latest portion of the body whorl, just reaching up to the lappet. The external side is not visible.

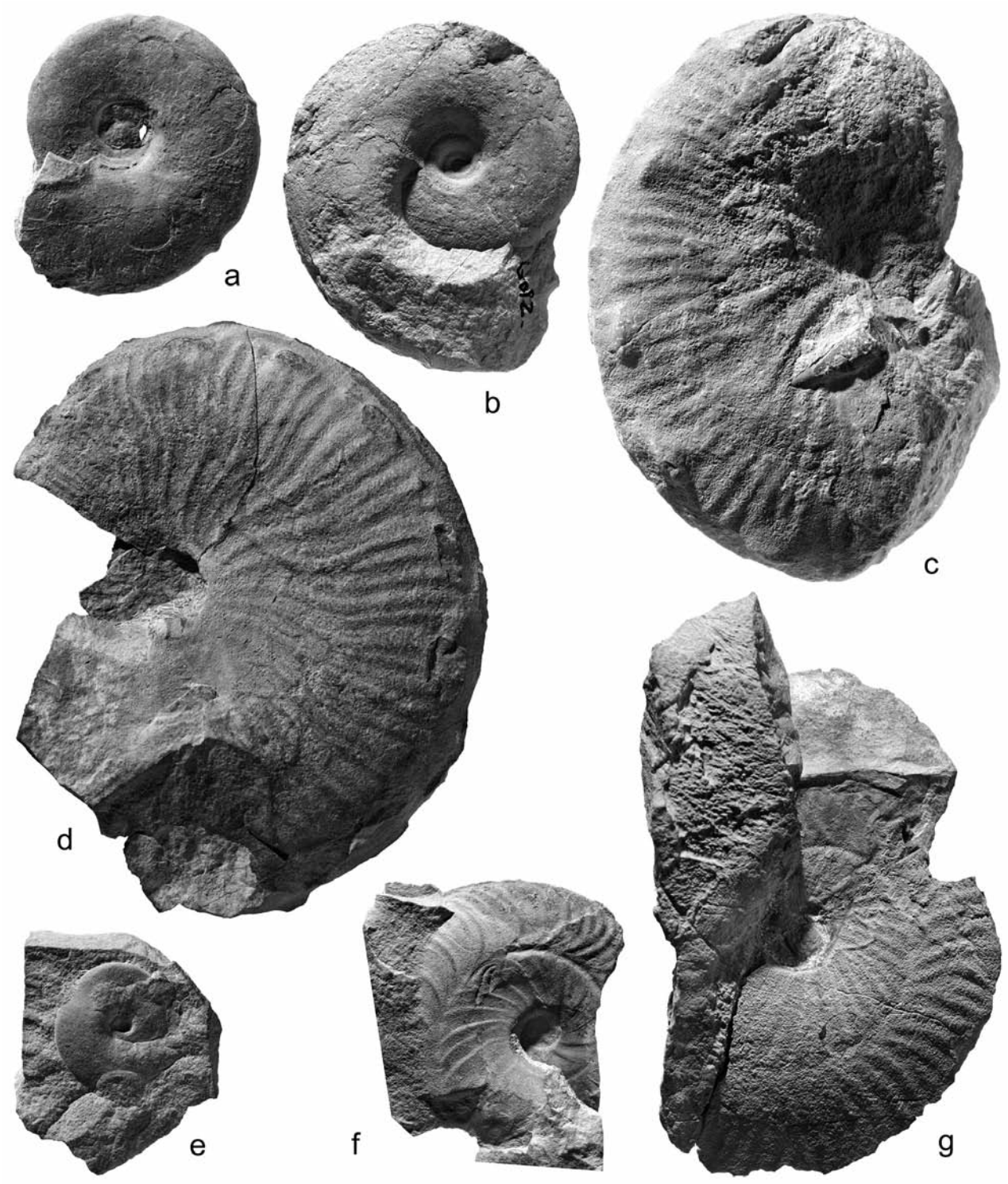

Fig. 6. **a** – *Sowerbyceras tortisulcatum* (D'ORBIGNY); Golbini, Gol.1. **b** – *Sowerbyceras tortisulcatum* (D'ORBIGNY); Golbini, Gol. 2. **c** – *Taramelliceras* (*Taramelliceras*) *costatum* (QUENSTEDT); Golbini, Gol. 8. **d** – *Taramelliceras* (*Taramelliceras*) *costatum* (QUENSTEDT); Golbini, Gol. 9. **e** – *Glochiceras* sp.; Golbini, Gol. 4. **f** – *Ochetoceras* sp.; Golbini, Gol. 6. **g** – *Ochetoceras* aff. *marantianum* (D'ORBIGNY); Golbini, Gol. 5. All figures in natural size.

Discussion: Concerning the shape of the lappet and the whorl width, our specimen resembles *Glochiceras* (*Coryceras*) sp. in Ziegler (1958: 126, pl. 11, figs. 29-30). Another similar species is *G.* (*C.*) *canale* (Quenstedt) in Ziegler (1958: 123, pl. 11, figs. 15-18) and in Gygi (1991: 18, pl. 5, fig. 1). Schweigert & Callomon (1997: 35) considered *Coryceras* as a sovereign genus.

Genus *Ochetoceras* Haug, 1885

Ochetoceras aff. *marantianum* (d'Orbigny, 1850) [M]
Fig. 6g

aff. *1850 *Ammonites marantianus*. – d'Orbigny, p. 533, pl. 207, figs. 3-5.
aff. 1929 *Ochetoceras Marantianum* d'Orb. – Wegele, p. 8, pl. 25, fig. 3.
aff. 1994 *Ochetoceras marantianum* (d'Orbigny, 1850). – Cariou in Fischer, p. 174, pl. 75, figs. 5a, b; 6; 7.
aff. 1997 *Ochetoceras marantianum* (d'Orbigny). – Schweigert & Callomon, p. 14, pl. 2, fig. 3.
aff. 2003 *Ochetoceras marantianum* (d'Orbigny, 1850). – Majidifard, p. 90, pl. 3, fig. 2.

Material: A single specimen from Golbini: Gol. 5.

Description: A poorly preserved phragmocone with a diameter of ca. 70 mm. It is a rather involute and oxycone form, with a high and acute whorl cross-section. The exact shape of the venter can not be seen. The ribbing consists of strongly prorsiradiate inner ribs which extend into a well developed lateral groove, from where they bifurcate mostly into rursiradiate, bow-formed outer ribs.

Discussion: Although not completely preserved, our specimen can be well compared to *O. marantianum*. However, the ribbing pattern in the specimen from Golbini is somewhat coarser than in the type material of d'Orbigny, figured by Cariou (1994), and in the specimen figured by Schweigert & Callomon (1997). Another similar taxon is *O.* (*O.*) *canaliculatum* (Buch, 1831) in Schlegelmilch (1994: 47, pl. 14, fig. 7), which, however, is even more coarsely ribbed on the external part of the last whorl, while the ribbing pattern is distinctly more dense on the inner part of the whorl.

Age: According to Cariou (1994: 174), *O. marantianum* is a common form in the border areas of the western Tethys (Submediterranean Province), occurring in the Bimammatum Zone.

Ochetoceras sp.
Fig. 6f

Material: A single incomplete specimen with parts of the body chamber: Gol. 6.

Description: Relatively involute and oxycone *Ochetoceras* with a high and acute cross section, a high keel, and a distinct lateral groove. The umbilical edge is rounded, the umbilical wall vertical. The inner ribs consist of rather fine, wide-standing, prorsiradiate and slightly concave ribs, ending into the lateral groove. The outer ribs (on the body whorl) are rursiradiate and strongly concave. There are alternately and irregularly stronger ribs which begin at the lateral groove, and two or three weaker intercalate ribs that start somewhat higher up on the flank or occasionally diverge from the stronger ribs.

Discussion: On the inner whorl, the ribbing pattern of our specimen closely resembles that seen in *O. marantianum* in Höroldt (1964, pl. 4, fig. 3), but on the last whorl, it differs from the latter by the more concave outer ribs and the irregular alternation of stronger and weaker ribs. In this character, our specimen resembles *O. irregulare* Berckhemer & Hölder (1959: 99, pl. 23, fig. 120), although the inner ribs of our specimen are much weaker and more regularly arranged. Another similar specimen is *O.* (*O.*) *palyssianum irregulare* in Höroldt (1964: 74, pl. 5, fig. 3). A similar ribbing pattern can be also observed in a specimen of *O. marantianum* from Oppel's collection at the BSPG, Munich (Oppel 1862: 157). This specimen is of larger size and the outer, stronger ribs already start on the inner whorls.

Ochetoceratinae gen. et sp. indet.
Fig. 7e

Material: A single incomplete and crushed specimen with body whorl and the peristome preserved: Gol. 7.

Description: The larger part of the last whorl of the described specimen, with a diameter of ca. 90 mm, belongs to the body chamber. It represents a relatively involute ochetoceratid (U = 14 %) with a high and acute whorl in cross section. The ribbing consists of blunt and biconcave ribs, bifurcating indistinctly on the mid-flank and bending forward in a strong arc. The peristome is externally spur-like elongated, biconcave on the flank, and with a ledge around the mid-flank.

Discussion: Our specimen differs from *Ochetoceras* s. str. by the absence of the lateral groove and perhaps the acute and oxycone whorl cross section.

Family Perisphinctidae Steinmann, 1890
Subfamily Ataxioceratinae Buckman, 1916
Genus *Orthosphinctes* Schindewolf, 1925

Orthosphinctes aff. *tiziani* (Oppel, 1863) [m]
Fig. 8d, e

aff. *1863 *Ammonites Tiziani*. – Oppel, p. 246.
aff. 1972 *Orthosphinctes* (*Orthosphinctes*) gr. *tiziani* Oppel – Alavi-Naini, p.151, fig. 42.
aff. 1997 *Orthosphinctes* (*Orthosphinctes*) *tiziani* (Oppel) – Matyja & Wierzbowski, pl. 6, fig. 1.

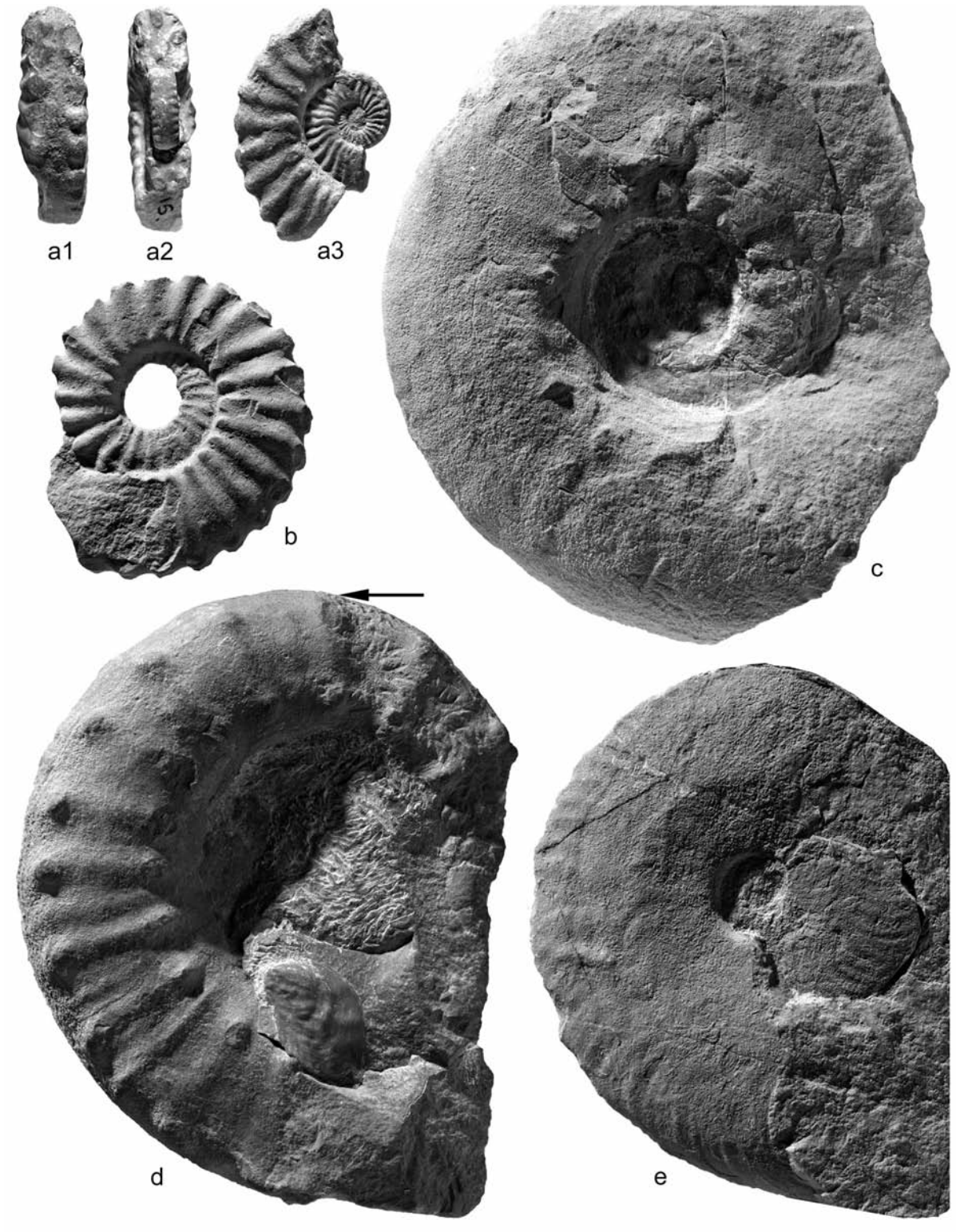

Fig. 7. a1-a3 – *Epipeltoceras bimammatum* (QUENSTEDT), lateral, ventral and dorsal views; Golbini, Gol.15. **b** – *Epipeltoceras bimammatum* (QUENSTEDT); Golbini, Gol.12. **c** – *Physodoceras* aff. *wulfbachense* SCHWEIGERT & CALLOMON; Golbini, Gol.19. **d** – *Euaspidoceras* sp.; Golbini, Gol.18. **e** – Ochetoceratinae gen. et sp. indet.; Golbini, Gol.7. All figures in natural size.

aff. 1997 *Orthosphinctes tiziani* (Oppel) [m]. – Schweigert & Callomon, p. 20, pl. 4, fig. 1.
aff. 2007 *Orthosphinctes tiziani* (Oppel, 1863) – Wierzbowski in Glowniak & Wierzbowski, p. 109, fig. 66, 1-2.

Material: Two specimens from Golbini: Gol. 21; Gol. 28.

Dimensions:	D	U	H	W	UR/2
Gol. 21	78	50	ca. 30	ca. 20	27

Description: Specimen Gol. 21 is an evolute, slightly compressed and nearly complete *Orthosphinctes*. The ribbing consists of rectiradiate, rather strong and biplicate ribs, beginning at the umbilical seam and bifurcating on the outer third of the flank. Constrictions are not observed, but parabolic ribs occur rather frequently, with few intercalate ribs. However, specimen Gol.28 has a shallow and relatively broad constriction with some parabolic ribs.

Discussion: Except a slightly denser ribbing pattern, our specimens show great similarities to *O. tiziani* (Oppel) in Schweigert & Callomon (1997: 20, pl. 4, figs. 1-2; pl. 5, fig. 1).

Age: *O. tiziani* is recorded from the Late Oxfordian, Bimammatum Zone, Hauffianum Subzone (Matyja & Wierzbowski 1997; Schweigert & Callomon 1997: 20).

Orthosphinctes sp. [m]
Fig. 8a, b

Material: A single impression: Gol. 22 and three additional compressed and incomplete internal molds: Gol. 23-25.

Dimensions:	D	U	H	W	UR/2
Gol. 25	73	42	-	-	ca. 30
Gol. 22	67	48	-	-	31
Gol. 24	64	ca. 41	-	-	33
Gol. 23	51	45	-	-	31

Description: Specimen Gol. 22 is a one-side preserved, evolute and full-grown impression with the entire body chamber and a short, narrow apophyse preserved. The body whorl accounts for approximately ¾ of the last whorl. Besides the single constriction before the aperture, there are three further narrow and relatively shallow constrictions on the last whorl. The ribbing is rather fine and dense, slightly prorsiradiate and mostly bifurcating high on the outer ¼ of the flank. Some ribs are simple with intercalate ribs. There are no parabolic ribs. Gol. 23 also represents a compressed half of a whorl with fine and dense ribbing and two parabolic ribs on the last whorl. Specimen Gol. 24 is rather involute with fine and dense ribbing. Gol. 25 is a nearly full-grown and relatively involute specimen with slightly coarser and irregular ribbing.

Discussion: In general, the ribbing patterns of our specimens show similarities to *Orthosphinctes freybergi* (Geyer, 1961) in Atrops (1982: 59, pl. 15, figs. 1-2; pl. 19, fig. 4). However, the latter has less rigid ribs, the bifurcation point is less high and there are relatively more, frequently polygyrate ribs. In addition, *O. freybergi* attains a larger maximum size and is more involute.

Genus *Praeataxioceras* Atrops, 1982

Praeataxioceras sp. [m]
Fig. 8f, g

Material: Two incomplete and flatly compressed specimens: Gol. 29; Gol. 30.

Dimensions:	D	U	H	W	UR/2
Gol. 30	57	40	-	-	19
Gol. 29	79	47	-	-	21

Description: Both specimens are flatly compressed, rather evolute Perisphinctidae with relatively numerous secondary ribs. The ribbing pattern on the inner whorls is rather fine and dense. Towards the aperture the ribs become coarser, more distant and blunt. The nearly rectiradiate primary ribs bifurcate on the outer third of the flank, often with an intercalate rib beginning at the same height. Parabolic ribs and constrictions are present.

Discussion: Specimen Gol. 29 shows similarities to the inner whorls of the type of *Praeataxioceras laufenensis* (Siemiradzki, 1899, pl. 26, fig. 46), but the secondary ribs on the outer part of the last whorl are remarkably less numerous. The specimen Gol. 30 (Fig. 8f) is somewhat more evolute in comparison to Gol. 29 (Fig. 8g) and also the specimen figured by Siemiradzki (1899). From the specimens figured by Koerner (1963: 359), our specimens are distinguished by the greater number of secondary ribs.

?*Praeataxioceras* sp. [M]
Fig. 8h

Material: Two incomplete specimens (macroconchs) from Golbini: Gol. 26 and Gol. 27.

Dimensions:	D	U	H	W	UR/2
Gol. 26	95	46	32	-	23

Description: Specimen Gol. 26 is an evolute perisphinctid with the body chamber beginning at ca. D = 71 mm. The ribbing is relatively coarse, moderately dense, mostly biplicate and partly also polygyrate. On the last preserved whorl there are five parabolic ribs. No constriction is observed. Specimen Gol. 27 looks similar, but is a little more involute.

Discussion: Except a denser ribbing, the very flat curve of the umbilical ribs on our specimens is similar to

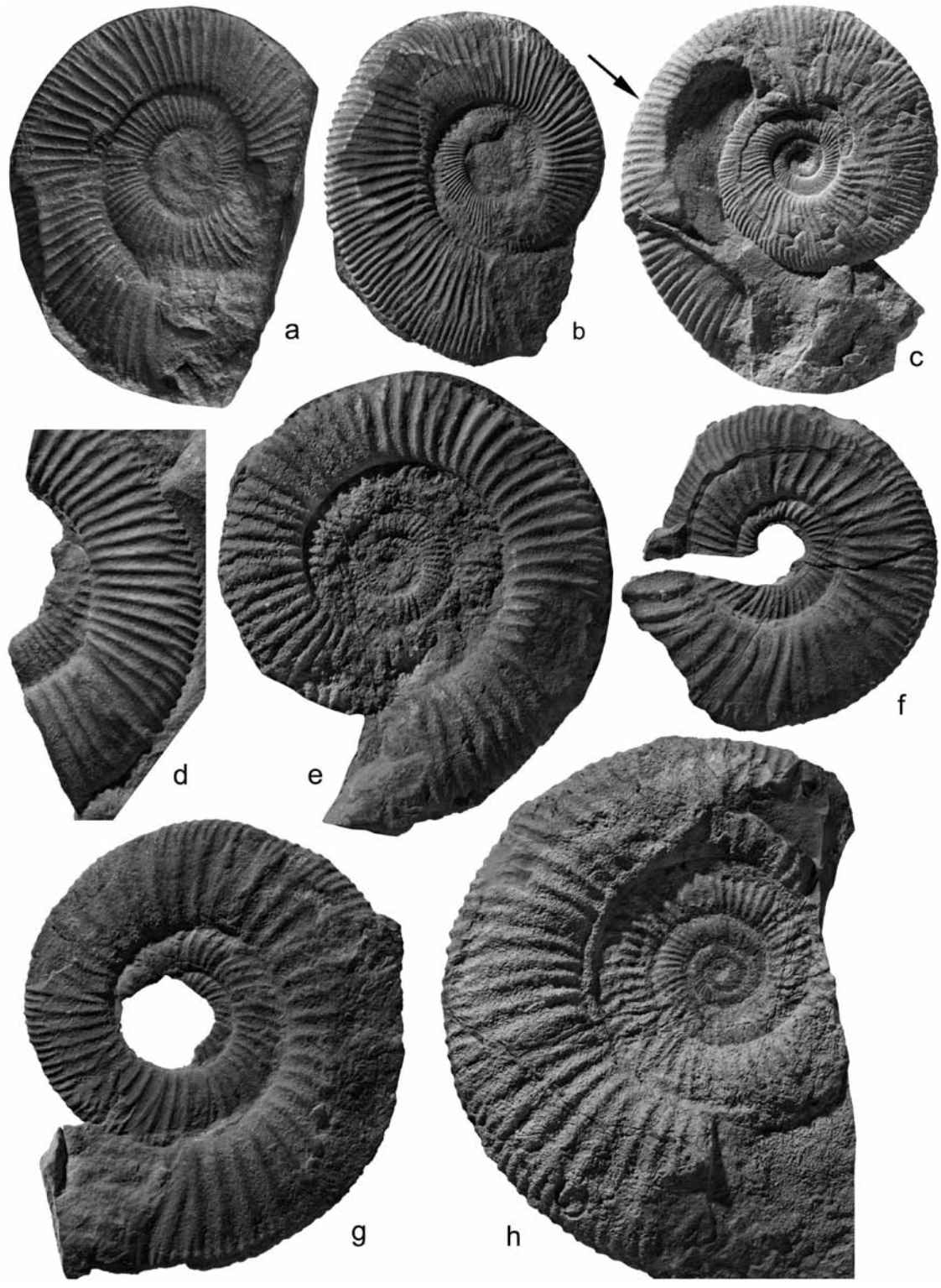

Fig. 8. a – *Orthosphinctes* sp.; Golbini, Gol. 22. **b** – *Orthosphinctes* sp.; Golbini, Gol. 24. **c** – ?*Larcheria* sp.; Golbini, Gol. 20. **d** – *Orthosphinctes* aff. *tiziani* (Oppel); Golbini, Gol. 28. **e** – *Orthosphinctes* aff. *tiziani* (Oppel); Golbini, Gol. 21. **f** – *Praeataxioceras* sp.; Golbini, Gol. 30. **g** – *Praeataxioceras* sp.; Golbini, Gol. 29. **h** – *Praeataxioceras*? sp.; Golbini, Gol. 26. All figures in natural size.

"*Perisphinctes*" *suevicus* SIEMIRADZKI (1899), which might be correctly attributed to *Praeataxioceras*, because ATROPS (1982: 50) assumed that the form group of "*P.*" *suevicus* represents the macroconch forms of *Praeataxioceras* ATROPS, 1982.

Genus *Larcheria* TINTANT, 1961

?*Larcheria* sp.
Fig. 8c

Material: A single crushed specimen with parts of the body whorl preserved: Gol. 20.

Description: The crushed specimen is a relatively involute perisphinctid (Dm 54, U 30) with a diameter of ca. 65 mm. About 1/3 of the last whorl belongs to the body chamber. On the inner whorl, up to ca. D = 37 mm, the ribbing is rather fine, dense, slightly prorsiradiate and biplicate. Towards the outer whorl the ribs gradually become more distant, with few intercalate ribs.

Discussion: Our specimen shows similarities to *Larcheria schilli* (OPPEL, 1863, pl. 65, fig. 7) figured also in CARIOU et al. (1997, pl. 21, fig. 13) and GYGI (2001). However, the specimen from Golbini is slightly more involute. Another similar species is *Larcheria*? *lewitzkii* BESNOSOV & MITTA, 1995, described from the Bimammatum-Planula zones of Usbekistan by these authors. However, the specimens figured by BESNOSOV & MITTA (1995: pl. 20, figs. 9-10) are distinctly more evolute as the specimen from Golbini. According to PAGE (2008: 49), *Larcheria* is a taxon restricted to the Submediterranean Province.

Age: According to BRANGER et al. (1995: 46, Tab. 4) and CARIOU et al. (1997: 83, Tab. 10), *Larcheria schilli* is recorded from the Middle Oxfordian, Transversarium Zone, Schilli Subzone.

Family Aspidoceratidae ZITTEL, 1895
Subfamilly Epipeltoceratinae DONOVAN, CALLOMON & HOWARTH, 1981
Genus *Epipeltoceras* SPATH, 1924

Epipeltoceras bimammatum (QUENSTEDT, 1857) [m]
Fig. 7a1-3, b

* 1857 *Ammonites bimammatus*. – QUENSTEDT, p. 616, pl. 76, fig. 9.
1887 *Ammonites bimammatus*. – QUENSTEDT, p. 880, pl. 95, figs. 1-10.
1962 *Epipeltoceras bimammatum* (QUENSTEDT). – ENAY, p. 54, pl. 4, fig. 1a-b, figs. 9-10.
1994 *Epipeltoceras bimammatum* (QUENSTEDT, 1858). – SCHLEGELMILCH, p. 68, pl. 23, fig. 10.
1995 *Epipeltoceras bimammatum* (QUENSTEDT). – BRANGER in BRANGER, NICOLLEAU & VADET, p. 136, pl.27, fig. 3.
1995 *Epipeltoceras bimammatum* (QUENSTEDT). – SCHWEIGERT, p. 4, fig. 6a, b.
2000 *Epipeltoceras bimammatum* (QUENSTEDT 1858). – GYGI, p. 101, pl. 10, fig. 4.

Material: Six crushed specimens and three external moulds from Golbini: Gol. 12-17; Gol. 31-33.

Dimensions:	D	U	H	W
Gol. 15	21	33	42	38

Description: Specimen Gol. 12 (Fig. 7b) is slightly compressed, with a diameter of 55 mm. It is evolute, with single, straight, distant and strong ribs (23 ribs per whorl at D = 55 mm). The cross-section can be observed in a smaller, not crushed specimen (Gol. 15; Fig. 7a1-3). It is broadly-rectangular and little higher than wide. All ribs end at rather strong ventrolateral and slightly clavate tubercles. The venter is smooth and slightly concave.

Discussion: Our specimens can be best compared to QUENSTEDT's originals of *E. bimammatum*, deposited as casts at the BSPG, Munich. From the closely related *E. treptense* ENAY (1962: 55), our specimens are distinguished by stronger and more rigid ribs.

Age: Late Oxfordian; index species of the Bimammatum Zone, *bimammatum* Horizon (see: SCHWEIGERT & CALLOMON 1997: 35, fig. 10).

Subfamily Euaspidoceratinae SPATH, 1931
Genus *Euaspidoceras* SPATH, 1925

Euaspidoceras sp.
Fig. 7d

Material: A single one-side preserved specimen with a diameter of 105 mm from Golbini: Gol. 18.

Description: The specimen is an evolute aspidoceratid with major parts of the body whorl preserved. The whorl cross section is nearly rectangular, slightly higher than wide. The flanks are almost parallel, slightly converging towards the venter. The external side is smooth and weakly convex. The umbilical edge is rounded, the umbilical wall steep to rectangular. The ribbing consists of strong, single, rectiradiate and widely spaced ribs with umbilical and ventro-lateral spiny tubercles. A few intercalations of weaker ribs without tubercles occur irregularly.

Subfamily Physodoceratinae SCHINDEWOLF, 1925
Genus *Physodoceras* HYATT, 1900

Physodoceras aff. *wulfbachense* SCHWEIGERT & CALLOMON, 1997
Fig. 7c

aff.*1997 *Physodoceras wulfbachense* n. sp. – SCHWEIGERT & CALLOMON, p. 18, pl. 6, fig. 1.

Material: A single crushed and heavily eroded specimen from Golbini: Gol. 19.

Dimensions:	D	U	H	W
Gol. 19	ca. 115	ca. 27	ca. 35	-

Description: The last whorl of the crushed and heavily eroded specimen belongs probably to the body whorl. It is a relatively large and evolute *Physodoceras* with ovate whorl cross section and rounded venter. The umbilical margin is rounded, the umbilical wall steep. The ornamentation consists of rather small and spiny umbilical tubercles (ca. 10 per whorl at D = 110 mm). Towards the aperture, the tubercles become more distant. There are also very faint and indistinct ribs, which begin at the tubercles and become slightly broader towards the external side.

Discussion: From the closely related *Ph. wulfbachense*, our specimen is distinguished by a smaller umbilicus, the greater number of tubercles and the pattern of the ribbing.

Age: The holotype of *Ph. wulfbachense* is recorded from the Bimammatum Zone, Hauffianum Subzone, *bauhini* horizon (Schweigert & Callomon 1997).

4. Conclusions

The ammonite fauna described herein comes from a narrow time interval, i.e. the Late Oxfordian Bimammatum Zone (a single dubious ?*Larcheria* sp. would indicate a slightly older age). The following taxa are recorded: *Sowerbyceras tortisulcatum*, *Taramelliceras (T.) costatum*, *Glochiceras* sp., *Ochetoceras* aff. *marantianum*, *Ochetoceras* sp., Ochetoceratinae gen. et sp. indet., *Orthosphinctes* aff. *tiziani*, *Orthosphinctes* sp., *Praeataxioceras* sp., ?*Praeataxioceras* sp., ?*Larcheria* sp., *Epipeltoceras bimammatum*, *Euaspidoceras* sp., *Physodoceras* aff. *wulfbachense*.

From the same locality and level, Majidifard (2003) described *Sowerbyceras* sp. *Ochetoceras marantianum*, *O. semifalcatum*, *Perisphinctes* (*Dichotomosphinctes*) *buckmani*, *Dichotomosphinctes* sp., *Perisphinctes* (*Dichotomoceras*) *bifurcatus*, *Subdiscosphinctes* sp., and *Euaspidoceras hypselum*.

Based on these records, the Late Oxfordian ammonites of the study area are closely related to those from epicontinental seas, bordering the northern margins of the western Tethys, and take an intermediate position between the Mediterranean and Submediterranean provinces (Cariou et al. 1997; Schweigert & Callomon 1997; Page 2008), although some Subboreal elements may also be present. Typical Boreal ammonites, such as Cardioceratidae, are absent. However, the studied ammonite fauna is distinguished from those of the Submediterranean and Subboreal provinces by the high percentage and partial dominance of Phylloceratina, occasionally totalling more than 50 % of the fauna. In this particular aspect, the fauna displays closer affinities to the Mediterranean Province. Altogether, the Phylloceratidae and Perisphinctidae account for nearly 90 % of the fauna. Interestingly, Phylloceratina are extremely rare elements in the Lower and early Middle Jurassic shallow-water and molassic/siliciclastic strata of the Alborz Range (Shemshak Group: Seyed-Emami et al. 2008), while they occur in high numbers in the deeper marine marl and carbonate settings of the Middle and Upper Jurassic strata of North Iran (Dalichai/Chaman Bid and, respectively, Lar/Mozduran formations), occasionally making up more than 50 % of the fauna.

In contrast to the Mediterranean ammonite faunas, Lytoceratina are extremely rare in the studied fauna. According to Page (2008: 40), "Lytoceratina have very similar distribution patterns to those of Phylloceratina, the two groups commonly occurring in association in deeper-water facies. There is however, some suggestion that latitudinal controls may have been more important for the Lytoceratina, as high-latitude records seem to be less common than for the Phylloceratina, and Lytoceratinae are typically only abundant in low-latitude Tethyan faunas". Moreover, Lytoceratinae are totally absent from the Lower and early Middle Jurassic of the Alborz Range (Shemshak Group: Seyed-Emami et al. 2008).

During the Early and early Middle Jurassic, North Iran occupied a fairly high latitudinal position of about N 45°, and the sedimentary environment was changing repeatedly between continental and shallow-marine facies (Seyed-Emami et al. 2008). This was partly due to eustatic sea-level fluctuations and to some extent also to the active synsedimentary tectonics (Fürsich et al. 2005). The rather scarce and little diversified ammonite fauna of this time interval is clearly related to the Subboreal areas of north-western Europe (Seyed-Emami et al. 2008). Remarkably, even some Boreal faunal elements, i.e. amaltheids (Seyed-Emami 1988; Seyed-Emami et al. 2008), occur during the Late Pliensbachian. Since the Late Bajocian, after the Mid-Cimmerian event (Fürsich et al. 2009) and the global transgression (Hallam 2001), the dominance of siliciclastic sedimentation ended abruptly. It was replaced by the deeper marine marls and limestones of the Dalichai and Chaman Bid formations and subsequently in Late Jurassic by the

carbonate platform settings of Lar/Mozduran formations. In addition, the palaeogeographic position of Alborz shifted from higher latitudes of about N 45° during the Early Jurassic, towards about N 30° in the Middle and Late Jurassic (Dercourt et al. 2000). Furthermore, most likely, new and direct marine connections became established, facilitating a direct and intensive faunal exchange with Mediterranean areas.

The shifting of palaeobiogeographic relations of the ammonite fauna from Subboreal (Northwest Europe) affinities during the Early Jurassic to a significant Submediterranean/Mediterranean influence during the Middle and Late Jurassic is highly related to the aforementioned environmental, sedimentological, and latitudinal changes. Moreover, the establishment of deeper marine sedimentary environments and likely also the development of new migration pathways are probably related to the onset of rifting and sea-floor spreading in the northern Atlantic (northwestern Tethys) and the South Caspian Basin at around the earliest Middle Jurassic (Hiscott et al. 1990; Brunet et al. 2003; Fürsich et al. 2009). These deeper and open marine conditions established in the Alborz area during the early Middle Jurassic and may have lasted up to the Early Tithonian, especially in the Koppeh Dagh Basin. However, a general shallowing tendency during the Late Jurassic is evident, starting usually during the Oxfordian, in some regions even later, and extensive carbonate platforms developed in large parts of the Alborz and Koppeh Dagh basins and eastern Central Iran (Lassemi 1995; Schairer et al. 1999; Seyed-Emami et al. 2001; Fürsich et al 2003).

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