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Article

Oxfordian ammonites from Rostam Kola, northern East Alborz, North Iran

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With 4 figures

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Abstract: The study of a set of ammonite samples from outcrops of the Lar Formation in northermost Iran (northwestern East Alborz) indicates a latest middle to early late Oxfordian age for this fauna. All the studied ammonites belong to the subfamilies Passendorferiinae (*Passendorferia uptonioides* and *P. gygii*) and Ataxioceratinae (*Orthosphinctes ariniensis*, *Orthosphinctes* sp. A and *O.* sp. B), and show dominant Submediterranean affinities, being largely comparable to ammonite successions recorded in South European epicontinental platforms, such as Iberian Range, French and Swiss Jura, Southern Germany and Polish Jura. Affinities with true Mediterranean (Northwest Tethyan) Province are also close. However, differences are marked by the virtual absence of representatives of suborders Phylloceratina and Lytoceratina in the recorded sequence, one of the dominant faunal components there. Nevertheless, the material available is scarce for supporting strong conclusions.

Key words: North Iran; western East Alborz; Lar Formation; Ammonoidea; Passendorferiinae; Ataxioceratinae; Oxfordian.

1. Introduction

The Upper Jurassic Lar Formation crops out extensively in the Alborz Mountains of northern Iran (Fig. 1). In these outcrops ammonites are never abundant although they can locally be collected in moderate number and good state of preservation. Assereto (1966) proposed the name Lar Formation for cliff-forming limestones located in vast areas of the Alborz Mountains; the type section is located at the northeast of Garmab, between the Lar and Jajrud river basins. The Lar Fm. overlies comformably the Dalichai Fm. in some areas, but its upper boundary is an erosive surface covered by rocks of different ages. The age of the Lar Fm. was considered by Assereto (1966) as Oxfordian-Kimmeridgian but after recent studies on the radiolarian and calpionellid faunas, the age has been extended up to the lower Cretaceous (Seyed-Emami 1975; Majidifard 2008). The Lar Fm. at the East Alborz has been extensively studied by Majidifard (2003, 2008) where complete descriptions of the local geology can be seen. A complete list of ammonites described hitherto from the Late Jurassic of the Alborz Range is given by Seyed-Emami & Schairer (2010).

We have studied the Oxfordian ammonite succession of a section in the northwesternmost extension of the East Alborz, in the region of Rostam Kola (Fig. 1). This section is located between Sari and Behshahr cities, Mazandaran Province, near the town Rostam Kola, 10 km far from Behshahr and 30 km from Sari. The Lar Fm. in this section is 105 m thick. Five main lithologies can be distinguished in it (Fig. 2) as briefly described below. The lower boundary of the formation is not visible in this region. The unit is covered on top by Quaternary deposits.

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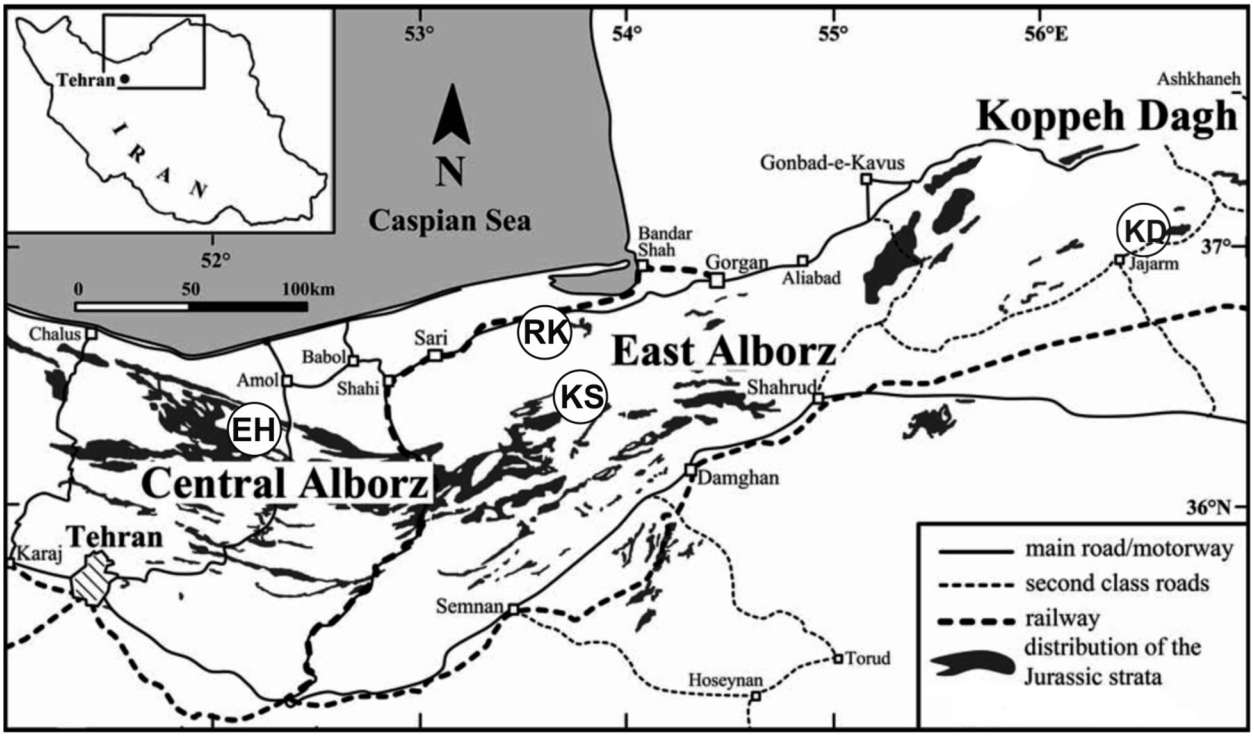

Fig. 1. Location map of the studied outcrop at Rostam Kola (RK), western East Alborz, and other localities cited in text. EH: Emamzadeh-Hashem, KS: Kuhe Sharaf, KD: Koppeh-Dagh. Modified from Seyed-Emami & Schairer (2011).

The results presented below are particularly interesting as no Oxfordian ammonites had been reported before from the studied area, which is located several kilometers north of the typical sections from where larger collections of ammonites have been described in several papers by other authors (e.g., Schairer et al. 2000, 2003; Seyed-Emami & Schairer 2010, 2011 and references therein). The closest locality from where Late Jurassic ammonites have been described is Kuhe-Sharaf (Seyed-Emami et al. 1998), about 50 km south of Rostam Kola. The results of the present study show that the studied sequence corresponds to the uppermost Middle and lower Upper Oxfordian.

The zonal chronostratigraphic scale used herein as reference (Fig. 2) for dating the material is somewhat different in respect to that of Cariou et al. (1997) or Schweigert & Callomon (1997). It was discussed in detail by Meléndez et al. (2006). The differences, which are mainly a matter of hierarchy of the units, respect to the scale used by Schweigert & Callomon (1997) are that the Hypselum, Bimammatum and Hauffianum subzones of the Bimammatum Zone, are herein used as full zones.

2. Local stratigraphic framework

The studied section is located in the western Northeast Alborz (Fig. 1), 20 km south of the Caspian Sea shoreline, in a region where the northernmost outcrops of Jurassic rocks of Iran can be observed.

The section consists of 105 m of limestones belonging to the Lar Fm. The sequence can be summarized as follows, from bottom to top (Fig. 2). The recorded ammonite levels are numbered RK-01 to RK-11.

– Covered

12 m of thin-bedded limestones, brown to cream in weathered state, light cream in fresh surfaces. Fossils: ammonites [RK-01 – RK-02] and brachiopods.

10 m of medium-bedded limestones with nodular cherts, red to yellow in weathered state, light red to white in fresh surfaces. Fossils: ammonites [RK-03 – RK-04], belemnites and brachiopods.

38 m of thick-bedded limestones with banded chert interbeddings, brown to light orange in weathered state, cream in fresh surfaces. Fossils: ammonites [RK-05 – RK-07], brachiopods (*Lacunosella*) and belemnites (*Belemnopsis*, *Hibolithes*), trace fossils.

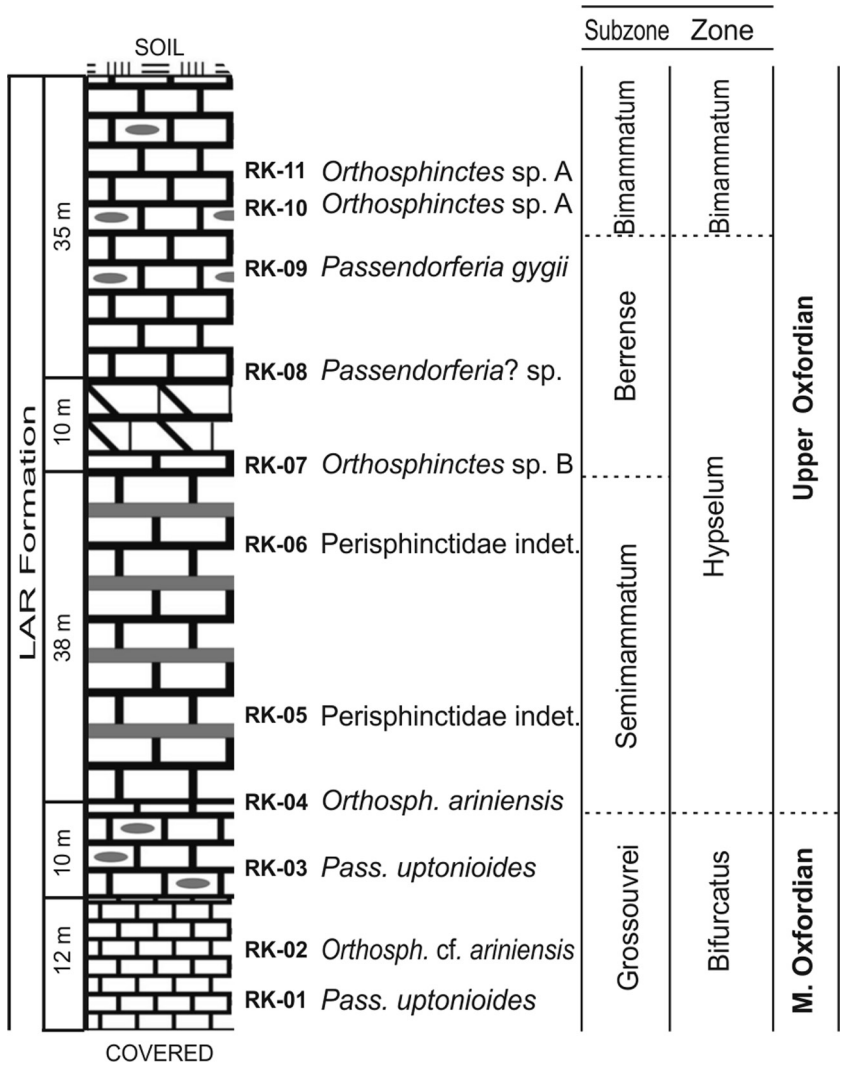

Fig. 2. Section of the upper part of the Lar Formation at Rostam Kola with indication of the relative position and age of the sampled ammonite beds (RK-01-RK-11).

10 m of limestones, partly dolomitized, white in weathered state, light cream in fresh surfaces. Fossils: ammonite fragments and brachiopods.

35 m of medium-bedded limestones with nodular cherts, grey to yellow in weathered state, white to light cream in fresh surfaces. Fossils: ammonites [RK-08 – RK-11], belemnites and brachiopods.

– Top is covered by Quaternary soils.

3. Systematic palaeontology

The available material is scarce and scattered throughout the section, with one or few specimens from each level. Consequently, only a morphotypic approach can be adopted for determination of the studied samples. Facing these limitations a comparison has been made with similar middle-upper Oxfordian successions in other Tethyan and adjacent regions, mainly Iberian Range (northeastern Spain), French Jura, Italy, and Polish Jura. The material seemed to be not promissory, but following this procedure we are confident to have obtained a rather consistent classification, which seems adequate for proposing a preliminary local biostratigrahic time-correlation which is discussed below.

The studied ammonites are stored at the Geology Department of the Payame Noor University in Shiraz, Iran (MFLA).

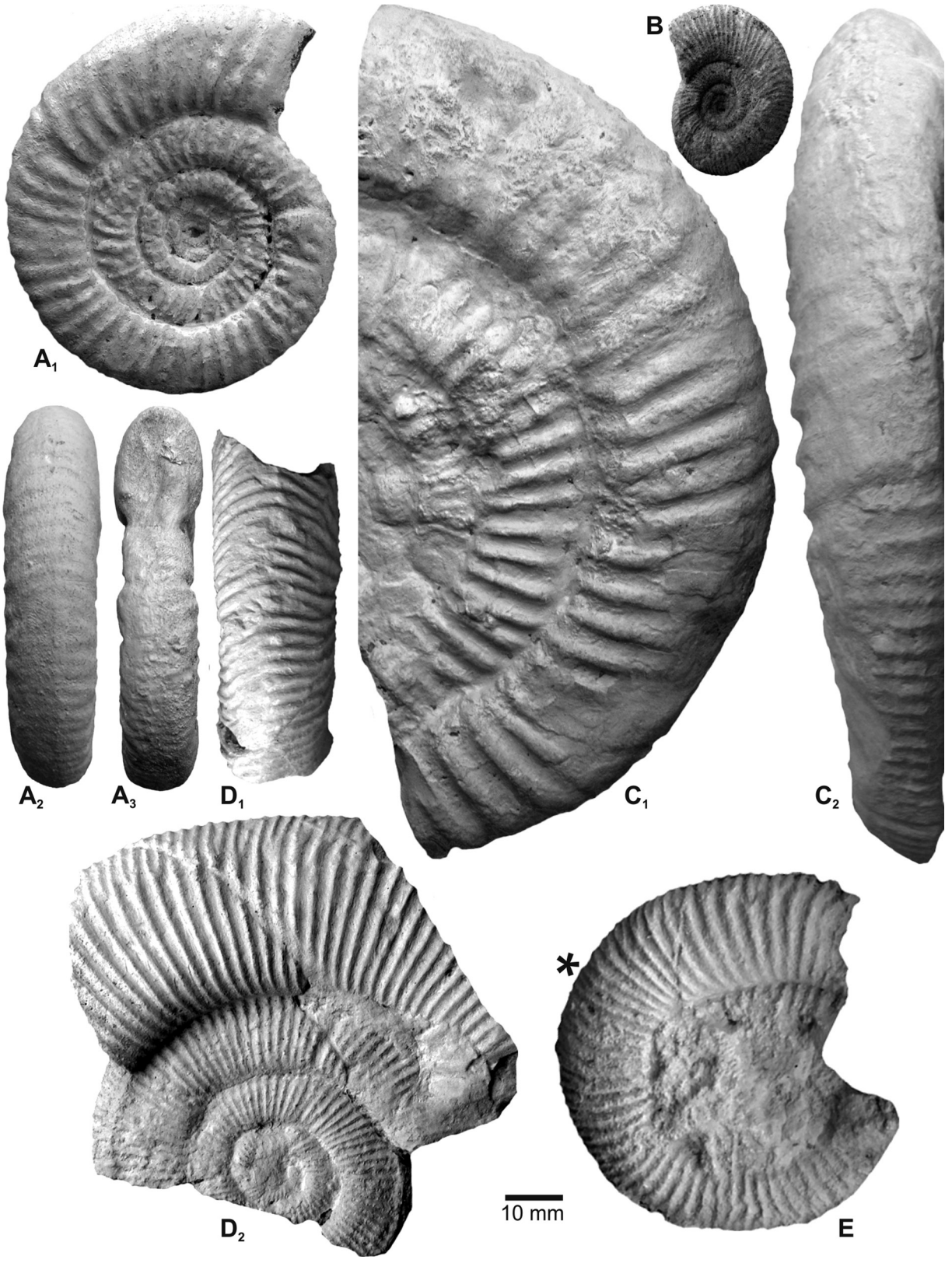

Fig. 3.

Superfamily Perisphinctoidea Steinmann, 1890
Family Perisphinctidae Steinmann, 1890
Subfamily Passendorferiinae Meléndez, 1989
Genus *Passendorferia* Brochwicz-Lewinski, 1973

Type species: *Nebrodites (Passendorferia) teresiformis* Brochwicz-Lewinski, 1973, by original designation.

Passendorferia uptonioides (Enay, 1966)
Fig. 3A, C

*1966 *Pseudarisphinctes uptonioides* n. sp. – Enay, p. 437, figs. 125-126; pl. 22, figs. 1-4; pl. 23, figs. 1-2.
1973 *Nebrodites (Passendorferia) uptoniodes* (Enay). – Brochwicz-Lewinski, p. 312, pls. 19-20; text-figs. 2-3.
1989 *Passendorferia (Passendorferia)* cf. *uptoniodes* (Enay). – Meléndez, p. 143, pl. 5, figs. 1-3; pl. 6, figs. 1-2. (With synonymy).

Material: The available material consists of two internal molds of incomplete, apparently wholly septate, macroconch specimens from levels RK-01 and RK-03.

Description: Diameters of the specimens are 70 and 150 mm, respectively. Inner whorls very evolute, rounded in whorl section, with moderately fine, blunt radial to slightly prosocline primary ribs (number of primary ribs per half whorl $P = 20$ at $D = 30$ mm). Outer whorls very evolute, subrectangular in whorl section with flat flanks and rounded venter. Ribbing composed by radial to slightly prorsiradiate primaries ($P = 24$ at $D = 100$ mm); these latter are prominent, raised on the ventro-lateral shoulder, showing the columnar aspect typical for the genus.

Discussion: *P. uptonioides*, originally assigned to *Pseudarisphinctes* Arkell, 1935 (TS: *P. shortlakensis* Arkell) was transferred to *Passendorferia* by Brochwicz-Lewinski (1973). The species is characterized by the very regular ribbing, showing a gradual change through ontogeny and the early development of a typical subquadrate whorl section with straight columnar single ribs, prominent on the ventro-lateral margin. The specimens described by Brochwicz-Lewinski (1973) from the Polish Jura are slightly more evolute with uniform single to biplicate ribbing. The specimens described by Enay (1966) and subsequently by Meléndez (1989) from the French Jura and the Iberian Range respectively, display a slightly more involute coiling with early occurrence of intercalatory ribs. These features lead Meléndez (1989) to propose this species as an early "synthetic" form, e.i., the origin of the divergent subfamily Ataxioceratinae in the upper middle Oxfordian Bifurcatus Zone (further discussed below). The described specimens from Iran are closer to those illustrated by Brochwicz-Lewinski (1973) from Poland. The specimen illustrated in Fig. 3C, showing a slightly more evolute coiling and thicker ribs and coming from a slightly higher level, could represent a transitional form between *Passendorferia uptonioides* (Enay) and *Passendorferia rozaki* Meléndez, of the lowermost Hypselum Zone.

A closely comparable but fragmentary specimen from S of Korond, Tabas Area (eastern Iran) was described by Schairer et al. (2003: fig. 8.1) as *Passendorferia* sp. and supposed to indicate the upper Transversarium Zone.

Stratigraphic distribution: *Passendorferia uptonioides* occurs in a well-defined interval within the Bifurcatus Zone, Grossouvrei Subzone. Its stratigraphic position characterizes the *uptonioides* biohorizon in the Mediterranean Province, roughly equivalent to the *bifurcatus* biohorizon in the Submediterranean Province.

Passendorferia gygii (Brochwicz-Lewinski & Rózak, 1976)
Fig. 4A

*1974 *Passendorferia birmensdorfensis* (Oppenheimer non Moesch). – Brochwicz-Lewiński & Rózak, p. 119, pl. 4, fig. 2.
*1976 *Nebrodites (Enayites) gygii* sp. n. – Brochwicz-Lewiński & Rózak, p. 383; fig. 2.2 [HT refigured]; pl. 35, fig. 2.
1989 *Passendorferia (Enayites) gygii* (Brochwicz-Lewinski & Rózak). – Meléndez, p.170; pl. 13, figs. 1-4.

Description: A single specimen from level RK-09 is available. It is a well-preserved, complete adult microconch. Shell serpenticonic in the inner whorls with subcircular section, becoming slightly more compressed with a suboval section in the adult bodychamber. The ribbing is fine and radial, composed of single and symmetrically bifurcated ribs.

Remarks: The ribbing pattern is similar but slightly more acute and thicker than that of *Ammonites birmensdorfensis* Moesch; moreover, the point of furcation in the bodychamber sets in slightly lower on the flanks in the adult stage. The illustrated specimen is remarkably similar to the holotype of. *P. gygii*. This form is distinctly characterized by its very evolute coiling in the inner whorls with a subcircular whorl section and a fine, sharp ribbing. These features make

Fig. 3. A – *Passendorferia uptonioides* (Enay), phragmocone (MFLA 01), level RK-01. **B** – *Orthosphinctes* cf. *ariniensis* (Meléndez), phragmocone (MFLA 02), level RK-02. **C** – *Passendorferia uptonioides* (Enay), phragmocone (MFLA 03), level RK-03. **D** – *Orthosphinctes ariniensis* (Meléndez), phragmocone of adult macroconch (MFLA 04), level RK 04. **E** – *Orthosphinctes* sp. B, juvenile specimen with bodychamber (MFLA 07), level RK-07. All natural size (x1). The asterisk indicates the last septum.

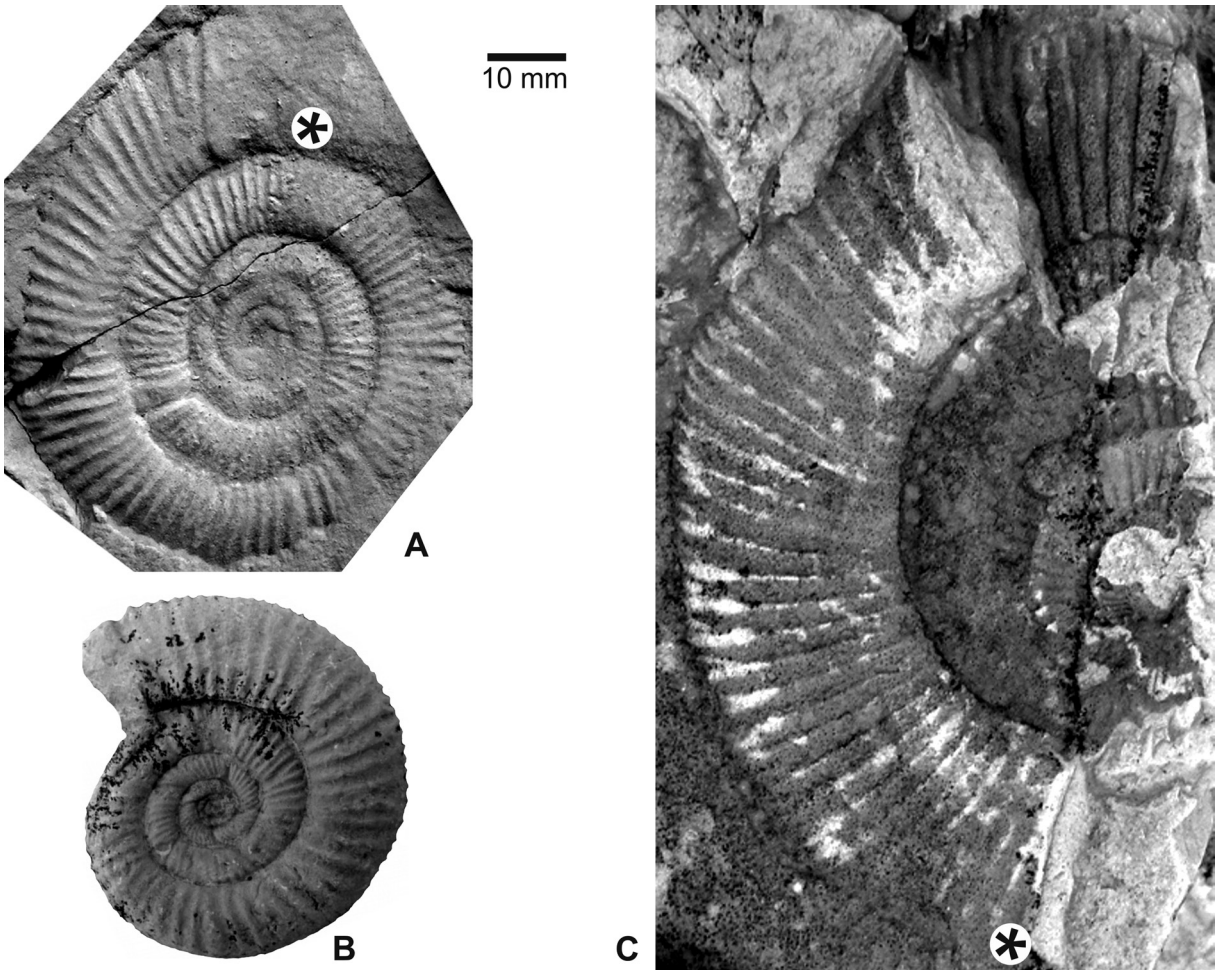

Fig. 4. A – *Passendorferia gygii* (Brochwicz-Lewinski & Rózak), almost complete adult microconch (MFLA 09), level RK-09. **B** – *Orthosphinctes* sp. A, adult ?microconch (MFLA 10), level RK-10. **C** – *Orthosphinctes* sp. A, ?adult macroconch with part of the bodychamber (MFLA 11), level RK-11. All natural size (x1). Asterisk indicates the last septum.

it clearly distinctive from *Passendorferia rozaki* Meléndez, which is characterized by an extremely evolute coiling and thick ribs. *Passendorferia sanpedroi* Meléndez is characterized by a slightly more involute coiling and thicker rounded ribs.

Distribution: The species has been reported and described from the Iberian Range (NE Spain; Meléndez 1989; Pérez-Urresti 1996; Pérez-Urresti et al. 1996; Meléndez et al. 1997) and from typically Mediterranean areas such as Sicily (D'Arpa & Meléndez 2002, D'Arpa et al. 2002), thus showing it as a widespread species around the Tethyan Province and also widely recorded in the Submediterranean Province. However, the known material consists of more or less complete microconchs. Complete adult macroconchs are still not clearly identified, although some large specimens occur in the same levels in the Iberian Range which could likely represent the corresponding macroconchs.

P. gygii seems to be confined in a lower horizon of the Hypselum Zone, at the basal upper Oxfordian. It has been clearly recognized by Meléndez (1989) as an early late Oxfordian representative of Passendorferiinae from the Hypselum to Bimammatum zones, followed by *Passendorferia rozaki* Meléndez and *Passendorferia sanpedroi* Meléndez, forming a homogeneous lineage.

Family Ataxioceratidae Buckman, 1921
Subfamily Ataxioceratinae Buckman, 1921
Genus *Orthosphinctes* Schindewolf, 1925

Type species: *Ammonites tiziani* Oppel, 1863, by original designation.

Orthosphinctes ariniensis (Meléndez, 1989)
Fig. 3D

*1989 *Passendorferia (Passendorferia) ariniensis* sp. nov. – Meléndez, p. 149; pl. 7, fig. 3a-b; pl. 8, fig. 1; text-fig. 28.

Material: One moderately well preserved specimen from level RK-04, and two cf.-specimens from level RK-02.

Description: The specimen is the incomplete phragmocone of a macroconch with a diameter of about 100 mm. Inner whorls are rounded and evolute rapidly turning into slightly more involute with massive rounded to subrectangular whorl section on the outer whorls. The sculpture of the inner whorls is composed of prosocline primary ribs and strong prosocline constrictions. In the outer whorls it is subradial to slightly prorsiradiate, alternating mostly biplicate and few single ribs; bifurcation occurs in the upper third of the flank, forming two narrowly splayed secondaries.

Discussion: The external "passendorferioid" style of ribbing and the quick growth in height and width of the whorl section makes the present specimen assignable to *Orthosphinctes ariniensis* (Meléndez).

Commonly the origin of the Ataxioceratinae is considered to be rooted in *Orthosphinctes* [microconchs of *Pseudorthosphinctes* Enay 1966], see, e.g., Donovan et al. (1981) and Schweigert & Callomon (1997). An alternative hypothesis proposed by Perez-Urresti (1996, see also Perez-Urresti et al. 1996; Meléndez 1989; Meléndez et al. 2006, 2009) supposes a derivation of the Ataxioceratinae from *Passendorferia*, considering *Passendorferia ariniensis* Meléndez as an early representative of *Orthosphinctes* from the base of the Hypselum Zone. The present specimen from level RK-04 is described under *Orthosphinctes* considering this latter hypothesis and in spite it is most likely a macroconch; otherwise, in morphological terms, it could be considered as a late representative of *Passendorferia*.

Two wholly septate, finely ribbed specimens (incomplete phragmocones) come from level RK-02 showing an involute coiling with a rather inflated whorl section and radial to slightly prorsiradiate, biplicate and single ribs, some of them irregularly parabolic. The best preserved of these specimens, shown in Fig. 3B (Dmax = 30 mm), is slightly distorted and shows a rounded, somewhat inflated whorl section with a convex umbilical wall and narrow, prorsiradiate constrictions.

Distribution: *O. ariniensis* occurs in a well-defined horizon at the base of the Hypselum Zone, Semimammatum Subzone (i.e., the *ariniensis* biohorizon in Meléndez et al. 2006). It was first recognized in the Iberian Range by Meléndez (1989) and later in larger areas across the Mediterranean Province (see Meléndez et al. 2009).

Orthosphinctes sp. A
Fig. 4B-C

Description: A moderately preserved specimen from level RK-10 (Fig. 4B) exhibits its bodychamber and seems to be a complete microconch due to its uncoiled terminal part of the last whorl, which apparently shows remains of the base of a lappet. The inner whorls are serpenticonic, densely ribbed with strongly prosocline primaries bifurcating in the upper part of the flank. There are about four strong constrictions per whorl, preceded by a primary divided on the mid-flank and again on the uppermost part of the flank. The end of the phragmocone and the bodychamber remain evolute and constricted, with a slightly lower density of lateral ribbing. At the end of the slightly uncoiled bodychamber, there is a deep and wide constriction which precedes the peristome.

Remarks: This form seems to represent a species of *Orthosphinctes* from the Bimammatum Zone. The densely ribbed inner whorls are also similar to those of early species of *Ardescia* Atrops, 1982. Nevertheless, the outermost whorl shows a simple pattern of bifurcate ribs on the uppermost flank, whereas in *Ardescia* from the Hauffianum Zone of Germany the bifurcation points are located deeper on the flanks (G. Schweigert, pers. comm. 23/11/2011).

Few poorly preserved specimens from level RK-11 are larger macroconchs. They could correspond to the described microconch from the underlying level RK-10. The best preserved specimen (D = 123 mm) is illustrated in Fig. 4C for showing the general aspect of these ammonites. The partially visible inner whorls are similar to those of the specimen in Fig. 4B. It is preliminarily labelled as *Orthosphinctes* sp. A. Seyed-Emami & Shairer (2010: fig. 8a, d-e) have described very similar microconchiate specimens from eastern Alborz as *Orthosphinctes* sp. and *O.* aff. *tiziani*, and consequently assigned them to the Bimammatum Zone (Hauffianum Zone in the zonation of Fig. 2, respectively).

The beds RK-10 to RK-11 with *Orthosphinctes* sp. A could be roughly assigned to the Bimammatum Zone (Fig. 2).

Orthosphinctes sp. B
Fig. 3E

Remarks: A fragmentary specimen (level RK-07), with half whorl of the bodychamber and parts of the phragmocone. Size (D = 65 mm), involution and ribbing, composed of primaries bifurcating high on the flanks in forwardly projected secondaries, and the scarce occurrence of single ribs, suggest that the specimen could be an early representative of *Orthosphinctes*.
The stratigraphic position of the level RK-07 is confirmed to lie within the Hypselum Zone by the occurrence of *O. ariniensis* below and *P. gygii* above (Fig. 2), both taxa being firmly assigned to this zone.

4. Discussion and conclusions

The small ammonite fauna described from Rostam Kola comes from the northernmost section of the west East Alborz (Fig. 1) hitherto described. The rock succession is dominated by light colored limestones in

rather thick sequences, suggesting deposition on a shallow and well-oxygenated carbonate platform.

The fauna of Rostma Kola is composed exclusively of Oxfordian perisphinctids belonging to the subfamilies Passendorferiinae as the predominant faunal elements, and Ataxioceratinae. They range from the Grossouvrei Subzone (upper Bifurcatus Zone) to the middle Bimammatum Zone in the chronostratigraphic scale adopted (Fig. 2; cf. Meléndez et al. 2006; Schweigert & Callomon 1997: fig. 10).

Oxfordian ammonites from the East Alborz Mountains are known from several localities as summarized by Seyed-Emami & Schairer (2010). These faunas as a whole cover all the Oxfordian and part of the Lower Kimmeridgian. The very small ammonite faunas collected from localities closest to Rostam Kola (Seyed-Emami et al. 1998), Emamzadeh-Hashem and Kuhe Sharaf, are dominated by oppeliids and aspidoceratids, ranging from a middle Oxfordian to early Kimmeridgian age.

The two best known assemblages come from the Lar Formation at Koppeh Dagh (Fig. 1; Seyed-Emami & Schairer 2010, 2011) and are the most interesting in the present context for comparison because they range through the upper middle Oxfordian to the lowermost Kimmeridgian. The lower assemblage (Seyed-Emami & Schairer 2011) seems to be mainly confined to the Bifurcatus Zone perhaps expanding to the lower Bimammatum Zone. It is composed of several Perisphinctinae (*Dichotomoceras*) and long-ranging oppeliids besides phylloceratids (*Sowerbyceras*), aspidoceratids and aulacostephanids, but no reference to any representatives of the Passendorferiinae is made by these authors. The upper assemblage (Seyed-Emami & Schairer 2010) has been confined to the Bimammatum Zone and is composed of phylloceratids (*Sowerbyceras*), oppeliids, aspidoceratids and various representatives of the Ataxioceratinae, but again, no reference to Passendorferiinae is made. The most similar forms are representatives of *Orthosphinctes*, but belonging to different, younger species.

The palaeobiogeographic character of the Rostam Kola fauna is clearly Tethyan, showing closest affinities with the correlative sequences of the Submediterranean Province recorded in epicontinental platforms in Eastern Iberia, SE France (French Jura; Provence), Swiss Jura, South Germany (and Central Europe) and Polish Jura, where representatives of Ataxioceratinae and, partly, of Passendorferiinae are predominant. This is clearly evidenced by the close correlation with ammonite forms and sequences described by Oppenheimer (1907), Enay, (1966), Meléndez (1989) and Brochwicz-Lewinski & Rózak (1976). Relationships with the Mediterranean Province are also evident although less marked, as evidenced by both the lithology (Rosso Ammonitico facies is lacking in the recorded sections) and by the virtual absence of representatives of the Phylloceratina and Lytoceratina in the studied assemblages, which in typically Mediterranean areas usually constitute more than 60% of the ammonite faunas (see Fözy & Meléndez 1996; D'Arpa & Meléndez 2002). This conclusion is in agreement with the palaeogeographic model for the North Iran proposed by Seyed-Emami & Schairer (2010, 2011). That is, a relative displacement of N Iran from a position close to the Russian platform at about 45°N towards a latitude of about 30°N for the Late Jurassic. This southern trend of the latitudinal change of the North Iran might have caused, together with sedimentological and environmental changes, a dominance of the Submediterranean character of the local faunas.

The differences in composition between the coeval faunas of Rostam Kola, dominated by Passendorferiinae without oppeliids, and Koppeh Dagh, dominated by Perisphinctinae and Ataxioceratinae associated with abundant Oppeliids but lacking Passendorferiinae, are a very interesting question to be addressed in future research.

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