Lower and Middle Jurassic Ammonoids of the Shemshak Group in Alborz, Iran and Their Palaeobiogeographical and Biostratigraphical Importance

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Lower and Middle Jurassic ammonoids of the Shemshak Group in Alborz, Iran and their palaeobiogeographical and biostratigraphical importance

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The Shemshak Group at Shahmirzad (northern Iran) is characterized by the most frequent and extensive marine intercalations and contains the most abundant and diverse ammonite faunas hitherto known from the Lower and lower Middle Jurassic strata of the Alborz Range. So far, 62 ammonite taxa have been recorded from this area, including 25 taxa from earlier studies. The taxa belong to the families Cymbitidae, Echioceratidae, Amaltheidae, Dactylioceratidae, Hildoceratidae, Graphoceratidae, Hammatoceratidae, Erycitidae, and Stephanoceratidae with the new species *Paradumortieria elmii* and *Pleydellia* (*P.*?) *ruttneri*. The fauna represents the Late Sinemurian, Late Pliensbachian, Toarcian, Aalenian, and Early Bajocian. Palaeobiogeographically, it is closely related to the Northwest European (Subboreal) Province, and exhibits only minor relations with the Mediterranean (Tethyan) Province.

Key words: Ammonitida, biostratigraphy, palaeobiogeography, Jurassic, Shemshak Group, Alborz Mountains, Iran.

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Introduction

The Shemshak Group (Assereto 1966; Fürsich et al. in press) is a thick siliciclastic succession, widely distributed across central and northern Iran (Fig. 1), the so-called Iran Plate. The nature of this succession, with immense thicknesses up to 4,000 m and rapid lateral and vertical changes, indicates sedimentation in several foreland basins in front of tectonically active, uplifted areas of the Cimmerian mountain belt to the north, created by Late Triassic movements (the Early Cimmerian Orogenic Event; e.g., Seyed-Emami 2003). The age of the Shemshak Group ranges from Late Triassic to Early Bajocian, and sedimentary environments comprise deep to shallow marine shelf, deltas, paralic swamps, lakes and meandering as well as braided rivers (Vollmer 1987; Repin 1987; Seyed-Emami et al. 2001, 2005, 2006; Seyed-Emami 2003; Fürsich et al. 2005; Fürsich et al. in press). Besides several short-lived marine ingressions in the Norian, Late Sinemurian, and Late Pliensbachian (Domerian), the most conspicuous and long-lasting transgression within the Shemshak Group occurred during the Toarcian and Aalenian, well documented by marine faunas (ammonites) practically everywhere in the Alborz Range and central Iran (Seyed-Emami 1988; Fürsich et al. 2005).

Institutional abbreviation.—BSPG, Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany. All fossil material described in this paper belong to this collection and institutional abbreviations are skipped (only specimen numbers are provided).

Other abbreviations.—D, diameter in mm; H, whorl height as % of diameter; U, umbilical width as % of diameter; W, whorl width as % of diameter.

Geological setting

In the area of Shahmirzad, 25 km north of Semnan, the Shemshak Group, with a thickness of up to 2,000 m, is widely distributed. It rests with erosional unconformity on Lower and Middle Triassic limestones and dolomites of the Elikah Formation and is succeeded, apparently disconformably, by the marls and limestones of the Middle Jurassic Dalichai Formation (Nabavi and Seyed-Emami 1977). The described ammonites come from three stratigraphic sections east and southeast of the small town Shahmirzad. Section 1 (Fig. 2) is situated about 1.5 km east of Shahmirzad, north of the asphalt road to Sari (N 35°47'15'', E 35°20'07''). Here only the

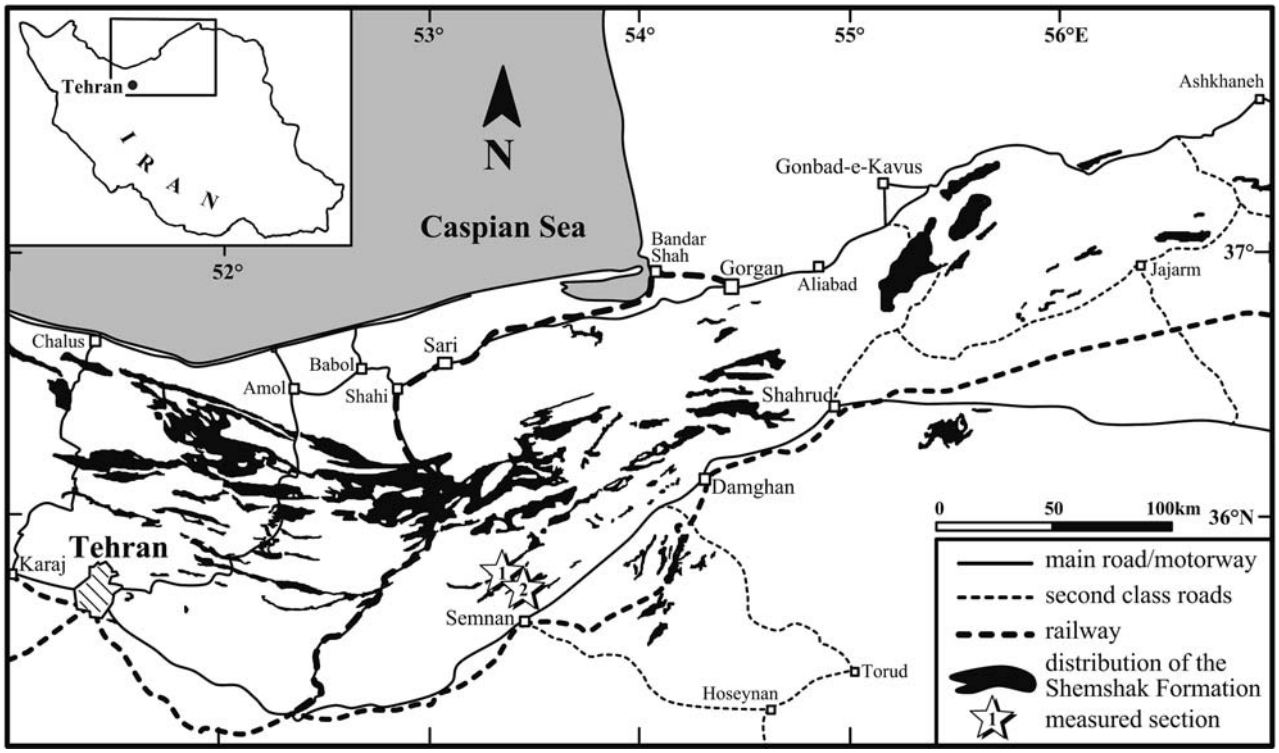


Fig. 1. Distribution of the Shemshak Group in the central and eastern Alborz, northern Iran. 1: Position of the Shahmirzad and Kuhe Bashm-e-Dehsufian sections; 2: Position of the Sharif Abad section.

lower part of the Shemshak Group is exposed. The upper part of the formation (Fig. 2) was studied at the Kuhe Bashm-e-Dehsufian pass (Kuhe Bashm), about 14 km further to the east, south of the road to Sari (N 35°49'35'', E 53°25'09''). The third section (Sharif-Abad; Fig. 3) is situated about 18 km NNE of Semnan, in a south-north trending valley ca 2 km west of the classic section of Diktash (N 35°42'59'', E 53°26'01''). Here again, only the upper part of the formation has been studied.

Previous investigations.—Marine fossils from the Shemshak Group of the classical area north of Semnan (Diktash) were collected and recorded for the first time by Stahl (1897, 1911). The few ammonites of this collection have been studied by Pompeckj (1897) and Fischer (1914, 1915) and later were revised by Seyed-Emami (1967). More detailed stratigraphic and palaeontological studies on the Shemshak Group of the Shahmirzad area have been carried out by Nabavi and Seyed-Emami (1977), Seyed-Emami and Nabavi (1985) Seyed-Emami (1985, 1987), Nabavi (1987), Repin (1987), Hosseinzadeh (2003), and Seyed-Emami and Hosseinzadeh (2006).

Ammonite levels and biostratigraphy.—The described ammonite faunas are usually concentrated in certain succeeding levels of the three measured sections at Shahmirzad, Kuhe Bashm, and Sharif-Abad (Figs. 2, 3). Each ammonite level consists of a single bed or of several beds, a few decimetres to several metres or more in thickness. Between the levels in which ammonites are concentrated, there are many metres, or even tens of metres, of barren strata. The ammonite levels usually coincide with transgressive episodes and tectonically relatively quiet intervals with little siliciclastic input. These intervals are often characterized by calcareous sandstones or silty-sandy limestone intercalations, which are otherwise very subordinate constituents within the predominantly siliciclastic rocks of the Shemshak Group. Taking into consideration the great thickness of the Shemshak Group (2,000 m and more) and the discontinuous occurrence and scarcity of the fossils, it was not possible to obtain a continuous, bed by bed collection of the fauna.

For a better characterization of the ammonite fauna from the Shemshak Group of the Shahmirzad area, also taxa from earlier studies and collections by Nabavi and Seyed-Emami (1977), Seyed-Emami and Nabavi (1985), Hosseinzadeh (2003), and Seyed-Emami and Hosseinzadeh (2006) have been included in Table 1 and in the discussion.

Due the close relationship of the described fauna with that of Northwestern Europe, the biozonation follows the standard Northwest European ammonite zonation proposed by Dean et al. (1961) and Cariou and Hantzpergue (1997).

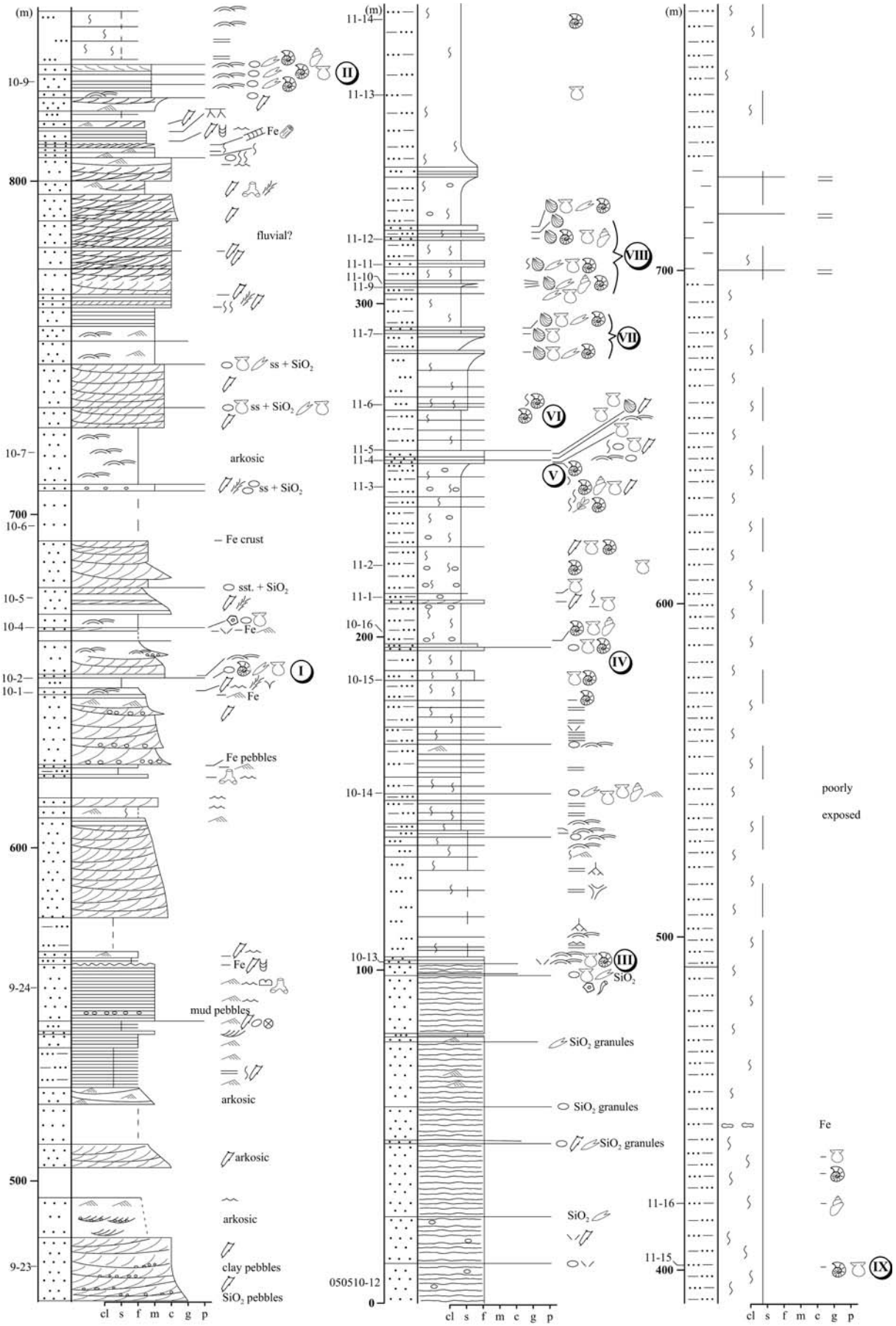
Level I (Shahmirzad)
Echioceras raricostatum Zone, Late Sinemurian.

Most ammonites are external moulds of small and juvenile forms, scattered on bedding planes of several successive, very hard, bioclastic sandstones.

The nearly monospecific fauna consists of *Paltechioceras* cf. *oosteri*. The Early Sinemurian ammonites, described earlier by Nabavi and Seyed-Emami (1977) from the same locality, probably come from the same level.

Table 1. Stratigraphic distribution and localities of the ammonite taxa from the Shemshak Group of the Shahmirzad area. Listed are all taxa from the present contribution (marked with *) and from previous publications (Nabavi and Seyed-Emami 1977; Seyed-Emami and Nabavi 1985; Seyed-Emami 1987; Seyed-Emami and Hosseinzadeh 2006).

Taxon	Series & Stage	Lower Jurassic																Middle Jurassic									Locality		
		U. Sinem.			Carixian			Domer. Pliensbachian		L		M			U Toarcian				L		M	U	Aalenian		L. Bajocian				
	Ammonite Zones (NW European)	Obtusum	Oxynotum	Raricostatum	Jamesoni	Ibex	Davoei	Margaritatus	Spinatum	Tenuicostatum	Serpentinum	Bifrons	Variabilis	Thouarsense	Dispansum	Pseudoradiosa	Aalensis	Opalinum	Murchisonae	Bradfordensis	Concavum	Discites	Laeviuscula	Propinquans	Humphriesianum	Shahmirzad	Kuhe-Bashm	Sharif-Abad
*Phylloceras sp.																		X										*
Ptychophylloceras aff. tatricum														X													*	
Cymbites (Metacymbites) fuersichi								X																		*		
*Paltechioceras cf. oosteri				X																						*		
*Amaltheus cf. stokesi								X																		*		
*Amaltheus margaritatus								X																		*		*
*Amaltheus subnodosus								X																		*		
Amauroceras sp.								X																			*	
*Dactylioceras (Dactylioceras) sp.												?															*	
*D. (Eodactylites?) pseudocommune										X																		*
*D. (Eodactylites) cf. pseudocommune										X																		*
*D. (Orthodactylites) aff. semicelatum										X																	*	*
*D. (Orthodactylites) cf. tenuicostatum										X																	*	
*Dactylioceratidae gen. et sp. nov.?												?															*	
*Catacoeloceras aff. raquinianum												X																*
*Oregonites cf. imlayi								X																		*		
*Protogrammoceras (P.) cf. celebratum								X																		*		
*P. (Matteiceras) cf. nitescens								X																		*		
*Pseudogrammoceras fallaciosum														X													*	
*Podagrosites latescens														X													*	
Dumortieria levesquei																X											*	
Dumortieria excentricostata																X											*	
Dumortieria aequicostata																X											*	
Dumortieria bleicheri																X											*	
Dumortieria brancoi																X											*	
Dumortieria radians																X											*	
Dumortieria gundershofensis																X											*	
*Dumortieria radiosa																X											*	
*Dumortieria moorei																X											*	
Paradumortieria rustica																X											*	
Paradumortieria explanata																X											*	
Paradumortieria semnanensis																X											*	
*Paradumortieria elmii																X											*	
Paradumortieria schaireri																X											*	
*Pleydellia (Pleydellia) mactra																	X										*	
*Pleydellia (Pleydellia) subcompta																	X										*	
Pleydellia (Pleydellia) celtica																	X										*	
Pleydellia (Pleydellia) fluens																	X										*	
*Pleydellia (Pleydellia) aalensis																	X										*	
*Pleydellia (Pleydellia) buckmani																	X										*	
*Pleydellia (Pleydellia?) ruttneri																	X										*	
Pleydellia (Pleydellia?) Arkelli																	X										*	
Pleydellia (Pleydellia?) distans																	X										*	
Pleydellia (Walkericeras) lotharingica																	X										*	
*Pleydellia (Cotteswoldia) fuselieri																	X										*	
*Pleydellia (Cotteswoldia) bifax																	X										*	
*Leioceras opalinum																		X									*	
*Leioceras comptum																		X									*	
*Graphoceras (Graphoceras) concavum																					X						*	*
*Graphoceras (Graphoceras) decorum																					X							*
*Graphoceras (Ludwigella) cornu																					X						*	
*Graphoceras (Ludwigella) cf. rudis																					X							*
Hammatoceras aff. tipperi																X											*	
*Bredyia alleoni																		X									*	
Bredyia iranica																		X									*	
Bredyia alborzensis																		X									*	
Bredyia guliensis																		X									*	
Bredyia shahmirzadensis																		X									*	
*Acardia aff. diadematoides																			X									*
Planammatoceras cf.tricolore																			X								*	
*Erycites aff. sphaeroconicus																		X									*	
*Stemmatoceras ? sp.																									X			*



This is the first record of the Late Sinemurian in Iran. The ammonites probably are evidence of the first marine ingression within the Jurassic part of the Shemshak Group. Palaeobiogeographically, *Paltechioceras oosteri* is a rather pandemic taxon, being known also from Europe (Schlatter 1991; Blau 1998) and North and South America (Hillebrandt 2002).

Level II (Shahmirzad); **level A** (Sharif-Abad)
Amaltheus margaritatus Zone, Late Pliensbachian.

This level consists of several layers of reworked, hard calcareous sandstone concretions in a matrix of fine-grained sandstone. The scarce fauna comprises, besides large belemnites and bivalves, the following ammonites: *Cymbites* (*Metacymbites*?) *fuersichi*, *Amaltheus* cf. *stokesi*, *A. subnodosus*, *A. margaritatus*, *Oregonites* cf. *imlayi*, *Protogrammoceras* (*P.*) cf. *celebratum*, *P.* (*Matteiceras*) cf. *nitescens*. *Cymbites* and *Protogrammeras* come from the lowest bed, below the beds with *Amaltheus*. This is the first record of these genera from Iran. So far only a few occurrences of *Amaltheus* have been recorded from Shahmirzad (Nabavi and Seyed-Emami 1977), some localities in Central Alborz (Lorenz 1964; Allenbach 1966; Dedual 1967; Pourmotamed and Motamed 1976; Repin 1987), and from a few sites in southwestern Alborz (at Zanjan and Maragheh; KSE personal observations). Until now *Amaltheus* and the above mentioned taxa have not been recorded from the Shemshak Group of Central Iran.

Palaeobiogeographically, Amaltheidae are typical Boreal taxa, being restricted to the northern part of the northern hemisphere (Dagis 1976; Meister 1988; Dommergues et al. 1997, 2005; Meister and Stampfli 2000; Smith et al. 2001). Also, Cymbitidae are more or less northern elements being recorded from Europe and North America (e.g., Seyed-Emami and Hosseinzadeh 2006). In contrast, Harpoceratinae (*Protogrammoceras* and *Matteiceras*) are originally Tethyan elements, being widely distributed in circum-Mediterranean areas, but are also known from Northwestern Europe and North America (e.g., Smith and Tipper 1996).

Level III (Kuhe Bashm); **level B** and **level C** (Sharif-Abad)
Dactylioceras tenuicostatum Zone, Early Toarcian.

At Kuhe Bashm the ammonites (*Dactylioceras* [*D.*] sp., *D.* [*Orthodactylites*] aff. *semicelatum*, *D.* [*O.*] cf. *tenuicostatum*, Dactylioceratidae gen. et sp. nov.?) occur in several metres of very hard, well-bedded, greyish-blue sandstone. At Sharif-Abad the ammonites come from level B (*D.* [*Eodactllites*] *pseudocommune*) and level C (*D.* [*E.*] cf. *commune*, *D.* [*O.*] cf. *semicelatum*), separated from each other by about 12 m of section.

The earliest Toarcian in northwest European as well in Mediterranean areas is characterized by the disruption of the Late Pliensbachian Tethyan-Boreal provinciality and the homogeneization of the ammonoid faunas of both provinces, which lasts until the Bajocian (Macchioni and Cecca 2002).

← Fig. 2. Middle part of the Shemshak Group in the Shahmirzad area, combined from the Shahmirzad section (left column) and the Kuhe Bashm-e-Dehsufian section (right two columns). For key see Fig. 3.

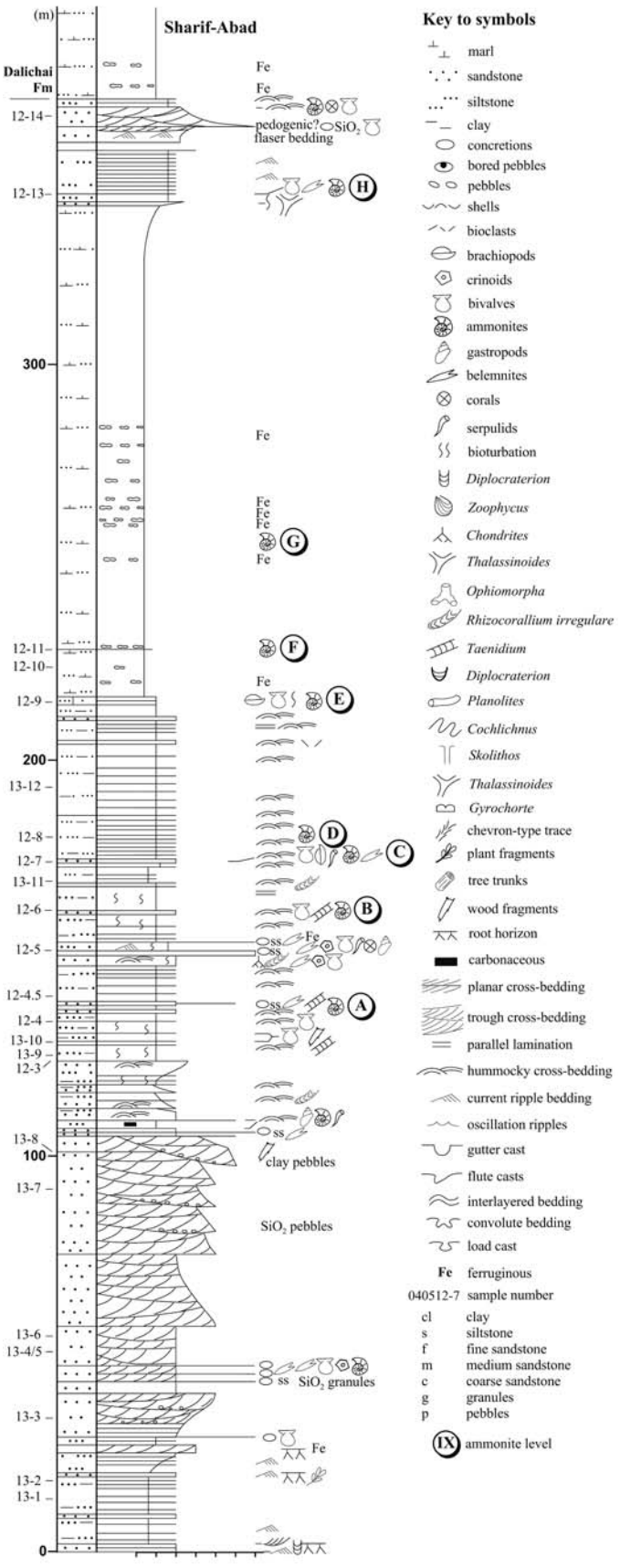


Fig. 3. Upper part of the Shemshak Group at Sharif-Abad.

Besides, the Early Toarcian *Dactylioceras tenuicostatum* Zone is characterized, both in Tethyan and in northwest European areas, by the explosion of Dactylioceratidae (Elmi et al. 1997; Page 2004). So far, the Early Toarcian Oceanic Anoxic Event and the overall extinction and drop in diversity of the ammonoids (Macchioni and Cecca 2002) could not be recognized in the Alborz Mountains, because of the scarcity and discontinuous dispersal of the fauna and the great thickness of the strata.

Dactylioceratidae have been reported sporadically from several sites in the Alborz Mountains (Repin 1987, 2000). In Central Iran only few occurrences are known from the regions of Kerman (Seyed-Emami 1967) and the northern Lut (Seyed-Emami et al. 2004). The few specimens of *Dactylioceras* do not allow to draw any significant palaeobiogeographic conclusions.

Level D (Sharif-Abad)
Hildoceras bifrons/*Haugia variabilis* Zone, Middle Toarcian.

Only a single specimen of *Catacoeloceras* aff. *raquinianum* was found at this level.

Middle Toarcian Hildoceatinae have been recorded from few sites in the central and eastern Alborz Mountains (Repin 1987; Seyed-Emami et al. 2005). There is no reliable record from Central Iran.

Level IV (Kuhe Bashm)
Grammoceras thouarsense Zone, *Pseudogrammoceras fallaciosum* Subzone, Late Toarcian.

The nearly monospecific fauna comes from a 10 m thick package of silty marl with intercalations of sandy limestones. It consists of *Pseudogrammoceras fallaciosum* and *Podagrosites latescens*. *Pseudogrammoceras fallaciosum* is the most constant and widely distributed taxon in the Shemshak Group of North and Central Iran, so that a *Pseudogrammoceras fallaciosum* Horizon can be established.

Level V (Kuhe Bashm); **Level E** (Sharif-Abad)
Dumortieria pseudoradiosa/*Pleydella aalensis* Zone, Late Toarcian.

The levels are represented by silty shales and marls with intercalations of lenticular concretionary limestones with large bivalves, gastropods, and belemnites. The relatively rich ammonite fauna consists predominantly of a variety of Dumortierinae, being often concentrated within head-sized calcareous concretions: *Dumortieria levesquei*, *D. excentricostata*, *D. aequicostata*, *D. bleicheri, D. brancoi*, *D. radians*, *D. gundershofensis*, *D. radiosa*, *D. moorei*, *Paradumortieria rustica*, *P. explanata*, *P. semnanensis*, *P. schaireri*, *P. elmii*, and *Hammatoceras* aff. *tipperi*. The great number of microconchs (*Paradumortieria*) is noteworthy.

Dumortieria appears clearly below the beds with *Pleydellia*, but continues higher up into the lower beds with *Pleydellia*. Neither in the Alborz region nor in Central Iran such a richness and diversity of Dumortierinae exist. The total absence of *Catulloceras*, and the scarcity of Hammatoceratinae is remarkable. These are common elements in strata of the same age in northwestern Europe as well as in the Tethys region (Elmi et al. 1997).

The *Phlyseogrammoceras dispansum* (*Hammatoceras speciosum*) Zone, which is characterized in Europe by the explosion of *Hammatoceras* (Elmi et al. 1997: 32), could not be proven with certainty. The absence of taxa indicative of this zone reflects ecological parameters or insufficient collecting rather than than non-deposition.

Level VI (Kuhe Bashm)
Pleydella aalensis Zone, Late Toarcian.

Lithologically, level VI is the continuation of the strata of level V. In the lower part there are still some *Dumortieria*. But higher up, the ammonite fauna consists nearly exclusively of a rich and diverse fauna of *Pleydellia*, being commonly concentrated, similarly to level V, in head-sized concretions: *Pleydellia* (*P.*) *mactra*, *P.* (*P.*) *subcompta*, *P.* (*P.*) *celtica*, *P.* (*P.*) *fluens*, *P.* (*P.*) *aalensis*, *P.* (*P.*) *buckmani*, *P.* (*P.*?) *ruttneri*, *P.* (*P.*?) *arkelli*, *P.* (*Walkericeras*) *lotharingica*, *P.* (*Cotteswoldia*) *fuselieri*, and *P.* (*C.*) *bifax*.

Dumortierinae comprise more than 50% of the total fauna and are closely related to those from northwestern Europe. According to Macchioni and Cecca (2002) all Toarcian Ammonitina derive from Tethyan ancestors, which belong to the Tethyan family Hildoceratidae.

Level VII (Kuhe Bashm); **level F** (Sharif-Abad)
Leioceras opalinum Zone (*Leioceras opalinum* Subzone), Early Aalenian.

The level consists of sandy marl with intercalations of sandy limestones containing large bivalves, gastropods, and belemnites. Besides few specimens of finer ribbed Leioceratinae (*Leioceras opalinum*) the level is characterized by the sudden appearance and dominance of partly new taxa of Hammatoceratinae: *Bredyia alleoni*, *B. guliense*, *B. iranica*, *B. alborzensis*, *B. shahmirzadense*, *Erycites* aff. *sphaeroconicus*. This level distinctly overlies the beds with *Pleydellia* and underlies the beds with more coarsely ribbed Leioceratinae of the *Leioceras comptum* group.

Hammatoceratinae are rather rare elements in the Shemshak Group of the Alborz Mountains, but are fairly common at Kuhe Bashm (about 10% of the ammonite fauna) and in the age-equivalent Badamu Formation of southeastern Central Iran (Kerman-Ravar region; e.g., Seyed-Emami 1967).

Level VIII (Kuhe Bashm)
Leioceras opalinum Zone, *Leioceras comptum* Subzone, Early Aalenian.

At this level coarsely ribbed Leioceratinae of the *Leioceras comptum/L. crassicostatum* group (*Leioceras comptum*) occur. The level contains the last calcareous beds, which first began to appear at level IV to form a package of about 120 m of marly silt with limestone intercalations, approximately in the middle part of the section at Kuhe Bashm (Fig. 2). These strata are characterized by a relatively rich and diverse ammonite fauna, as a result of favourable ecological conditions, environmental stability, and a low rate of sedimentation. The greater part of the fauna comes from this succession.

Level IX (Kuhe Bashm); **level G** (Sharif-Abad)
Otoceras concavum Zone, Late Aalenian.

The few ammonites occurring at this level are *Graphoceras* (*G.*) *concavum*, *G.* (*G.*) *decorum*, *G.* (*Ludwigella*) *cornu*, *G.* (*L.*) cf. *rudis*, and *Acardia* aff. *diadematoides*.

At Kuhe Bashm, above the last limestone bed of level VIII, follows several hundred metres thick package of dark, monotonous, fine-grained siliciclastics in which fossils are extremely rare. At Sharif-Abad, this unit comprises only 120 m. The few ammonites (Graphoceratinae) mostly come from concretions in the lower third of the succession. The absence of Middle Aalenian (*Ludwigia murchisonae* Zone) ammonites is for sure related to the scarcity of the fauna due to the high rate of sedimentation, unfavourable ecological conditions (a dysoxic to anoxic environment), and to preservational conditions, lasting until the end of the Aalenian and the beginning of the Bajocian (Fürsich et al. 2005).

In contrast to North Iran, Middle–Late Aalenian ammonites are fairly well known from the Badamu Formation of east-central Iran (Seyed-Emami 1967).

Level G (Sharif-Abad)
Waagenia propinquans/*Stephanoceras humphriesianum* Zone, Early Bajocian.

Several metres of sandy limestones with large bivalves (e.g., *Plagiostoma*), belemnites, and only a single fragment of Stephanoceratidae (*Stemmatoceras*? sp.). This is the first record of Early Bajocian ammonites from the Shemshak Group of North Iran. Contrary to the Alborz area, Early Bajocian Sonniniidae and Stephanoceratidae are well represented in east-central Iran (Seyed-Emami 1967, 1971, 1988; Seyed-Emami et al. 1993, 2004).

Systematic palaeontology

Order Ammonitida Zittel, 1884
Suborder Phylloceratina Arkell, 1950
Superfamily Phylloceratoidea Zittel, 1884
Family Phylloceratidae Zittel, 1884
Genus *Phylloceras* Suess, 1865
Phylloceras sp.

Fig. 4A.

Material.—A single inner whorl from Sharif-Abad (050512-11/13).

Stratigraphic and geographic range.—The single inner whorl was collected from the scree together with a mixed fauna from the Lower Aalenian.

Suborder Ammonitina Hyatt, 1889
Superfamily Psiloceratoidea Hyatt, 1867
Family Echioceratidae Buckman, 1913
Genus *Paltechioceras* Buckman, 1927
Paltechioceras cf. *oosteri* (Dumortier, 1867)

Fig. 4F.

1867 cf. *Ammonites oosteri*; Dumortier 1867: 164, pl. 30: 3, 4.
1977 *Arnioceras mendax rariplicata* Fucini; Nabavi and Seyed-Emami 1977: 80, fig. 9 (2, 3).
1991 cf. *Paltechioceras* cf. *oosteri* (Dumortier); Schlatter 1991: 44, pl. 5: 8–11; text-fig. 29.
1998 cf. *Paltechioceras oosteri* (Dumortier, 1867); Blau 1998: 213, pl. 10: 14, 17, 19; pl. 14: 2.
2002 cf. *Paltechioceras oosteri* (Dumortier, 1867); Hillebrandt 2002: 107, pl. 11: 14–21.

Material.—One external mould (050510-2) and several juvenile specimens from Shahmirzad.

Dimensions (in mm)

Specimen	D	U	H	W	ribs/whorl
050510-2	27	~59	24	–	36
69-N-183b	34	58	26	26	36

Description.—The figured specimen is extremely evolute, tricarinate-bisulcate, with a nearly quadrate whorl cross-section. Ribs are strong, sharp and radiate. At the ventrolateral edge the ribs thicken slightly, bend forward and die out near the ventral grooves. In a smaller specimen (050510-3/1) the suture line is visible. It is relatively simple with minor indentations.

Discussion.—With respect to the number and coarseness of ribs, which slightly thicken towards the venter, as well as in dimensions our specimens are closely comparable with *P. oosteri*, especially the specimens figured by Schlatter (1991: pl. 5: 8) and Blau (1998: pl. 10: 4).

Previous records of *Vermiceras* and *Arnioceras* (Nabavi and Seyed-Emami 1977) from the same locality and probably from the same level, are most likely misidentifications and also belong to the genus *Paltechioceras*. Similarly, *Vermiceras scylla* (Reynès, 1879) in Nabavi and Seyed-Emami (1977: 80, fig. 9/1) is probably a *Paltechioceras*. Except for the venter, which does not seem to be tricarinate, the latter closely resembles *P. aplanatum* (Hyatt, 1889) of Schlatter (1991: pl. 7: 2).

Stratigraphic and geographic range.—Shahmirzad, level I. *Paltechioceras oosteri* is widely distributed in the Late Sinemurian of Europe, being also recorded from North and South America (Hillebrandt 2002). Blau (1998: 234) recorded *P. oosteri* from the *Paltechioceras aplanatum* Subzone of the *Echioceras raricostatum* Zone, Upper Sinemurian (Lotharingian). This is the first record of *Paltechioceras* from Iran.

Superfamily Hildoceratoidea Hyatt, 1867
Family Amaltheidae Hyatt, 1867
Genus *Amaltheus* de Monfort, 1808
Amaltheus cf. *stokesi* (J. Sowerby, 1818)

Fig. 4B.

1818 cf. *Ammonites Stokesi*; J. Sowerby 1818: 205, pl. 190.
1977 *Amaltheus stokesi* (Sowerby); Nabavi and Seyed-Emami 1977: 81, fig. 9 (5, 6 only).

1998 cf. *Amaltheus stokesi* (Sowerby, 1818); Géczy and Meister 1998: 102, pl. 6: 10 (with synonymy).
2003 *Amaltheus stokesi* (Sowerby, 1818); Hosseinzadeh 2003: 61, pl. 1: 17, 18.

Material.—Several poorly preserved inner whorls from Shahmirzad (050514-6).

Description and discussion.—Among the small and poorly preserved amaltheids from Shahmirzad there are several specimens which may be assigned to *A. stokesi*. The figured specimen (050514-6/6) is a relatively coarsely ribbed *Amaltheus*. The ribs bifurcate near the venter and cross it as chevrons. The passage from the flank to the venter is gradual, and the keel is not as prominent as that of *A. margaritatus*. Juvenile specimens of *A. stokesi* and *A. margaritatus* cannot be distinguished from each other with certainty, which has been already mentioned by Howarth (1958: 5).

Stratigraphic and geographic range.—Shahmirzad, level II. *A. stokesi* is widely distributed in the boreal regions of northwest Europe, northwest America, Siberia and Caucasus, occurring in the *Amaltheus stokesi* Subzone of the *Amaltheus margaritatus* Zone, Late Pliensbachian (Smith and Tipper 1996: 51).

Amaltheus margaritatus de Montfort, 1808

Fig. 4C, D, G, T.

1808 *Amaltheus margaritatus*; de Montfort 1808: 91, fig. 90.
1958 *Amaltheus margaritatus* de Montfort; Howarth 1958: 13, pl. 3: 4–6; text-figs. 8, 9 (with synonymy).
1976 *Amaltheus margaritatus* de Montfort; Pourmotamed and Motamed 1976: 106, fig. 3.
1977 *Amaltheus stokesi* (Sowerby); Nabavi and Seyed-Emami 1977: 81, fig. 9 (4, 5 only).
1986 *Amaltheus margaritatus* (de Montfort 1808); Meister 1986: 95, pl. 20: 9; pl. 22: 1; pl. 23: 6 (with synonymy).
1998 *Amaltheus margaritatus* de Montfort, 1808; Géczy and Meister 1998: 103 (with synonymy).

Material.—One specimen from Gardaneh-e-Emamzaheh-Hashem (northeast of Tehran, Central Alborz) and more than 10 poorly preserved inner whorls from Shahmirzad (050514-6) and Sharif-Abad (050512-5). Specimens H-233 and 90-SE-1 come from earlier collections made by Mohammad Hosseinzadeh from Shahmirzad and K.S.-E. from Emam-Zadeh Hashem Pass in Central Alborz.

Dimensions (in mm)

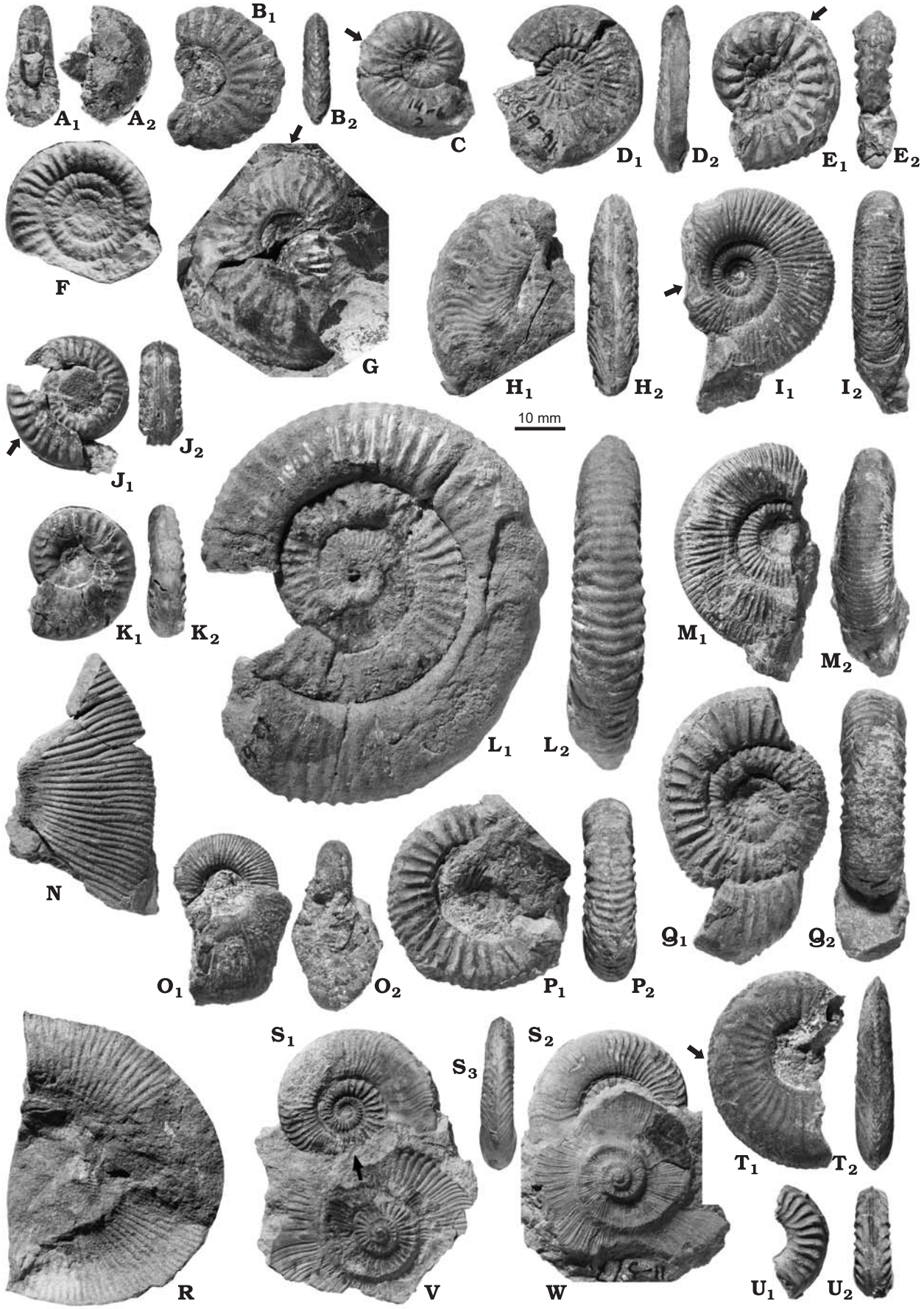
Specimen	D	U	H	W
050514-6/3	16	31	44	–
050514-6/2	24	31	42	~25
050514-6/5	31	38	37	~23 (evolute specimen)
H-233	38	34	41	~21 (finely ribbed specimen)
90-SE-1	44	23	~48	–

Description.—Specimen 90-SE-1 (Fig. 4G) is a flat, oxycone and relatively involute *Amaltheus*, with a rather prominent and fairly finely crenulated keel. Ribs are medium-coarse and slightly sigmoidal. Close to the venter the ribs curve forward and almost fade before reaching the keel.

Discussion.—The specimens from Shahmirzad are small inner whorls, with a varying degree of involution and coarseness of the ribs. Specimen H-233 (Fig. 4T) is very finely ribbed, looking much like *A. depressus* Simpson, 1843, stadium *compressum* Quenstedt in Frentzen (1937: pl. 2: 4). The latter has been regarded as a synonym of *A. margaritatus* by Howarth (1958: 140). Nevertheless, the juvenile, poorly preserved specimens from Shahmirzad can be placed, with caution, within the range of variation of *A. margaritatus* of Meister (1988). On a slab with *A. margaritatus* (90-SE-1) there is a fragment of *Amauroceras* sp., looking much like *A. ferruginum* (Simpson, 1843) of Meister (1986: pl. 20: 7). The genus *Amauroceras* has been considered to be the microconch form to *Amaltheus* by Meister (1986: 125).

Stratigraphic and geographic range.—Shahmirzad, level II; Sharif-Abad, level A; *Amaltheus margaritatus* Zone, Late Pliensbachian (Domerian). Amaltheids are typical Boreal and "Euroboreal" taxa (Dagis 1976; Meister 1988; Meister

Fig. 4. Upper Sinemurian to Lower Aalenian ammonoids from the Shemshak Group. **A**. *Phylloceras* sp., Sharif-Abad, 050512-11/13, Lower Aalenian; apertural (A_1) and lateral (A_2) views. **B**. *Amaltheus* cf. *stockesi* (J. Sowerby, 1818), Shahmirzad, 050514-6/6, *Amaltheus margaritatus* Zone, Upper Pliensbachian; lateral (B_1) and ventral (B_2) views. **C**, **D**, **G**, **T**. *Amaltheus margaritatus* de Montfort, 1808, *A. margaritatus* Zone, Upper Pliensbachian. **C**. Shahmirzad, 050514-6/2, lateral view. **D**. Shahmirzad, 050514-6/5; lateral (D_1) and ventral (D_2) views. **G**. Gardaneh-e-Emmamzadeh-Hashem, Central Alborz, 80-SE-1, lateral view. **T**. Shahmirzad, H-233; lateral (T_1) and ventral (T_2) views. **E**. *Amaltheus subnodosus* (Young and Bird, 1828), Shahmirzad, 050514-6/1, *A. subnodosus* Subzone, *A. margaritatus* Zone; lateral (E_1) and apertural (E_2) views. **F**. *Paltechioceras* cf. *oosteri* (Dumortier, 1867), Shahmirzad, 050510-2, *Echioceras raricostatum* Zone, Upper Sinemurian (plaster cast), lateral view. **H**. *Protogrammoceras* (*Protogrammoceras*) cf. *celebratum* (Fucini, 1900), Shahmirzad, 050514-6/12, *A. margaritatus* Zone, Upper Pliensbachian; lateral (H_1) and ventral (H_2) views. **I**, **M**. *Dactylioceras* (*Orthodactylites*) aff. *semicelatum* (Simpson, 1843), *Dactylioceras tenuicostatum* Zone, Lower Toarcian. **I**. Sharif-Abad, 050512-7/1; lateral (I_1) and ventral (I_2) views. **M**. Sharif-Abad, 050512-7/4; lateral (M_1) and ventral (M_2) views.. **J**. *Oregonites* sp. cf. *O. imlayi* Wiedenmayer, 1980, Shahmirzad, 050514-6/10, Upper Pliensbachian; lateral (J_1) and ventral (J_2) views. **K**. *Protogrammoceras* (*Matteiceras*) cf. *nitescens* (Young and Bird, 1828), Shahmirzad, 050514-6/10, *A. margaritatus* Zone, Upper Pliensbachian; lateral (K_1) and ventral (K_2) views. **L**. *Dactylioceras* (*Eodactylites*?) *pseudocommune* Fucini, 1935, Sharif-Abad, 050512-6/1, *D. tenuicostatum* Zone, Lower Toarcian; lateral (L_1) and ventral (L_2) views. **N**, **R**. *Dactylioceras* (*Orthodactylites*) sp., cf. *D.* (*O.*) *tenuicostatum* (Young and Bird, 1822), Kuhe Bashm-e-Dehsufian, Lower Toarcian. **N**. 80-SE-5 (crushed specimen), lateral view. **R**. 80-SE-19 (plaster cast), lateral view. **O**. Dactylioceratidae indet., Kuhe Bashm-e-Dehsufian, H-204, *D. tenuicostatum* Zone, Lower Toarcian; lateral (O_1) and apertural (O_2) views. **P**. *Dactylioceras* (*Eodactylites*?) cf. *pseudocommune* Fucini, 1935, Sharif-Abad, 050512-7/2, *Arnioceras semicostatum* Zone, Lower Toarcian; lateral (P_1) and ventral (P_2) views. **Q**. *Dactylioceras* (*Dactylioceras*) sp., Kuhe Bashm-e-Dehsufian, 80-SE-16, ?Middle Toarcian; lateral (Q_1) and apertural (Q_2) views. **S**. *Paradumortieria schaireri* (Seyed-Emami, 1985) [m], Kuhe Bashm-e-Dehsufian, 050511-3/5, *Pleydella aalensis* Zone, Upper Toarcian; lateral (S_1, S_2) and ventral (S_3) views. **U**. *Podagrosites latescens* (Simpson, 1843), Kuhe Bashm-e-Dehsufian, 050510-16/3, *Pseudogrammoceras fallaciosum* Subzone, *Grammoceras thouarsense* Zone, Upper Toarcian; lateral (U_1) and ventral (U_2) views. **V**. *Dumortieria radiosa* (Seebach, 1864), Kuhe Bashm-e-Dehsufian, 050511-3/7, *Pleydella aalensis* Zone, Upper Toarcian, lateral view (impression of Fig. 5J$_1$). **W**. *Dumortieria moorei* (Lycett, 1857), Kuhe Bashm-e-Dehsufian, 050511-3, *Pleydella aalensis* Zone, Upper Toarcian, lateral view (impression). Arrows indicate onset of body chamber; m = microconch. →



and Stampfli 2000; Smith et al. 2001), which occur only sporadically in northern Iran (Nabavi and Seyed-Emami 1977; Seyed-Emami 1988). So far, this is the southernmost occurrence of the family within the northern hemisphere (northwestern Tethys).

Amaltheus subnodosus (Young and Bird, 1828)

Fig. 4E.

1828 *Ammonites subnodosus*; Young and Bird 1828: 258, pl. 13: 3.
1958 *Amaltheus subnodosus* (Young and Bird); Howarth 1958: 8, pl. 2: 11–18; text-fig. 6 (with synonymy).

Material.—One fairly well preserved specimen with parts of the body whorl (050514-6/1) and two fragments (050514-6/4, 050514-6/9) from Shahmirzad.

Dimensions (in mm)

Specimen	D	U	H	W	ribs/whorl
050514-6/1	23	37	39	~35	15 (end of phragmocone)
	31	38	35	~24	18 (on the body whorl)

Description.—The figured specimen is a rather small, evolute and coarsely ribbed *Amaltheus* with elliptical whorl cross-section and a prominent crenulated keel. On the inner part of the flank ribs are strong, radiate-straight, with tubercles about the mid-flank. Near the venter, the ribs bend forward, become fainter, and bifurcate indistinctly. On the body chamber, the ribbing is slightly denser and less coarse and the tubercles gradually fade.

Discussion.—The described specimen matches well the neotype of *A. subnodosus*, designated by Howarth (1958: pl. 2: 11). Another very similar specimen is *A. margaritatus* forme *subnodosus* of Meister (1988: pl. 1: 6).

Stratigraphic and geographic range.—Shahmirzad, level II. *A. subnodosus* is reported to occur in the lower part of the *Amaltheus margaritatus* Zone (*A. subnodosus* Subzone).

Family Dactylioceratidae Hyatt, 1867

Genus *Dactylioceras* Hyatt, 1867

Subgenus *Dactylioceras* Hyatt, 1867

Dactylioceras (*Dactylioceras*) sp.

Fig. 4Q.

Material.—One specimen from earlier collections by K.S.-E. from Kuhe Bashm: (80-SE-16).

Dimensions (in mm)

Specimen	D	U	H	W
80-SE-16	41	48	29	29

Description.—Evolute *Dactylioceras* with nearly flat flanks, a quadratic whorl cross-section and a slightly rounded venter. On the last preserved whorl the ribbing is relatively coarse and widely spaced. The slightly prorsiradiate primaries bifurcate ventrolaterally.

Discussion.—The coarse ribbing and the quadratic whorl cross-section are similar to the lectotype of *D. commune* (J. Sowerby, 1815) refigured by Dean et al. (1961: pl. 72: 5a, b).

Stratigraphic and geographic range.—The precise stratigraphic position of the loosely collected specimen is not known. Elsewhere, *D. commune* occurs in the Middle Toarcian (*D. commune* Subzone).

Subgenus *Eodactylites* Schmidt-Effing, 1972

Dactylioceras (*Eodactylites*?) *pseudocommune* Fucini, 1935

Fig. 4L.

1935 *Dactylioceras pseudocommune* sp. nov.; Fucini 1935: 86, pl. 9: 1–3.
1966 *Dactylioceras pseudocommune* Fucini 1935; Fischer 1966: 26, pl. 1: 5; pl. 4: 3, 6.
1972 *Dactylioceras* (*Eodactylites*) *pseudocommune* Fucini, 1935; Schmidt-Effing 1972: 91, pl. 3: 1a–c; pl. 18: 7; text-fig. 15.
1973 *Dactylioceras* (*Dactylioceras*) *pseudocommune* Fucini; Howarth 1973: 253, pl. 1: 1 (with synonymy).
1994 *Eodactylites pseudocommunis* (Fucini); Faraoni et al. 1994: pl. 3: 1; pl. 4: 1–3, 5.

Material.—Two specimens from Sharif-Abad (050512-6/1, 050506/2).

Dimensions (in mm)

Specimen	D	U	H	W
050512-6/1	79	54	26	23

Description.—The figured specimen is a very evolute *Dactylioceras*, with nearly parallel, flat flanks and an arched venter. The whorl cross-section is rectangular to ovate. On the last preserved whorl the ribs are coarse, rectiradiate, rather sharp, and widely spaced. Most of the ribs bifurcate at the ventrolateral edge, but a few ribs are simple. There are no distinct tubercles at the point of bifurcation. On the crushed inner whorl the ribbing is relatively fine and dense.

Discussion.—Our specimen closely matches the one figured by Fucini (1935: pl. 9: 1), which has been designated as lectotype by Schmidt-Effing (1972: 91). The characteristic gable-shaped venter, being discussed by Fischer (1966) and Schmidt-Effing (1972), cannot be observed in our specimen, partly because of erosion.

Stratigraphic and geographic range.—*Dactylioceras* (*E.*) *pseudocommune* is largely a Mediterranean form, known to occur in the Late Pliensbachian (Domerian) or Early Toarcian (Fucini 1935; Schmidt-Effing 1972; Faraoni et al. 1994). Howarth (1973) recorded it from the base of the *Dactylioceras tenuicostatum* Zone. At Sharif-Abad it was found at level B, above the beds with *Amaltheus* and below the beds with *Dactylioceras semicelatum*.

Dactylioceras (*Eodactylites*?) cf. *pseudocommune* Fucini, 1935

Fig. 4P.

1935 cf. *Dactylioceras pseudocommune* n. sp.; Fucini 1935: 86, pl. 9: 1–3.

Material.—One specimen, partly covered by matrix, from Sharif-Abad (050512-7/2).

Dimensions (in mm)

Specimen	D	U	H	W
050512-7/2	36	50	32	28

Description.—Evolute Dactylioceratidae with flat flanks, a nearly rectangular whorl cross-section and a rounded venter. The ribbing is coarse, with straight and slightly prorsiradiate primaries, bifurcating near the venter, apparently without any tubercles.

Discussion.—The coarse ribbing, flat sides, and rectangular whorl cross-section are very similar to *D.* (*E.*) *pseudocommune* Fucini, 1935.

Stratigraphic and geographic range.—The specimen was found together with *D.* (*O.*) *semicelatum* from the Early Toarcian *Dactylioceras semicelatum* Zone (Sharif-Abad, level C).

Subgenus *Orthodactylites* Buckman, 1926

Dactylioceras (*Orthodactylites*) aff. *semicelatum* (Simpson, 1843)

Fig. 4I, M.

1843 aff. *Ammonites semicelatus*; Simpson 1843: 20.
1972 aff. *Dactylioceras* (*Orthodactylites*) *semicelatum* (Simpson, 1843); Schmidt-Effing 1972: 95, pl. 4: 1–4; pl. 19: 13; text-figs. 16, 17.
1980 aff. *Dactylioceras* (*Orthodactylites*) *semicelatum* (Simpson); Howarth 1980: 646, pls. 80, 81; pl. 82: 11, 12; text-figs. 2, 3 (with synonymy).
2004 aff. *Dactylioceras* (*Orthodactylites*) *semicelatum* (Simpson 1843); Seyed-Emami et al. 2004: 81, pl. 1: 1.

Material.—Three inner whorls from Sharif-Abad (050512-7/1, 050512-7/3, 050512-7/4) and two specimens from Kuhe Bashm collected earlier on by K.S.-E. (80-SE-18, H-209).

Dimensions (in mm)

Specimen	D	U	H	W
050512-7/1	36	42	31	29
050512-7/4	40	42	30	31

Description.—Moderately evolute *Dactylioceras* with an ovate, slightly higher than wide whorl cross-section, which converges a little towards the rounded venter. The ribs are slightly prorsiradiate, sharp, dense, relatively fine, single or bifurcating on the outer part of the flank. Ventrolateral tubercles are not developed at any stage.

Discussion.—Except for the somewhat narrower umbilicus, our specimens fits well within the range of variation of the species given by Howarth (1980: pl. 81: 1, 2).

Stratigraphic and geographic range.—Kuhe Bashm, level III; Sharif-Abad, level C. *D.* (*O.*) *semicelatus* is widely distributed in Europe, occurring in the *Dactylioceras tenuicostatum* Zone (?*Dactylioceras semicelatum* Subzone) of the Early Toarcian.

Dactylioceras (*Orthodactylites*) cf. *tenuicostatum* (Young and Bird, 1822)

Fig. 4N, R.

Material.—Four fragmentary and crushed specimens from Kuhe Bashm (050510-13/1, 050513/2, and from earlier collections by K.S.-E. (80-SE-5, 80-SE-19).

Discussion.—The wide umbilicus with extremely fine and dense ribs allows the fragmentary specimens to be compared with *D.* (*O.*) *tenuicostatum* and allied forms, discussed and figured by Howarth (1973: 258, pl. 5: 1, 2; pl. 6: 2, 3) and Howarth (1980: 650, pl. 82: 1–10, 13, 14).

Stratigraphic and geographic range.— Kuhe Bashm, level III. *D.* (*O.*) *tenuicostatum* has been recorded from the Lower Toarcian *Dactylioceras tenuicostatum* Zone.

Dactylioceratidae indet.

Fig. 4O.

Material.—One fragmentary phragmocone collected by Hosseinzadeh (2003) from Kuhe Bashm (H-204).

Description.—At a diameter of 20 mm the specimen is relatively evolute with an ovate whorl cross-section and flanks converging slightly towards the arched venter. The last preserved whorl becomes distinctly involute with a deep umbilicus and a vertical umbilical wall. Moreover, the whorls become considerably wider (W/H ratio = 92%), with flanks converging strongly towards the venter, resulting in a triangular-ovate whorl cross-section. The ribbing is extremely fine, dense, and sharp. The slightly prorsiradiate primaries (22 per half-whorl at D = 20 mm) bifurcate almost regularly about the mid-flank. The slightly finer secondaries cross the arched venter in a straight line. No tubercles are developed at the bifurcation point.

Discussion.—To some extent, the specimen has the appearance of a *Macrocephalites*. The narrow umbilicus and the fine ribbing of the last preserved whorl resembles *Dactylioceras* (*Iranodactylites*) *ketevanae* Repin (2000: 40, pl. 3: 1, 2), from which our specimen differs by its distinct broadness and a nearly triangular whorl cross-section. A very similar, perhaps conspecific specimen is *Dactylioceras* sp. nov. from the Shemshak Group of the Lut Block, East Central Iran (Seyed-Emami et al. 2004: 81, pl. 1: 3a, b). However, the latter has a finer and denser ribbing.

Stratigraphic and geographic range.—Repin (2000: 41) recorded *D.* (*I.*) *ketevanae* from the *Hildoceras bifrons* Zone. The specimen from the Lut Block comes from the Lower Toarcian (Seyed-Emami et al. 2004). Hosseinzadeh (2003: 67) found the described specimen, together with *D.* (*O.*) *semicelatum*, in the *Dactylioceras tenuicostatum* Zone of the Early Toarcian.

Genus *Catacoeloceras* Buckman, 1923

Catacoeloceras aff. *raquinianum* (d'Orbigny, 1845)

Fig. 5O.

1845 aff. *Ammonites Raquinianum*; d'Orbigny 1845: 332, pl. 106: 4, 5 (only).
1972 aff. *Catacoeloceras raquinianum* (d'Orb.); Guex 1972: 640, pl. 11: 6.
1994 aff. *Catacoeloceras raquinianum* (d'Orbigny, 1845); Atrops in Fischer 1994: 94, pl. 33: 2a–c.

Material.—One fragmentary impression and a small fragment from Sharif-Abad (050512-8/2, 0505128/4).

Description.—The figured specimen (050512-8/2) is a plaster cast of an external mould. It is a depressed and rather evolute member of the Dactylioceratidae with broad venter. The rib-

bing consists of relatively strong, prorsiradiate primary ribs, beginning at the umbilical seam. These end ventrolaterally in small and sharp tubercles, from where they usually trifurcate into fine secondary ribs. One or two intercalatory ribs, beginning at the seam or higher up, are present.

Discussion.—Except for the finer ribbing and the more numerous secondaries, our specimens compare well with the smaller specimen of d'Orbigny (1845: figs. 4, 5), which has been designated as lectotype by Guex (1972: 640).

At the same time Schmidt-Effing (1972: 63) designated the larger specimen of d'Orbigny (1845: figs. 1, 2) as lectotype. Also Atrops (Fischer 1994: 94) considered the larger of d'Orbigny's specimens (d'Orbigny 1845: fig. 1a, b) as the lectotype of the species.

Stratigraphic and geographic range.—Sharif-Abad, level D. *C. raquinianum* has been recorded from the Middle Toarcian *Hildoceras bifrons*/*Haugia variabilis* Zone.

Superfamily Hildoceratoidea Hyatt, 1867
Family Hildoceratidae Hyatt, 1867
Subfamily Arieticeratinae Howarth, 1955
Genus *Oregonites* Wiedenmayer, 1980
Oregonites cf. *imlayi* Wiedenmayer, 1980

Fig. 4J.

Material.—A fragmentary inner whorl with a small portion of the body-whorl, starting at a diameter of ca. 24 mm, from Shahmirzad (050510-9).

Dimensions (in mm)

Specimen	D	U	H	W
050510-9	20	~50	30	42

Description.—The small specimen is evolute, tricarinate-bisulcate with a depressed, broad-elliptical whorl cross-section and a strong keel bordered by rather deep sulci. The strong and slightly rursiradiate ribs start irregularly paired at the umbilical margin. On the venter, the ribs bend forward and fade before reaching the sulci.

Discussion.—The evolute specimen resembles *Oregonites imlayi* Wiedenmayer, 1980. *Oregonites* differs from the similar genus *Fontanelliceras* (Fucini, 1931) by more depressed whorls, a distinctly tricarinate-bisulcate venter and paired ribs.

Stratigraphic and geographic range.—Shahmirzad, level II. *Oregonites* is a very rare taxon, being known so far only from the Late Pliensbachian of the Mediterranean area (Wiedenmayer 1980) and North America (Imlay 1968; Smith and Tipper 1996).

Subfamily Harpoceratinae Neumayr, 1875
Genus *Protogrammoceras* Spath, 1913
Subgenus *Protogrammoceras* Spath, 1913
Protogrammoceras (*Protogrammoceras*) cf. *celebratum* (Fucini, 1900)

Fig. 4H.

1900 cf. *Grammoceras celebratum*; Fucini 1900: 41, pl. 10: 1, 2.
1989 cf. *P.* (*Protogrammoceras*) *celebratum* (Fucini, 1900); Meister 1989: 40, pl. 3: 14, 15; pl. 4: 1 (with synonymy).
1997 cf. *Protogrammoceras celebratum* (Fucini); Dommergues et al. in Cariou and Hantzpergue 1997: pl. 8: 3.
1998 cf. *Protogrammoceras* gr. *celebratum* (Fucini, 1900); Géczy and Meister 1998: 108, pl. 12: 7–9; pl. 13: 1–3, 5.

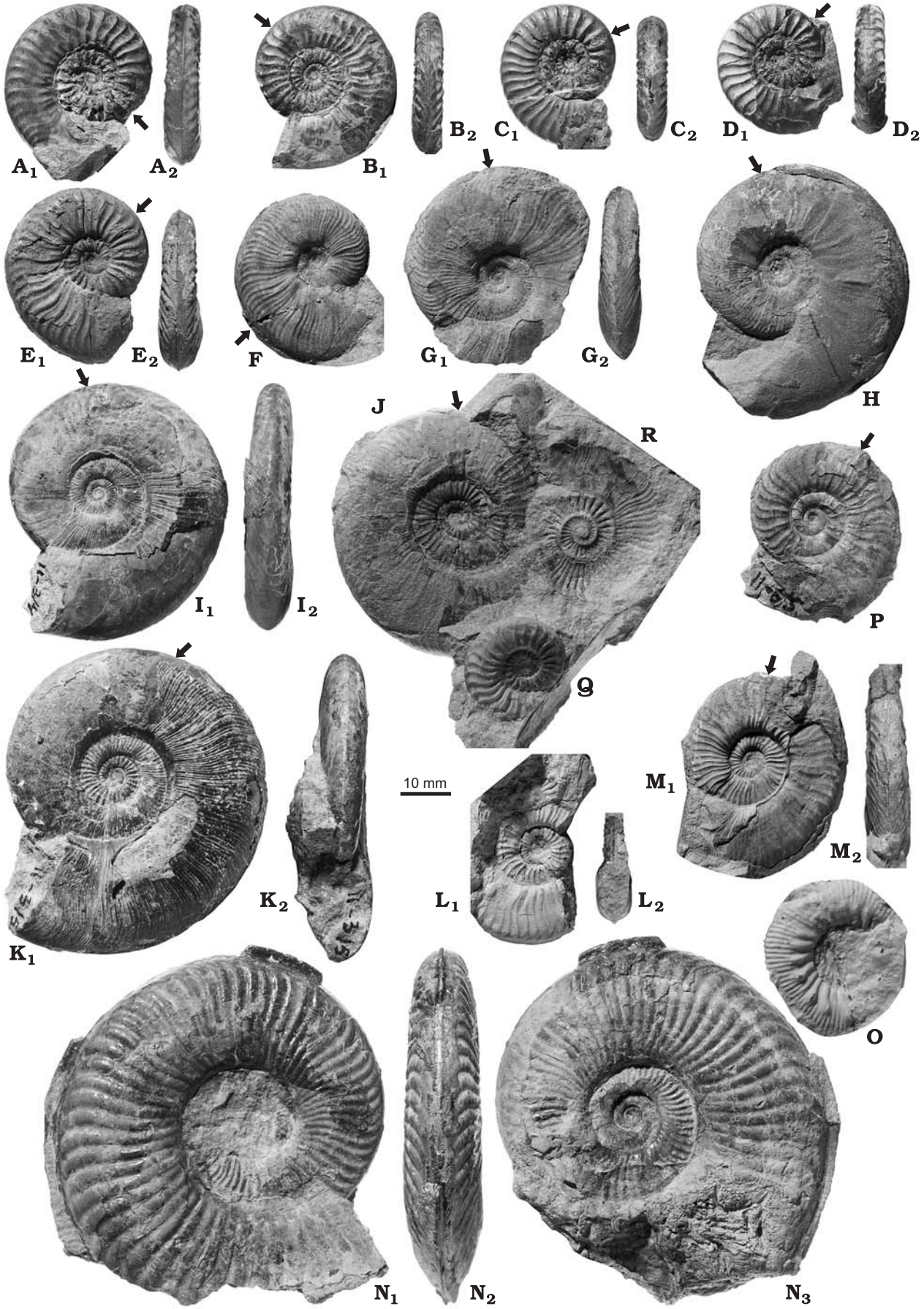
Material.—Two fragmentary specimens from Shahmirzad (050514-6/11, 050514-6/12).

Description.—The figured specimen (050514-6/12) is a planulate and evolute member of the Harpoceratinae with a high-ovate acute whorl cross-section and a distinct, high keel. The ribs are simple, falciform, fine and dense, projecting strongly on the venter.

Discussion.—The strongly falciform and fine ribbing resembles *P. celebratum.* The specimens therefore is placed, with reservation, within the range of variation of the species, as given by Ferretti (2002: 208).

Stratigraphic and geographic range.—Shahmirzad, level II. *P. celebratum* is widely distributed within eastern Europe and the Mediterranean, occurring in the *Amaltheus stokesi* Subzone of the *Amaltheus margaritatus* Zone. In Iran, *Protogrammoceras* is a very rare taxon. At Shahmirzad, it was collected just below the beds with *Amaltheus*.

Fig. 5. Toarcian ammonoids from the Shemshak Group. **A**–**D**, **Q**. *Paradumortieria elmii* Seyed-Emami nov. sp. [m], Kuhe Bashm-e-Dehsufian, *Pleydella aalensis* Zone, Upper Toarcian. **A**. Holotype, 050511-3/1 (full-grown specimen with lappets); lateral (A_1) and ventral (A_2) views. **B**. Paratype, 050511-3/6; lateral (B_1) and ventral (B_2) views. **C**. 7-21-1; lateral (C_1) and ventral (C_2) views. **D**. 14-49 (full-grown specimen with lappets); lateral (D_1) and ventral (D_2) views. **Q**. Paratype, 050511-3/2, lateral view. **E**. *Pleydellia* (*Pleydellia*) *aalensis* (Zieten, 1830), Kuhe Bashm-e-Dehsufian, 050511-6/3, *P. aalensis* Zone, Upper Toarcian; lateral (E_1) and ventral (E_2) views. **F**, **G**. *Pleydellia* (*Pleydellia*) *buckmani*, Maubeuge, 1947, Kuhe Bashm-e-Dehsufian, *P. aalensis* Zone, Upper Toarcian. **F**. 050511-6/2, lateral view. **G**. 050511-6/13; lateral (G_1) and ventral (G_2) views. **H**. *Pleydellia* (*Pleydellia*) *subcompta* (Branco, 1879), Kuhe Bashm-e-Dehsufian, 050511-5/1, *P. aalensis* Zone, Upper Toarcian, lateral view. **I**, **K**. *Dumortieria moorei* (Lycett, 1857), Kuhe Bashm-e-Dehsufian, *P. aalensis* Zone, Upper Toarcian. **I**. 050511-3/4; lateral (I_1) and ventral (I_2) views. **K**. 050511-3/5; lateral (K_1) and apertural (K_2) views. **J**. *Dumortieria radiosa* (Seebach, 1864), Kuhe Bashm-e-Dehsufian, 050511-3/3, *P. aalensis* Zone, Upper Toarcian, lateral view. **L**, **M**. *Pleydellia* (*Pleydellia*?) *ruttneri* Seyed-Emami sp. nov. [m], Kuhe Bashm-e-Dehsufian, *P. aalensis* Zone, Upper Toarcian. **L**. Paratype, 050511-6/10; lateral (L_1) and apertural (L_2) views. **M**. Holotype, 050511-6/9 (complete specimen with lappets); lateral (M_1) and ventral (M_2) views. **N**. *Pseudogrammoceras fallaciosum* (Bayle, 1878), Kuhe Bashm-e-Dehsufian, 050510-16/1, *Pseudogrammoceras fallaciosum* Subzone, *Grammoceras thouarsense* Zone, Upper Toarcian; lateral (N_1, N_2) and ventral (N_3) views. **O**. *Catacoeloceras* aff. *raquinianum* (d'Orbigny, 1845), Sharif-Abad, 050512-8/4, *Hildoceras bifrons/Haugia variabilis* Zone, Middle Toarcian (plaster cast), lateral view. **P**. *Pleydellia* (*Cotteswoldia*) *bifax* Buckman, 1904, Kuhe Bashm-e-Dehsufian, *P. aalensis* Zone, Upper Toarcian, lateral view. **R**. *Paradumortieria schaireri* (Seyed-Emami, 1985) [m], Kuhe Bashm-e-Dehsufian, 050511-3/3, *P. aalensis* Zone, Upper Toarcian, lateral view (external mould of Fig. 4S_1). Arrows indicate onset of body chamber; m = microconch. →



Subgenus *Matteiceras* Wiedenmayer, 1980

Protogrammoceras (*Matteiceras*) cf. *nitescens* (Young and Bird, 1828)

Fig. 4K.

1828 cf. *Ammonites nitescens*; Young and Bird 1828: 257.
1992 cf. *Protogrammoceras* (*Matteiceras*) *nitescens* (Young and Bird, 1828); Howarth 1992: 66, pl. 4: 4–6; pl. 5: 2; text-fig. 12 (with synonymy).

Material.—One fully septate inner whorl from Shahmirzad (050514-6/10).

Dimensions (in mm)

Specimen	D	U	H	W
050514-6/10	26	34	39	~38

Description.—A relatively evolute form with a slightly higher than wide, ovate whorl cross-section. The venter is fairly broad, with a well-defined keel. The ribs are moderately coarse, simple or indistinctly bifurcating close to the umbilicus. On the inner part of the flank the ribs are prorsiradiate. On the outer part of the flank the ribs bend backward and become rursiradiate. Near the venter the ribs become raised and project strongly on the venter but fade before reaching the keel.

Discussion.—The described specimen is a fully septate inner whorl. Although incomplete, it shows some resemblance to *P.* (*M.*) *nitescens*, especially to the specimen figured by Meister (1989: pl. 3: 12). Compared with the latter, our specimen is less evolute and the ribbing less coarse.

Stratigraphic and geographic range.—Shahmirzad, level II. In Europe, *P.* (*M.*) *nitescens* is not uncommon in the *Amaltheus stokesi* Subzone. In Iran, it has been encountered for the first time, just below the beds with *Amaltheus*.

Subfamily Grammoceratinae Buckman, 1904

Genus *Pseudogrammoceras* Buckman, 1901

Pseudogrammoceras fallaciosum (Bayle, 1878)

Fig. 5N.

1878 *Grammoceras fallaciosum*; Bayle 1878: pl. 78: 1, 2.
2005 *Pseudogrammoceras fallaciosum* (Bayle, 1878); Seyed-Emami et al. 2005: 357, fig. 5B, C (with synonymy).

Material.—Over ten well preserved specimens from Kuhe Bashm-e-Dehsufian (050510-15/1–050510-15/12, 050510-16/1, 050510-16/2).

Dimensions (in mm)

Specimen	D	U	H	W
050510-16/1	71	31	41	~21 (fully septate)

Description and discussion.—See Seyed-Emami et al. (2005).

Stratigraphic and geographic range.—Kuhe Bashm, level IV. Late Toarcian *Grammoceras thouarsense* Zone, *Pseudogrammoceras fallaciosum* Subzone.

Genus *Podagrosites* Guex, 1973

Podagrosites latescens (Simpson, 1843)

Fig. 4U.

1843 *Ammonites latescens*; Simpson 1843: 54–55.
2005 *Podagrosites latescens* (Simpson, 1843); Seyed-Emami et al. 2005: 357, figs. 4C, 5A.

Material.—One fragmentary inner whorl from Kuhe Bashm (050510-16/3).

Description and discussion.—See Seyed-Emami et al. (2005).

Stratigraphic and geographic range.—Kuhe Bashm, level IV. Late Toarcian, *Grammoceras thouarsense* Zone, *Pseudogrammoceras fallaciosum* Subzone.

Family Graphoceratidae Buckman, 1905

Subfamily Dumortieriinae Maubeuge, 1950

Genus *Dumortieria* Haug, 1885

Dumortieria radiosa (Seebach, 1864)

Figs. 4V, 5J.

1864 *Ammonites radiosus*; Seebach 1864: 142, pl. 9: 2.
2006 *Dumortieria radiosa* (Seebach, 1864); Seyed-Emami et al. 2006: 265, fig. 5/21.

Material.—Two specimens from Kuhe Bashm-e-Dehsufian (050511-3/3, 050511-3/7).

Description.—See Seyed-Emami and Nabavi (1985: 254) and Seyed-Emami et al. (2006).

Stratigraphic and geographic range.—Kuhe Bashm, level V. Late Toarcian, *Dumortieria pseudoradiosa*/*Pleydella aalensis* Zone.

Dumortieria moorei (Lycett, 1857)

Figs. 4W, 5I, K.

1857 *Ammonites Moorei*; Lycett 1857: 122, pl. 1: 2.
1985 *Dumortieria* moorei (Lycett); Seyed-Emami and Nabavi 1985: 255, fig. 9a, b.
1993 *Dumortieria moorei* (Lycett, 1857); Seyed-Emami et al. 1993: 16, pl. 1: 2.

Material.—More than ten well-preserved specimens from Kuhe Bashm (050511-3).

Dimensions (in mm)

Specimen	D	U	H	W
050511-3/4	42	37	38	22
050511-3/8	52	38	35	~20
050511-3/5	59	35	37	–

Description and discussion.—See Seyed-Emami and Nabavi (1985: 255).

Stratigraphic and geographic range.—Kuhe Bashm, level V. Late Toarcian, *Dumortieria pseudoradiosa*/*Pleydella aalensis* Zone.

Genus *Paradumortieria* Elmi and Caloo, 1985

Paradumortieria schaireri (Seyed-Emami, 1985)

Figs. 4S, 5R.

1985 *Dumortieria schaireri* Seyed-Emami, 1985; Seyed-Emami and Nabavi 1985: 259, figs. 7a, b, 8a, b.

Material.—One slightly crushed internal mould (D = 30 mm) with beginning of the lappet from Kuhe Bashm (050511-3/5).

Description and discussion.—See Seyed-Emami and Nabavi (1985: 259).

Stratigraphic and geographic range.—Kuhe Bashm, level V. Together with *Dumortieria radiosa/moorei* in the Late Toarcian *Dumortieria pseudoradiosa/Pleydella aalensis* Zone.

Paradumortieria elmii Seyed-Emami sp. nov.

Fig. 5A–D, Q.

1985 *Dumortieria* aff. *schaireri* Seyed-Emami, 1985; Seyed-Emami and Nabavi 1985: 260, fig. 6a–c.

Type material: The holotype is a complete microconch form with lappet (050511-3/1; Fig. 5A$_1$, A$_2$). Paratypes: specimens 050511-3/2 and -3/6. Hypotype: 14-2-3 (originally figured as *Dumortieria* aff. *schaireri* Seyed-Emami by Seyed-Emami and Nabavi 1985: fig. 6a–c).

Type horizon: Shemshak Group, Upper Toarcian, *Pleydella aalensis* Zone, Kuhe Bashm section, level V at 245 m (Fig. 2).

Type locality: Kuhe Bashm, 13.5 km east of Shahmirzad, about 25 km north of Semnan.

Derivation of the name: In honour of the Late Prof. Dr. S. Elmi (1936–2007)

Material.—Seven, mostly well-preserved specimens from the Kuhe Bashm section (050511-3 and earlier collections by K.S.-E.: 7-21-1, 14-2-3, 14-49).

Diagnosis.—Small, evolute microconchs with elongated lappets and rectangular to high-ovate whorl cross-section. Venter tectiform with a distinct keel. Ribbing relatively coarse, slightly flexuous, ventrolaterally strongly projecting forward. Body whorl about 3/4 of the last whorl.

Dimensions (in mm)

Specimen	D	U	H	W
050511-3/1 (holotype)	30	42	34	24 (end of body-chamber)
	25	40	36	26
14-2-3 (hypotype)	27	41	36	24
7-21-1	27	41	33	23
050511-3/6 (paratype)	31	40	35	–

Description.—Small (D: 27–32 mm), evolute microconchs with rectangular to high-ovate whorl cross-section. The venter is tectiform with a distinct keel, persisting up to the end of body whorl. Ribs are slightly flexuous, relatively coarse, spaced, and projecting strongly forward ventrolaterally. Towards the end of the body whorl the ribs become finer, denser and irregularly paired. The body whorl occupies about 3/4 of the last whorl and carries elongated, spatula-like lappets.

Discussion.—The new species is intermediate between *P. schaireri*, *P. explanata* (Buckman 1904: suppl. 104, pl. 22: 28–30), and *P. tabulata* (Buckman 1904: suppl. 185, pl. 22: 25–27). From the closely related *P. schaireri* the new species differs in having coarser and wider spaced ribs. Compared to *P. explanata* and *P. tabulata* the new species is less coarsely ribbed and its final size is probably smaller. Similarly, the new taxon differs from *P. tectiforme* Elmi and Caloo, 1985 by its finer ribbing and distinctly smaller final size.

Stratigraphic and geographic range.—The new species was found, together with *P. schaireri*, *P. explanata*, and several specimens of the *Dumortieria radiosa/moorei* group, in a single concretion from Kuhe Bashm, level V.

Genus *Pleydellia* Buckman, 1899

Subgenus *Pleydellia* Buckman, 1899

Pleydellia (*Pleydellia*) *subcompta* (Branco, 1879)

Fig. 5H.

1879 *Harpoceras subcomptum*; Branco 1879: 90, pl. 5: 3, 3a.
2004 *Pleydellia subcompta* (Branco, 1879); Myczyński 2004: 65, fig. 25/4.
2005 *Pleydellia* (*Pleydellia*) *subcompta* (Branco, 1879); Seyed-Emami et al. 2005: 360, fig. 6E, J.

Material.—One specimen from Kuhe Bashm (050511-5/1).

Dimensions (in mm)

Specimen	D	U	H	W
050511-5/1	45	29	41	–

Description and discussion.—See Seyed-Emami and Nabavi (1985: 264) and Seyed-Emami et al. (2005).

Stratigraphic and geographic range.—Kuhe Bashm, level VI. Late Toarcian, *Pleydella aalensis* Zone.

Pleydellia (*Pleydellia*) *aalensis* (Zieten, 1830)

Fig. 5E.

1830 *Ammonites aalensis*; Zieten 1830: pl. 28: 3.
2004 *Pleydellia aalensis* (Zieten, 1830); Myczyński 2004: 64, fig. 26/3.
2005 *Pleydellia* (*Pleydellia*) *aalensis* (Zieten, 1830); Seyed-Emami et al. 2005: 360, fig. 6C, D, F.

Material.—Several specimens from Kuhe Bashm (050511-6).

Dimensions (in mm)

Specimen	D	U	H	W
050511-6/3	33	30	45	26

Description and discussion.—See Seyed-Emami and Nabavi (1985: 266) and Seyed-Emami et al. (2005).

Stratigraphic and geographic range.—Kuhe Bashm, level VI. Late Toarcian *Pleydella aalensis* Zone.

Pleydellia (*Pleydellia*) *buckmani* Maubeuge, 1947

Fig. 5F, G.

1947 *Pleydellia Buckmani*; Maubeuge 1947: 76, pl. 2 (upper figures).
2005 *Pleydellia* (*Pleydellia*) *buckmani* Maubeuge, 1947; Seyed-Emami et al. 2005: 362, fig. 6A, B, G.

Material.—Seven specimens from Kuhe Bashm (050511-5, 050511-6).

Dimensions (in mm)

Specimen	D	U	H	W
050511-6/2	27	26	47	26
050511-6/3	34	25	45	25

Description and discussion.—See Seyed-Emami and Nabavi (1985: 265) and Seyed-Emami et al. (2005).

Stratigraphic and geographic range.—Kuhe Bashm, level VI, Late Toarcian, *Pleydella aalensis* Zone.

Pleydellia (*Pleydellia*?) *ruttneri* Seyed-Emami sp. nov.

Fig. 5L, M.

Type material: The holotype (050511-6/9) is a nearly complete shell. Paratype: A fragmentary specimen (050511-6/10).

Type horizon: Shemshak Group, Upper Toarcian, *Pleydella aalensis* Zone, Kuhe Bashm section level VI at 270 m (Fig. 2).

Type locality: Kuhe Bashm-e-Dehsufian, 13.5 km east of Shahmirzad, about 25 km north of Semnan.

Derivation of the name: In honour of the Late Dr. Anton Ruttner (1911–2006), who contributed much to the geology of east-central Iran.

Material.—Three specimens from Kuhe Bashm (050511-6).

Dimensions (in mm)

Specimen	D	U	H	W	
050511-6/9 (holotype)	31	~34	~39	~25	(at the end of phragmocone)
	38	~35	~37	~24	(at the end of body whorl)

Description.—The holotype (Fig. 5M$_1$, M$_2$) is a slightly crushed microconch with rather short lappets and parts of the original shell. The body whorl begins at a diameter of 40 mm and occupies about 1/2 of the last whorl. It is moderately evolute, with nearly parallel flanks and a rectangular to ovate whorl cross-section. The venter is distinctly tectiform, with a narrow and sharp keel, which persists to the end of the body chamber. The umbilicus is shallow, with a nearly vertical wall. The ribs are fairly fine, dense and sinuous. They start at the seam and project strongly on the venter forming an angle and end at the keel. Some ribs are irregularly paired on the body whorl. Towards the end of the body chamber the ribbing becomes slightly finer and denser.

Discussion.—The new species can be considered as a microconch belonging to the *P. aalensis* group. The short lappets look very much like those of *P. aalensis* figured by Buckman (1890: pl. 32: 3), but the ribbing is different. The species also differs from the microconchs of *P. aalensis* figured by Henrique and Ureta (2002: 150, fig. 93). The parallel flanks and the fastigate venter with rather fine and partly pair-wise bundled ribs is reminiscent of *Cotteswoldia* and *Walkeria*. However, it cannot be assigned to any known species of these subgenera.

Stratigraphic and geographic range.—The new species was found on a slab, together with *Pleydellia* (*P.*) *buckmani*, from the (uppermost?) Late Toarcian, *Pleydella aalensis* Zone.

Subgenus *Cotteswoldia* Buckman, 1902

Pleydellia (*Cotteswoldia*) *fuselieri* Rulleau and Elmi, 2001

Fig. 6A.

2001 *Pleydellia* (*Cotteswoldia*) *fuselieri*; Rulleau and Elmi in Rulleau et al. 2001: 77, pl. 16: 7, 8.

Material.—A one-side preserved specimen from Kuhe Bashm (050511-6/1).

Dimensions (in mm)

Specimen	D	U	H	W
050511-6/1	~46	~43	~33	~30

Description.—Evolute form with an ovate whorl cross-section, slightly higher than wide, and with a low, blunt keel. Ribs are single, strong, and well spaced. Ventrolaterally, the ribs bend slightly forward and fade on the fairly broad venter.

Discussion.—Except for the slightly coarser ribbing and wider umbilicus, our specimen closely matches *P.* (*C.*) *fuselieri*.

Stratigraphic and geographic range.—Kuhe Bashm, level VI. Together with *P. aalensis* and *P. subcompta* from the Late Toarcian *Pleydella aalensis* Zone.

Pleydellia (*Cotteswoldia*) *bifax* Buckman, 1904

Fig. 5P.

1904 *Cotteswoldia bifax*; Buckman 1904: suppl. 136, fig. 110 A.
2005 *Pleydellia* (*Cotteswoldia*) *bifax* Buckman, 1904 sensu Rulleau and Elmi, 2001; Seyed-Emami et al. 2005: 362, fig. 6K, L.

Material.—One crushed specimen from Kuhe Bashm (050511-6/5).

Description and discussion.—See Seyed-Emami et al. (2005).

Stratigraphic and geographic range.—Kuhe Bashm, level VI. Late Toarcian, *Pleydella aalensis* Zone.

Subfamily Leioceratinae Spath, 1936

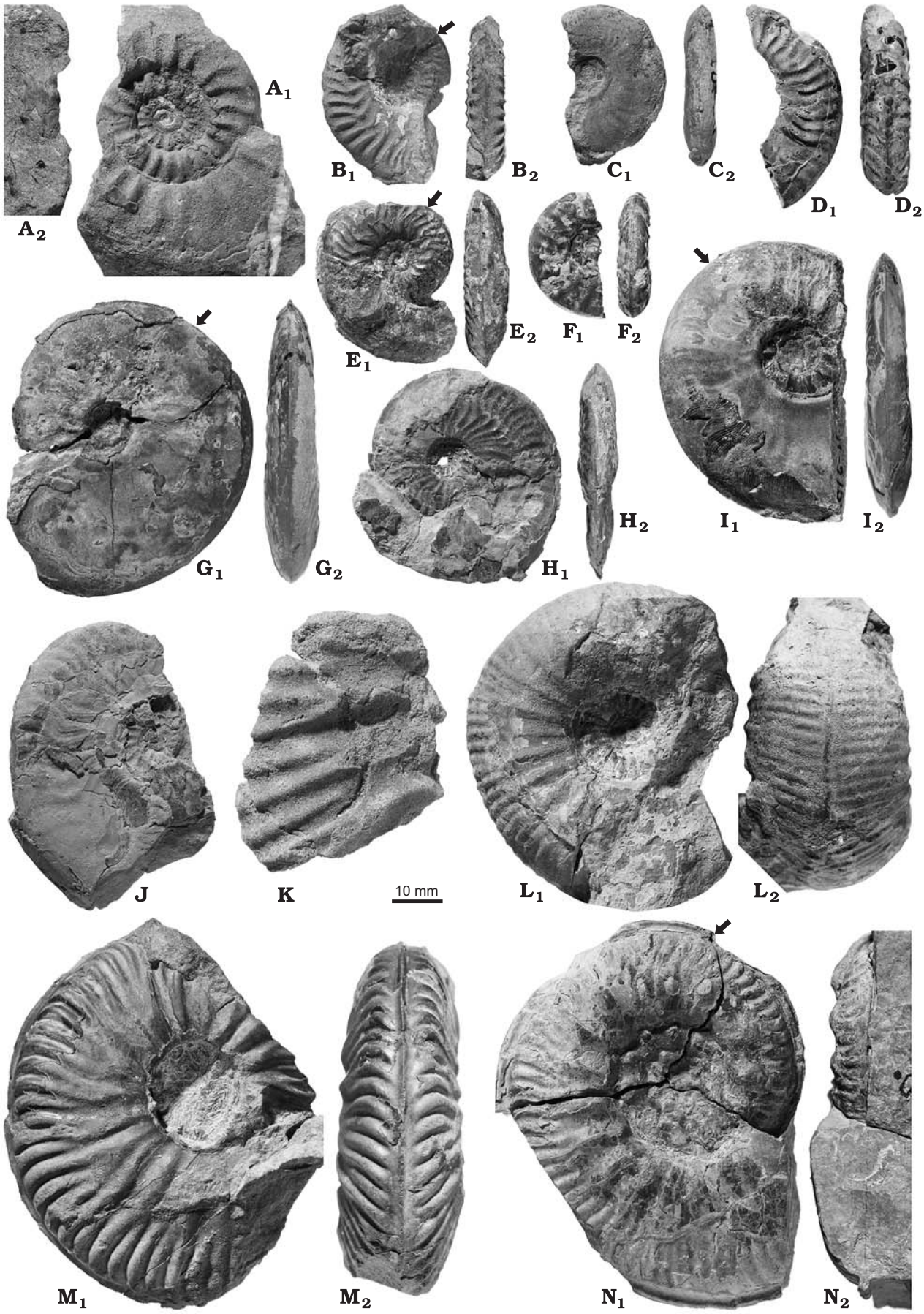
Genus *Leioceras* Hyatt, 1867

Leioceras opalinum (Reinecke, 1818)

Fig. 6C.

1818 *Nautilus opalinum*; Reinecke 1818: 55, pl. 1: 1, 2.
1967 *Leioceras opalinum* (Reinecke) 1818; Seyed-Emami 1967: 48, pl. 1: 12; pl. 7: 3a, b.
1987 *Leioceras opalinum* (Reinecke), 1818; Goy and Ureta 1987: 216, pl. 1: 1–13; text-figs. 2, 3 (with synonymy).
2001 *Leioceras* (*Leioceras*) *opalinum* (Reinecke); Rulleau et al. 2001: pl. 20: 4.
2004 *Leioceras opalinum* (Reinecke, 1818); Myczyński 2004: 73, figs. 26/8, 27/5.

Fig. 6. Upper Toarcian to Bajocian ammonoids from the Shemshak Group. **A**. *Pleydellia* (*Cotteswoldia*) *fuselieri* Rulleau and Elmi, 2001, Kuhe Bashm-e-Dehsufian, 050511-6-1, *Pleydella aalensis* Zone, Upper Toarcian; lateral (A_1) and cross-section (A_2) views. **B**, **E**. *Graphoceras* (*Ludwigella*) *cornu* Buckman, 1887, Kuhe Bashm-e-Dehsufian, *Otoceras concavum* Zone, Upper Aalenian. **B**. 050511-15/9; lateral (B_1) and ventral (B_2) views. **E**. 050511-15/8; lateral (E_1) and ventral (E_2) views. **C**. *Leioceras opalinum* (Reinecke, 1818), Kuhe Bashm-e-Dehsufian, 050511-7/10, *Leioceras opalinum* Subzone, *Leioceras opalinum* Zone, Lower Aalenian; lateral (C_1) and ventral (C_2) views. **D**, **F**. *Graphoceras* (*Ludwigella*) cf. *rudis* (Buckman, 1889), Sharif-Abad, *Otoceras concavum* Zone, Upper Aalenian. **D**. 050512-11a/13; lateral (D_1) and ventral (D_2) views. **F**. 050512-11/4; lateral (F_1) and ventral (F_2) views. **G**, **I**. *Leioceras comptum* (Reinecke, 1818); Kuhe Bashm-e-Dehsufian, *Leioceras comptum* Subzone, *Leioceras opalinum* Zone, Lower Aalenian. **G**. 050511-9/4; lateral (G_1) and ventral (G_2) views. **I**. 050511-9/5; lateral (I_1) and ventral (I_2) views. **H**. *Graphoceras* (*Graphoceras*) *decorum* Buckman, 1898, Sharif-Abad, 050512-11/8, *Otoceras concavum* Zone, Upper Aalenian; lateral (H_1) and ventral (H_2) views. **J**. *Graphoceras* (*Graphoceras*) *concavum* J. Sowerby, 1815, Sharif-Abad, 050512-12/1, *Otoceras concavum* Zone, Upper Aalenian, lateral view. **K**. *Stemmatoceras*? sp., Sharif-Abad, 050512-13, Middle Bajocian, lateral view. **L**. *Erycites* aff. *sphaeroconicus* Buckman, 1922, Kuhe Bashm-e-Dehsufian, 050511-7/1, *Leioceras opalinum* Zone, Lower Aalenian; lateral (L_1) and ventral (L_2) views. **M**. *Bredyia alleoni* (Dumortier, 1874), 050511-8, *Leioceras opalinum* Zone, Lower Aalenian; lateral (M_1) and ventral (M_2) views. **N**. *Accardia* aff. *diadematoides* (Mayer, 1871), Sharif-Abad, 050512-11/10, Middle Aalenian; lateral (N_1) and apertural (N_2) views. Arrows indicate onset of body chamber. →



Material.—A small specimen from Kuhe Bashm (050511-7/10).

Description.—Involute Leioceratinae with high-ovate to lanceolate whorl cross-section and a sharp keel. Umbilical border is rather sharp, with an indistinct peri-umbilical depression. Ornamentation consists of fine and sinuous striae.

Stratigraphic and geographic range.—Kuhe Bashm, level VII. Together with *Bredyia* from the Early Aalenian, *Leioceras opalinum* Zone, *Leioceras opalinum* Subzone.

Leioceras comptum (Reinecke, 1818)

Fig. 6G, I.

1818 *Nautilus comptus*; Reinecke 1818: 57, pl. 1: 5, 6.
2005 *Leioceras comptum* (Reinecke, 1818); Seyed-Emami et al. 2005: 365, fig. 7D, J.

Material.—Six specimens from Kuhe Bashm (050511-9/2–050511-9/5, 050511-12/1, 050511-12/2).

Dimensions (in mm)

Specimen	D	U	H	W
050511-9/5	54	24	44	19
050511-9/4	56	16	48	21

Description and discussion.—See Seyed-Emami et al. (2005).

Stratigraphic and geographic range.—Kuhe Bashm, level VII. Together with *Planammatoceras* cf. *planinsigne* (Vacek, 1886) from the Early Aalenian *Leioceras opalinum* Zone (*Leioceras comptum* Subzone).

Subfamily Graphoceratinae Buckman, 1905

Genus *Graphoceras* Buckman, 1898

Subgenus *Graphoceras* Buckman, 1898

Graphoceras (*Graphoceras*) *concavum* (J. Sowerby, 1815)

Fig. 6J.

1815 *Ammonites concavus*; J. Sowerby 1815: 274, pl. 94.
1967 *Ludwigia* (*Graphoceras*) *concava concava* (Sowerby) 1815; Seyed-Emami 1967: 66, pl. 2: 5; pl. 8: 5.
1969 *Graphoceras* (*Graphceras*) *concavum* (Sowerby); Contini 1969: 61, pl. 5: 3–6; pl. 21: 1–9; pl. 22: 1–3; pl. 24: 48–51; text-figs. 16, 17 (with synonymy).
2001 *Graphoceras* (*Graphoceras*) *concavum* (Sowerby); Rulleau et al. 2001: pl. 23: 1–3.
2004 *Graphoceras concavum* (J. Sowerby, 1825); Myczyński 2004: 99, fig. 33/1.

Material.—Four fragmentary specimens from Sharif-Abad (050512-11/1–050512-11/4) and three fragmentary specimens from Kuhe Bashm (050511-15/2, 050511-15/4, 050511-15/6).

Description.—The figured specimen (Fig. 6J) is a crushed member of the Graphoceratinae with parts of the original shell preserved. It is relatively involute, with a high-ovate, compressed whorl cross-section and a sharp keel. The ribbing is strongly anguliform-falcate. The last preserved whorl is probably part of the body chamber. It egresses slightly with a distinct peri-umbilical depression.

Discussion.—The figured specimen falls within the range of variation of *G.* (*G.*) *concavum* as given by Contini (1969) and Caloo (1971).

Stratigraphic and geographic range.—Kuhe Bashm, level IX; Sharif-Abad, level G. Late Aalenian, *Otoceras concavum* Zone.

Graphoceras (*Graphoceras*) *decorum* Buckman, 1904

Fig. 6H.

1904 *Graphoceras decorum*; Buckman 1904: p. 98, pl. 15: 3, 4.
2004 *Graphoceras decorum* Buckman, 1888; Myczyński 2004: 100, fig. 33/4.
2006 *Graphoceras* (*Graphoceras*) *decorum* Buckman, 1902; Seyed-Emami et al. 2006: 268, figs. 5/5a, b, 12a, b, 18.

Material.—Eight fragmentary specimens from Sharif-Abad: 050512-11 (11/1–11/8).

Dimensions (in mm)

Specimen	D	U	H	W
050512-11/8	35	20	49	–

Description and discussion.—See Seyed-Emami et al. (2006).

Stratigraphic and geographic range.—Sharif-Abad, level G. Late Aalenian, *Otoceras concavum* Zone.

Subgenus *Ludwigella* Buckman, 1901

Graphoceras (*Ludwigella*) *cornu* (Buckman, 1887)

Fig. 6B, E.

1887 *Ludwigia cornu*; Buckman 1887: pl. 4: 3, 4.
1969 *Graphoceras* (*Ludwigella*) *cornu* (Buckman, 1887); Contini 1969: 73, pl. 5: 8, 9; pl. 12: 13–15, 17; pl. 24: 55–57; text-figs. 20–23 (with synonymy).
1971 *Graphoceras* (*Ludwigella*) *cornu* (Buckman, 1887); Caloo 1971: pl. 1: 3–6, 10–12; pl. 2: 16, 19; pl. 3: 23–28, 30, 31.
2004 *Graphoceras cornu* (Buckman, 1887); Myczyński 2004: 102, figs. 29/4, 30/8.

Material.—Three specimens from Kuhe Bashm (050511-15/1, 050511-15/8, 050511-15/9).

Dimensions (in mm)

Specimen	D	U	H	W
050511-15/9	26	~32	~43	~32
050511-15/8	29	29	~44	~29

Description.—Moderately involute Graphoceratinae with high-ovate, slightly fastigate whorl cross-section and a sharp keel. The ribbing is strongly falcate. The prorsiradiate primary ribs bifurcate mostly within the inner half of the flank. The secondary ribs are strongly rursiradiate, slightly concave and nearly angular to the primaries.

Discussion.—Our specimens falls well within the range of variation of the species as given by Contini (1969: especially pl. 12: 5).

Stratigraphic and geographic range.—Kuhe Bashm, level IX. Together with *Graphoceras* (*G.*) *concavum* from the Late Aalenian, *Otoceras concavum* Zone.

Graphoceras (*Ludwigella*) cf. *rudis* (Buckman, 1889)

Fig. 6D, F.

1889 cf. *Ludwigia rudis*; Buckman 1889: 103, pl. 15: 12.

1967 cf. *Ludwigia (Ludwigella) rudis* Buckman 1889; Seyed-Emami 1967: 61, pl. 2: 3; pl. 7: 16.
1969 cf. *Graphoceras* (*Ludwigella*) *rudis* (Buckman) 1889 emend.; Contini 1969: 71, pl. 5: 7; pl. 22: 6–12; pl. 14: 52–53; text-fig. 19 (with synonymy).
2001 cf. *Graphoceras* (*Ludwigella*) *rudis* Buckman; Rulleau et al. 2001: pl. 23: 6a, b, 7a, b.

Material.—Two fragmentary specimens from Sharif-Abad (050512-11/4, 050512-11a/13).

Description.—The fragmentary specimens are relatively evolute, with a rectangular-ovate whorl cross-section, a broad venter and a low blunt keel. The ornamentation consists of falcate, blunt ribs, irregularly bifurcating near to the umbilicus.

Discussion.—The fragmentary specimens is closely comparable to the specimens figured by Rulleau et al. (2001: pl. 23: 6, 7).

Stratigraphic and geographic range.—Sharif-Abad, level G. Late Aalenian, *Otoceras concavum* Zone.

Family Hammatoceratidae Buckman, 1887
Subfamily Hammatoceratinae Buckman, 1887
Genus *Bredyia* Buckman, 1910
Bredyia alleoni (Dumortier, 1874)

Fig. 6M.

1874 *Ammonites alleoni*; Dumortier 1874: 259, pl. 52: 3, 4.
1963 *Parammatoceras alleoni* (Dumortier, 1874); Elmi 1963: 55, pl. 8: 1–3; text-fig. 22.
2001 *Bredyia alleoni* (Dumortier, 1874); Rulleau et al. 2001: pl. 25: 10a, b.
2002 *Bredyia alleoni* (Dumortier, 1874); Cresta and Martinez in Pavia and Cresta 2002: 192, figs. 125–126.

Material.—Two specimens from Kuhe Bashm (050511-7/2, 050511-8).

Dimensions (in mm)

Specimen	D	U	H	W
050511-8	73	~27	~45	~34

Description.—The figured specimen is slightly crushed. It is relatively involute with a high-ovate to triangular whorl cross-section and a narrow and fairly high keel. The flanks converge towards the relatively broad venter. The ribbing is coarse and sinuous with strong and nearly radiate primaries, which often trifurcate within the lower third of the flank. On the venter the ribs bend forward and nearly reach the keel.

Discussion.—The differences to the closely related *B. subinsigne* (Oppel, 1836) and *B. iranica* Seyed-Emami have been discussed by Senior (1977) and Seyed-Emami (1987).

Stratigraphic and geographic range.— Kuhe Bashm, level VII. Late Aalenian, *Leioceras opalinum* Zone. *Bredyia alleoni* was found in the beds with *Leioceras opalinum*.

Genus *Accardia* Cresta, 1997
Accardia aff. *diadematoides* (Mayer, 1871)

Fig. 6N.

1871 aff. *Ammonites diadematoides*; Mayer 1871: 243, pl. 8: 9.
2006 aff. *Accardia diadematoides* (Mayer, 1871); Seyed-Emami et al. 2006: 269, figs. 5/8a, b, 16a, b (with synonymy).

Material.—A specimen preserved one side from Sharif-Abad (050512-11/10).

Dimensions (in mm)

Specimen	D	U	H	W
050512-11/10	57	35	39	~39
	76	34	39	~32

Description.—Coarsely ribbed Hammatoceratinae with a high hollow-floored keel. The whorl cross-section on the inner whorls is broad-ovate, becoming triangular high-ovate at the last preserved whorl. On the inner whorls the ribbing consists of short and blunt primaries ending in strong tubercles (about 15 tubercles at D = 50 mm). From a diameter of 50 mm onwards, the nodes give way to short, strong, and radiate primaries, often bifurcating below the mid-flank into slightly sinuous secondaries. On the venter the ribs curve slightly forward and end at the keel.

Discussion.—The figured specimen matches well the original of Mayer (1871) figured by Rieber (1963: pl. 8: 5, 7). Compared with a larger specimen from the Shemshak Group of the Tazareh section, described by Seyed-Emami et al. (2006), the present specimen has a greater number and more densely spaced tubercles.

Stratigraphic and geographic range.—Sharif-Abad, level G. Late Aalenian, *Otoceras concavum* Zone.

Family Eryceritidae Spath, 1928
Genus *Erycites* Gemmellaro, 1886
Erycites aff. *sphaeroconicus* Buckman, 1922

Fig. 6L.

1922 aff. *Erycites sphaeroconicus*; Buckman 1922: pl. 315.

Material.—A specimen preserved on one-side from Kuhe Bashm (050511-7/1).

Dimensions (in mm)

Specimen	D	U	H	W
050511-7/1	62	27	38	~65

Description.—Fairly involute and highly depressed *Erycites*, with a deep umbilicus, a broad and cadicone whorl cross-section and a flat keel. The ribbing is relatively strong and nearly rectiradiate.The straight primary ribs usually trifurcate ventrolaterally, without any tubercles. The secondary ribs continue straight onto the broad venter and end nearly vertically oriented with respect to the flat keel. About 11 primaries and 33 secondaries have been counted on the last preserved half-whorl (ratio 1:3).

Discussion.—The described specimen is most probably a new species, being characterized by its highly depressed and cadicone whorl cross-section. Concerning the narrow umbilicus and the depressed whorls, it can be somehow compared to the inner whorls of the group of *Erycites fallax* (Benecke, 1865), which has been considered a synonym of *E. fallifax* Arkell, 1950 by Callomon and Chandler (1994: 21). Compared to the latter our specimen is clearly more involute, much

more depressed and has a coarser ribbing. Concerning the narrow umbilicus and the broad, cadicone whorls, our specimen can be best compared to *Erycites* aff. *sphaeroconicus* Buckman, 1922 of Rulleau et al. (2001: pl. 27: 7a, b). Other similar taxa are *E. barodiscus* Gemmellaro, 1886 in Cresta (1997: pl. 3: 5) and *E. involutus* Prinz, 1904 in Prinz (1904: 90, pl. 32, pl. 33: 7) and Géczy (1966: 103, pl. 25: 5). From these, our specimen is distinguished again by more depressed and cadicone whorls.

Stratigraphic and geographic range.—*Erycites* is a typical Mediterranean taxon, being only known sporadically from the Kerman area of southeastern Central Iran (Seyed-Emami 1967, 1971). This is the first record of the genus from the Alborz Range. The single specimen was found at Kuhe Bashm (level VII) above the beds with *Pleydellia*, co-occurring with *Leioceras opalinum* from the Late Aalenian *Leioceras opalinum* Zone.

Superfamily Stephanoceratoidea Neumayr, 1875
Family Stephanoceratidae Neumayr, 1875
Genus Stemmatoceras Maschke, 1907
Stemmatoceras? sp.

Fig. 6K.

Material.—A single specimen from Sharif-Abad (050512-13).

Discussion.—A fragment of a large and coarsely ribbed Stephanoceratidae was found at Sharif-Abad (level H), which may be a *Stemmatoceras* from the Middle Bajocian. Stephanoceratidae are common in the Badamu Formation of the Kerman area (Seyed-Emami 1967, 1971, 1988), but have been never reported with certainty from the Alborz Range.

Palaeogeography and palaeobiogeography

After closure of the Palaeotethys in the Late Triassic, the Iran Plate (Central and North Iran) occupied a position at the southern margin of Eurasia (Seyed-Emami 2003). Close lithologic and faunistic relationships between North and Central Iran during deposition of the Shemshak Group indicates that the two areas were palaeogeographically closely related, probably forming a kind of archipelago. According to palaeogeographic maps of the Early Jurassic (Dercourt et al. 1993, 2000) North Iran (Alborz) occupied a fairly high latitudinal position of approximately N 44°, at the northeastern margin of the Western Tethys (Fig. 7). During the Middle Jurassic (Middle Callovian) it shifted to a lower latitude of about N 30°, which roughly corresponds to the latitude of the northwest European Archipelago.

The close palaeobiogeographic relationship of the ammonite faunas with those of Northwest Europe and the northwestern Tethys during the Jurassic and Cretaceous systems indicates the existence of direct but episodic marine connections and faunal exchange between the two areas (Seyed-Emami 1988). The faunal migration routes during the Early Jurassic and earliest Middle Jurassic followed most probably the epicontinental platforms at the southern margin of the Eurasian landmass (Fig. 7).

Marine intercalations and faunas within the Shemshak Group are apparenly related to transgressive episodes in the Norian, Late Sinemurian, Late Pliensbachian, Toarcian, and Aalenian. Strikingly the transgressive phases do not neccessarily follow the global sea-level rise and fall (Hardenbol et al. 1998; Hallam 2001), but apparently were greatly influenced by the local and regional synsedimentary tectonic activity (Fürsich et al. 2005).

On the whole, the ammonite fauna of the Shemshak Group is rather poor and discontinuously distributed, with low species richness and low generic diversity but a strong dominance of certain taxa (one or a few genera). The abundance and diversity of the fauna is evidently related to periods of reduced siliciclastic input (starvation) in connection with sea level rises. These periods are usually indicated by intercalations of calcareous beds, which are minor constituents within the overwhelmingly siliciclastic sediments of the Shemshak Group.

In total, 236 ammonite specimens have been collected from the sections north of Semnan, comprising 62 taxa. The relative abundances at the family level are: Phylloceratinae (<1%), Cymbitidae (<0.5%), Echioceratidae (~2%), Amaltheidae (~8%), Dactylioceratidae (6%), Hildoceratide (8.5%), Graphoceratidae (63%), Hammatoceratinae (10%), Erycitidae (<0.5%), and Stephanoceratidae (<0.5%). Summing up, besides few endemic taxa (~6%), the fauna is closely related to northwestern Europe (Subboreal Province) with minor Tethyan (Mediterranean) elements. The few representatives of Tethyan elements are, without exception, taxa that also occur in northwestern Europe. The nearly total absence of Lytoceratinae and the scarcity of Phylloceratinae (<1%), as elsewhere in North and Central Iran, is remarkable. Contrary to the situation in the Shemshak Group, Phylloceratidae are very well represented in Middle and Upper Jurassic strata of the Alborz region (Dalichai and Lar formations) since the Late Bajocian (up to 50% of the total fauna), and the Tethyan (Submediterranean) influence is also much more evident and stronger (Seyed-Emami et al. 2001). This indicates environmental changes (e.g., in bathymetry and sea-water temperatures) and probably the existence of new marine connections.

Even though the diversity of the taxa within the Shemshak Group is much lower than in age-equivalent strata of northwestern and central Europe, the Graphoceratidae (concerning the number of the specimens as well as the number of taxa) make up the bulk of the fauna. The subfamily Dumortierinae alone accounts for more than 50% of the total fauna. The low relative abundance of Hammatoceratidae compared with southeastern Central Iran is noteworthy as is the scarcity of Hildoceratidae, except Grammoceratinae. Of special palaeobiogeographic interest is the presence of Amaltheidae, because of their strictly boreal distribution (Smith et al. 2001).

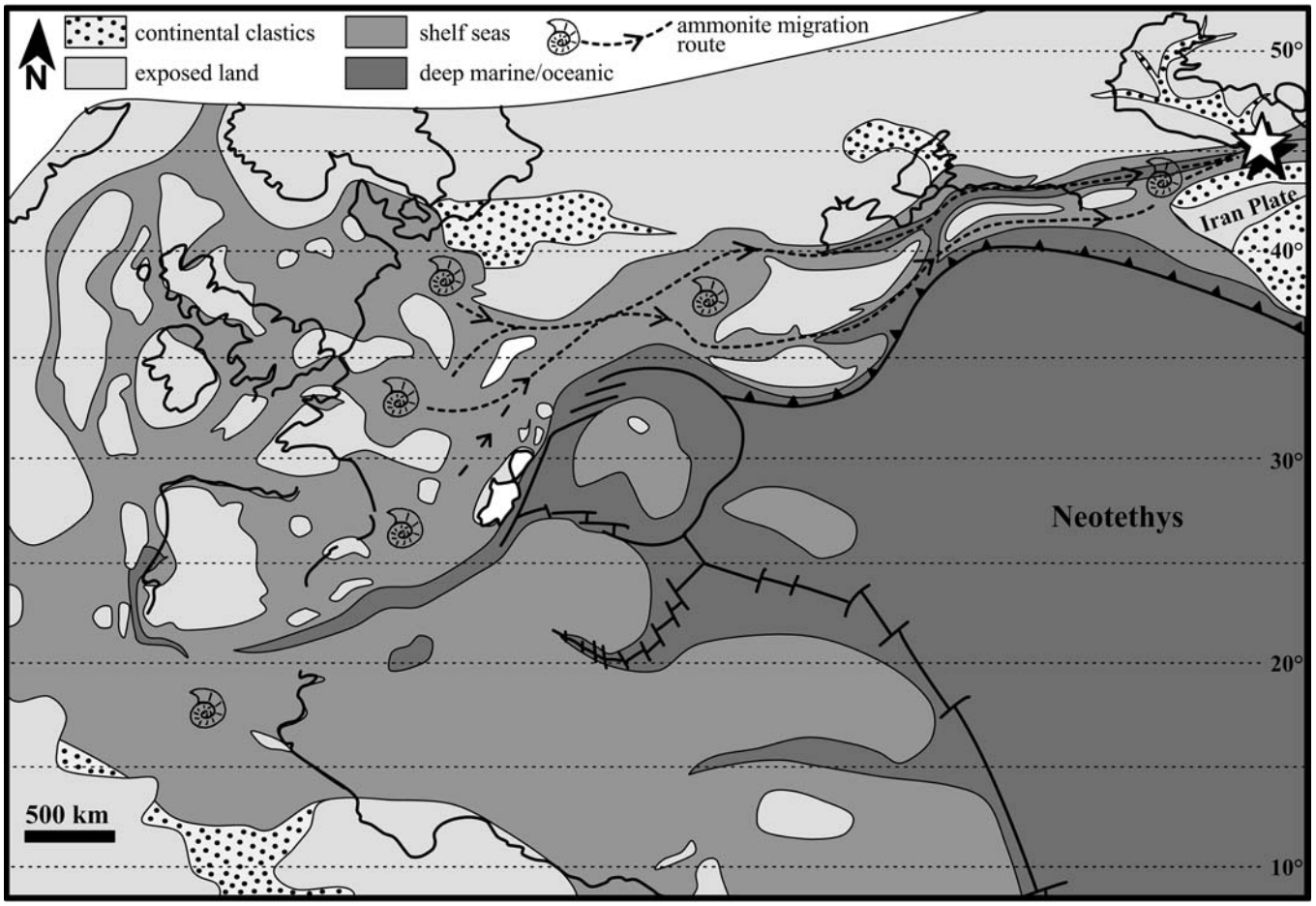


Fig. 7. Palaeogeography of the western and central peri-Tethyan area showing inferred ammonite migration routes (modified after Dercourt et al. 2000). The asterisk indicates the position of the ammonite fauna of this study.

A boreal influence in central and northeastern Iran is again evident in the Albian and Cenomanian, indicated by the presence of Leymeriellidae, Hoplitidae, and *Schloenbachia* (Seyed-Emami 1988). Remarkably, there is no faunal relationship at all with the southern Tethys and southwestern Iran (Zagros).

Conclusions

Of the various sections of the Shemshak Group in the southeastern Alborz Mountains studied by our team (Tazareh: Fürsich et al. 2005; Seyed-Emami et al. 2006; Jajarm: Seyed-Emami et al. 2005), the sections east of Shahmirzad so far contain the most abundant marine intercalations. Apart from short-lived marine ingressions in the Norian (unpublished data), Late Sinemurian, and Late Pliensbachian, the most extensive and long-lasting marine transgression occurred during the Toarcian and Aalenian, as is the case in the most parts of the Iran Plate. Concerning the number, diversity, and preservation quality of the ammonite faunas, the sections east of Shahmirzad are unique in the Alborz Range. Up to now, more than 60 taxa have been described from the Shemshak Group (Table 1; Nabavi and Seyed-Emami 1977; Seyed-Emami and Nabavi 1985; Seyed-Emami 1987; Seyed-Emami and Hosseinzadeh 2006, and this study). They comprise the families Cymbitidae, Echioceratidae, Amaltheidae, Dactylioceratidae, Hildoceratidae, Graphoceratidae, Hammatoceratidae, Erycitidae, and Stephanoceratidae. As in northwestern and central Europe (Callomon and Chandler 1994; Myczyński 2004) and elsewhere in Iran (Seyed-Emami et al. 2005), members of the family Graphoceratidae make up the bulk of the fauna (>60%). Of these, the subfamily Dumortierinae alone accounts for more than one-third of the entire taxa. Noteworthy is also the relative abundance of Hammatoceratidae (~10%), which usually are much less common in the Alborz region. As usual, Lytoceratidae are entirely absent and Phylloceratidae form less than 1% of the total fauna. Of special palaeobiogeographic interest is the presence of Amaltheidae, because of their boreal and subboreal distribution (Smith et al. 2001).

As previously discussed (Seyed-Emami 1988; Seyed-Emami et al. 2001, 2005, 2006) the ammonite faunas from the Shemshak Group are closely related to those occurring in northwestern and central Europe, the Northwest European Province of Dean et al. (1961) and Cariou and Hantzpergue (1997). They exhibit minor relationships with the Mediterranean Province but none with faunas from the southern hemisphere (southwestern Iran and southern Tethys).

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