Lower Tithonian ammonites from the Chaman Bid Formation in northeastern Iran, Koppeh-Dagh Basin

Mahmoud Reza Majidifard[1]*, Franz Theodor Fuersich[2], Helmut Keupp[3], Kazem Seyed-Emami [4]
[1] *Research Institute for Earth Sciences, Geological Survey of Iran, Tehran, Iran*
[2] *GeoZentrum Nordbayern, Friedrich-August Universität Erlangen-Nürnberg, Germany*
[3] *Freie Universität Berlin, Institut für Geologische Wissenschaften, Germany*
[4] *School of Mining Engineering, University College of Engineering, University of Tehran, Tehran, Iran*
**Corresponding author, e-mail: m_majidifard@yahoo.com*
(*received: 21/07/2016 ; accepted: 11/02/2017*)

Abstract
The type section of the Middle and Upper Jurassic Chaman Bid Formation is in the western Koppeh-Dagh Basin (Northeast Iran). It is unusually thick and contains a rather rich ammonite fauna, ranging from Bathonian to Tithonian. The ammonites described here come from a 134-m-thick interval in the upper part of member (D) in the middle part of the formation, consisting of an alternation of grey limestone and marly limestone. The following ammonite families are present: Haploceratidae, Oppeliidae, Perisphinctidae, and Ataxioceratidae, among them the following taxa have being recorded for the first time from Iran: *Phanerostephanus subsenex, Phanerostephanus* aff. *intermedius, Nothostephanus* aff. *kurdistanensis*, *Nannostephanus* cf. *subcomutus* and *Oxylenticeras* cf. *lepidum.* This assemblage is belonging to the Lower Tithonian Semiforme Zone or even older zones. The Fallauxi Zone is represented by *Richteria richteri*.

Keywords: *Jurassic, Tithonian, ammonites, Chaman Bid Formation, Koppeh-Dagh.*

Introduction

Jurassic rocks are widely distributed and superbly exposed in the Koppeh-Dagh Mountains of northeastern Iran (Afshar-Harb, 1979, 1994). Parts of the lower Middle Jurassic are characterized by a thick siliciclastic successions (Kashafrud and Bashkalateh formations; e.g., Taheri *et al.* 2009), whereas the Upper Bathonian to Tithonian rocks are predominantly carbonates, which represent platform, slope, and basin systems (Mozduran Formation; e.g., Lasemi, 1995). The Middle and Upper Jurassic sedimentary successions of Koppeh-Dagh comprise four formations: Kashafrud/ Bashkalateh, Chaman Bid, and Mozduran**.** The Lower Tithonian ammonites from the Chaman Bid Formation (Afshar-Harb, 1979, 1994) at the type locality is the scope of this paper (Fig. 1).

The first report of Tithonian *Richteria* in the study region was by (Bogdanowitch, 1889). Afshar-Harb (1979, 1994) indicated a Bathonian to Kimmeridgian age for the Chaman Bid Formation. Schairer *et al.* (1999) proved with records of *Richteria* that the Chaman Bid Formation at the type locality continues up to the Tithonian. The ammonite fauna of the type section has been studied by Majidifard (2003). The Chaman Bid Formation is rich in ammonites, which main ones were studied by Raisossadat *et al.* (2006), Motamedalshariati *et al.* (2006), Ashuri *et al.* (2008), Ashuri *et al.* (2011), Faridani *et al.* (2012), Dabagh Sadr *et al.* (2012), Raoufian *et al.* (2014), Parent *et al.* (2014), Majidifard (2015).

The type section of the Chaman Bid Formation is located 3.5 km northwest of Chaman Bid village in the Kourkhod Mountains (Afshar-Harb, 1994, quadrangle map of Kuh-e-Khurkhud, 1:250,000), 60 km W of Bojnourd with the following co-ordinates: N 37°26´00´´, E 56°30´50´´ (Fig. 1).

The Chaman Bid Formation has a thickness of 1556m. (Afshar-Harb 1979; Majidifard 2003; Fig. 2) at the type section north of the village Bash Kalateh (Chaman Bid) and consists predominantly of alternation of grey limestone, marly limestone (mudstone to packstone) and a few beds of sandstone. It overlies the fine-grained siliciclastic and turbiditic Bashkalateh (= Kashafrud) Formation and is overlain transitionally by the light-grey and massive carbonates of the Mozduran Formation (Figs. 3, 4). According to the lithology and ammonite fauna, the Chaman Bid Formation is more or less equivalent to the Dalichai Formation of the Alborz Mountains (Majidifard 2003, 2008; Fig. 4).

At the type section, the Chaman Bid Formation has been subdivided, from base to top, into seven members A–G (Majidifard 2008; Fig. 2):
member A has a thickness of 30m, consists of gery shale and sandy limestone and is of questionable

Bathonian age.

member B has a thickness of 408m, consists of an alternation limestone and argillaceous limestone and is of questionable Bathonian to Callovian age.

member C has a thickness of 33m, consists of an alternation sandstone, silty marl, silt and is of Late Callovian age.

member D has a thickness of 357m and consists of an alternation of grey limestones, argillaceous shale, and marl that are rich in ammonites. It is assigned to the Oxfordian to Lower Tithonian (Fig. 3).

member E has a thickness of 78m, consists of an alternation sandstone, silty marl, silt and is of Late Tithonian age.

member F has a thickness of 42m, consists of an alternation of marl, limestone, argillaceous shale and is of the Late Tithonian - ?Neocomian age.

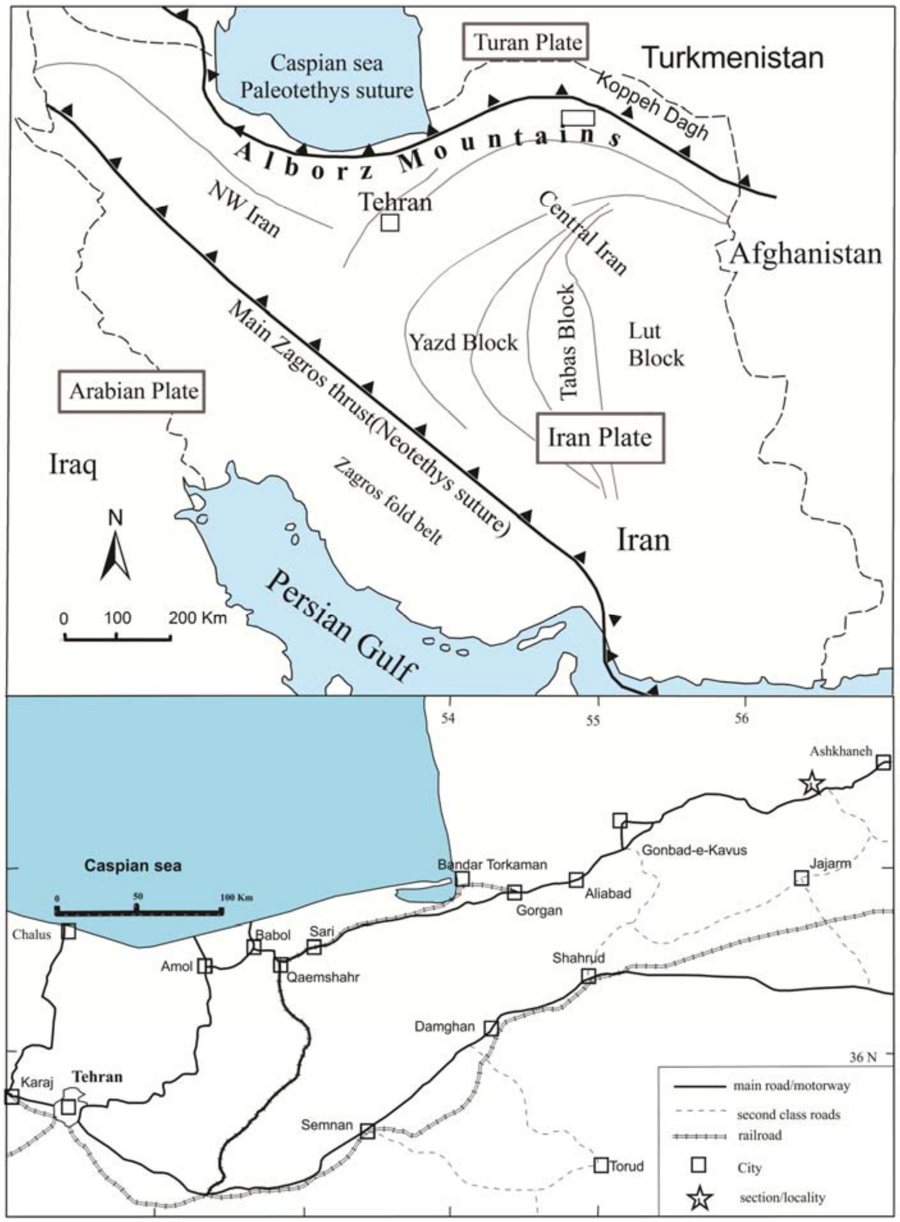

Figure 1. Position of the type section of the Middle and Upper Jurassic Chaman Bid Formation in the western Koppeh-Dagh of northeastern Iran.

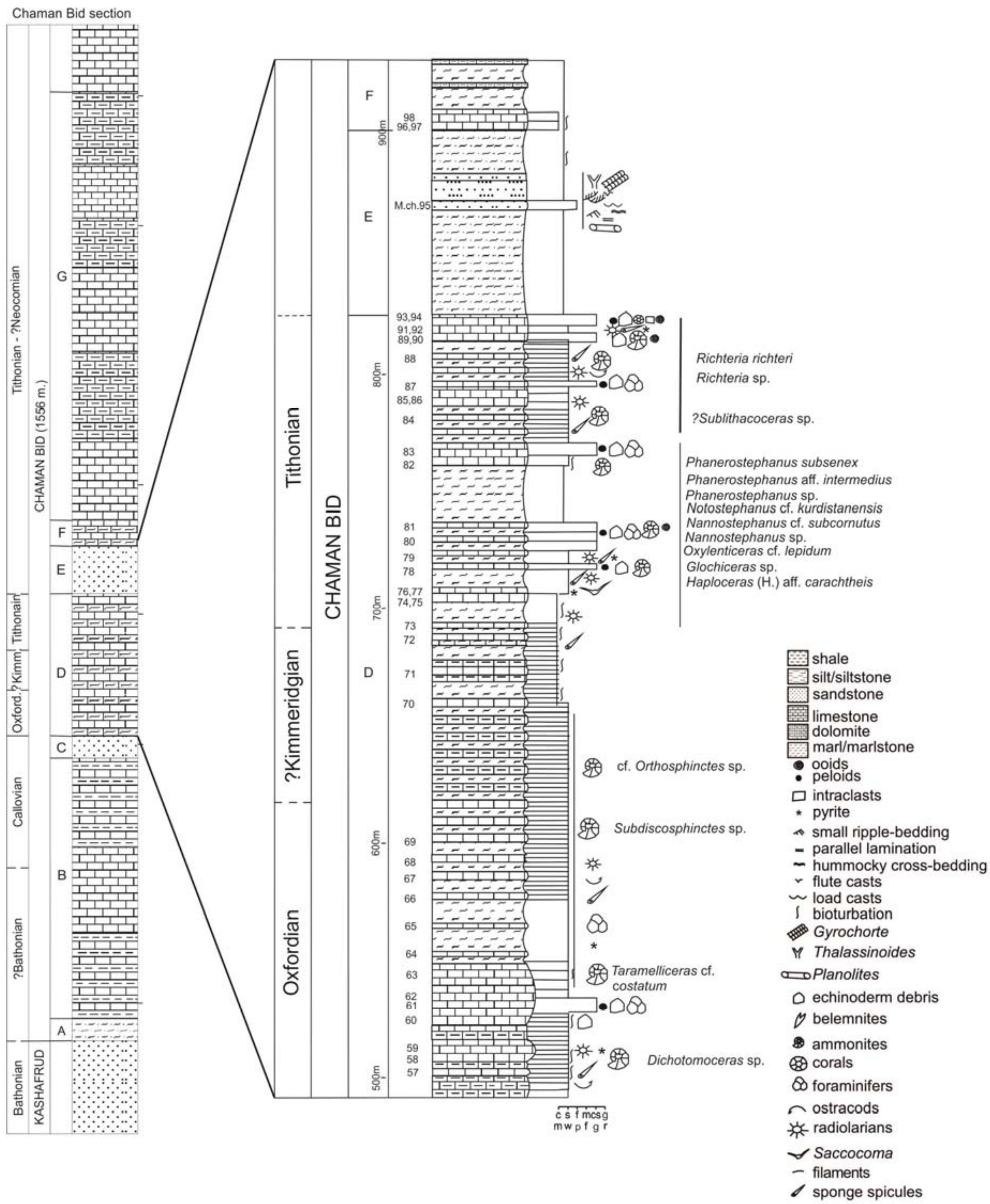

Figure 2. Stratigraphic log of the type section of the Chaman Bid Formation. c/m= clay/mudstone; s/w= siltstone/wackstone; f/p= fine-grained sandstone/packstone; m/fl= medium-grained sandstone/floatstone; c/g= coarse-grained sandstone/grainstone; g/r=gravel/rudstone

member G has a thickness of 658m, consists of grey limestone with argillaceous shale and is of the Late Tithonian - ?Neocomian age.

Systematic palaeontology

As far as permitted by the preservation of the specimens, measurements of the following parameters are given: diameter (D) in mm, umbilical width (U), whorl height (H), whorl width (W), the latter all in % of diameter; numbers of primary ribs per whorl (PR) and secondary ribs (SR). [M] = macroconch; [m] = microconch.

All specimens are figured in natural size, except otherwise indicated. The figured specimens are located at the Bayerische Staatssammlung für Paläontologie und historische Geologie, Munich.

Superfamily Haploceratatoidea Zittel, 1884

Family Haploceratidae Zittel, 1884

Genus *Haploceras* Zittel, 1870

Haploceras (Haploceras) aff. *carachtheis* (Zeuschner)

Pl. 1, Fig. 2

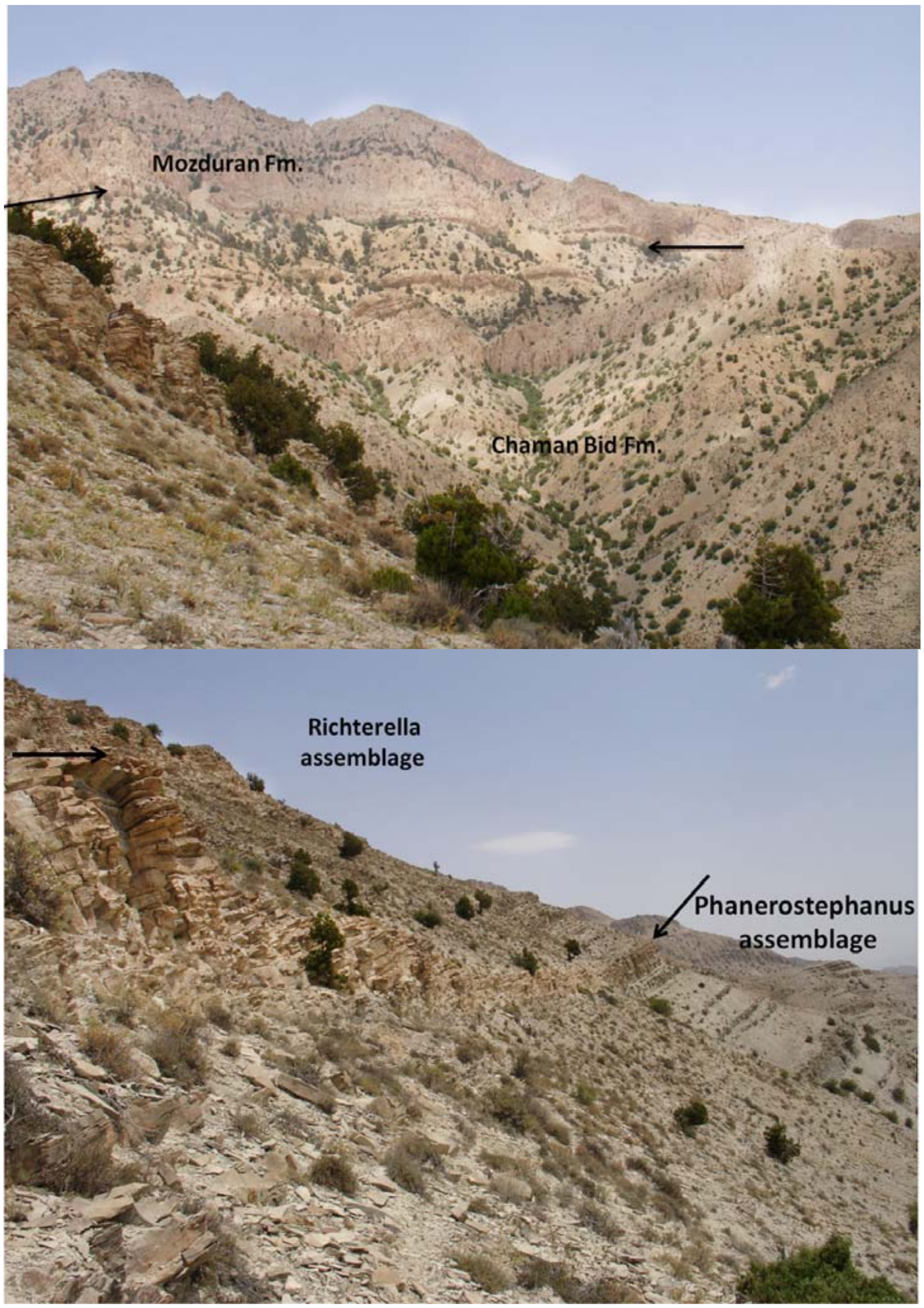

Figure 3. Field aspects of the Chaman Bid Formation at the type locality. A, massive to thickly-bedded limestones of the Mozduran Formation conformably but sharply overlying alternations of limestones, argillaceous limestones and argillaceous shales of the Chaman Bid Formation. B, Contact (arrowed) between the *Phanerostephanus*, *Nothostephanus*, *Nannostephanus* and *Richteria* assemblage of the Chaman Bid Formation.

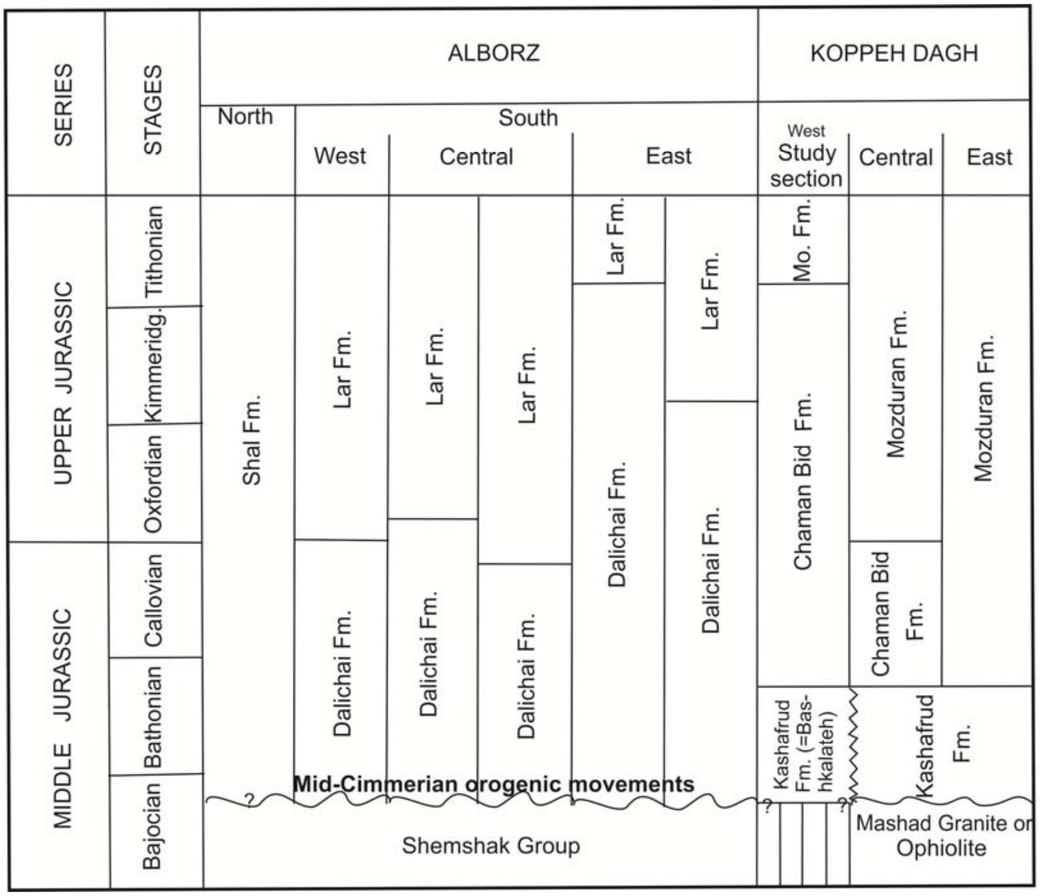

Figure 4. Lithostratigraphic scheme of Middle and Upper Jurassic rocks in North and North-East Iran; Mo.= Mozduran Formation; Kimmeridg.=Kimmeridgian.

1986 *Haploceras (Haploceras)* [m] *carachtheis* (Zeuschner) – Enay & Cecca: pl. 1, figs. 3–4; pl. 2, figs. 1, 2, 10–16, 18, 19.
1994 *Haploceras (Haploceras) carachtheis* (Zeuschner) – Zeiss *et al.:* pl. 2, fig. 3.
1999 *Haploceras (Haploceras) carachtheis* (Zeuschner) – Schairer et al.: pl. 1, fig. 3.
2005 *Haploceras (Haploceras) carachtheis* (Zeuschner) – Boughdri *et al*.: pl.1, fig. 7.
2011 *Haploceras (Haploceras) carachtheis* (Zeuschner) – Grigore: pl. 2, figs. 6-7.

Material: 3 specimens (GZN2011I-CH-6-3, GZN2011I-CH-6-5, GZN2011I-CH-6-4).

Dimensions: Table 1

specimen	D	U%	H%	W%
GZN2011I-CH-6-3	50	18	52	36
GZN2011I-CH-6-5 (body chamber)	43	18	50	36
GZN2011I-CH-6-4	29	20	48	33

Description: Shell involute, cross-section of whorl elliptical, umbilical wall high and vertical, umbilical shoulder distinct, surface smooth, without ribbing. Shell becoming increasingly higher and wider towards aperture. The body chamber in specimen GZN2011I-CH-6-5 seems to occupy about 2/3 of the outer whorl.

Remarks: The present specimens very closely resemble *H. (H.) carachtheis* as illustrated by Enay & Cecca (1986) and Schairer et al. (1999).

Stratigraphic distribution: *H. (H.) carachtheis* come from Lower Tithonian to Berriasian (Oloriz 1978; Enay & Cecca 1986). The specimens from Iran are recorded from the Lower Tithonian.

Family Oppeliidae Bonarelli, 1894
Genus *Glochiceras* Hyatt, 1900
Glochiceras sp.
Pl. 1, Fig. 1

1950 *Glochiceras* sp. juv. ind. – Spath: 139, pl. 6, fig. 6a, b.

Material: 1 specimen (GZN2011I-CH-6-41).

Dimensions: Table 2

specimen	D	U%	H%	W%
GZN2011I-CH-6-41	41	13	51	13

Description: Shell moderately involute, compressed, whorl section high-oval, umbilical wall low. Surface of shell smooth except for a lateral groove at mid-flank.
Remarks: The present specimen is closely similar to *Glochiceras* sp. of Spath (1950: 139, pl. 6, fig. 6a, b) but appears to differ in having a more strongly compressed whorl section.
Stratigraphic distribution: Lower Tithonian.

Subfamily Streblitinae Spath, 1925
Genus *Oxylenticeras* Spath, 1950
Oxylenticeras cf. *lepidum* Spath, 1950
Pl. 1, Fig. 3

1950 *Oxylenticeras lepidum* sp. nov. – Spath: 99, pl. 6, figs. 1–5.

Material: 1 incomplete phragmocone (GZN2011I-CH-6-8).

Dimensions: Table 3

specimen	D	U%	H%	W %
GZN2011I-CH-6-8	----	15	55	37

Description: Shell involute, smooth, oxycone. Whorl cross-section high-oval. Whorl flank perfectly smooth, partly because in an attempt to expose the suture line the delicate growth striae were obliterated. Most of the extremely acute keel is broken off, but it is visible at the beginning of the outer whorl.

Remarks: The present specimen closely resemble the holotype of Spath (1950: pl. 6, figs. 1-5), but differs in lacking the acute venter.
Stratigraphic distribution: According to Spath (1950), the species occurs in the Tithonian. The specimen from Iran is from the Lower Tithonian.

Family Perisphinctidae Steinmann, 1890
Subfamily Virgatosphinctinae Spath, 1923
Genus *Sublithacoceras* Spath, 1925
?Sublithacoceras sp.
Pl. 2, Fig. 1

1999 *Sublithacoceras* sp. – Schairer et al.: 27, Taf. 2, fig. 1.

Material: 1 specimen (GZN2011I-CH-7-42).

Dimensions: Table 4

specimen	D	U%	H%	W%
GZN2011I-CH-7-42	59	19	21	7

Description: Shell compressed, venter very narrow. The inner whorls are finely, densely and regularly ribbed with long secondaries. The primaries start at the umbilical margin and divide into two secondaries at around mid-flank, which cross the venter with frequent simple ribs.

Stratigraphic distribution: The present specimen comes from the Lower Tithonian Richteri Zone.

Genus *Phanerostephanus* Spath, 1950
Phanerostephanus subsenex Spath, 1950
Pl. 2, Figs. 2, 5, 6; Pl. 3, Figs. 2, 5, 6

1950 *Phanerostephanus subsenex* sp. nov. – Spath: 105, pl. 6, fig. 15, pl. 7, figs. 5–7.
1992 *Phanerostephanus subsenex* Spath – Howarth: pl. 1, figs. 7, 8.

Material: 13 specimens and 9 fragments (GZN2011I-CH-6-13, GZN2011I-CH-6-14, GZN2011I-CH-6-15, GZN2011I-CH-6-16, GZN2011I-CH-6-33, GZN2011I-CH-6-35, GZN2011I-CH-6-32a, GZN2011I-CH-6-10a, GZN2011I-CH-6-25a, GZN2011I-CH-6-9, GZN2011I-CH-6-27).

Dimensions: Table 5

specimen	D	U%	H%	W%	PR	SR
GZN2011I-CH-6-13(body whorl)	103	41	33	25	10	
GZN2011I-CH-6-14(body whorl)	80	42	31		17	
GZN2011I-CH-6-15(body whorl)	72	40	33	29	12	
GZN2011I-CH-6-16 (body whorl)	67	36	37	31	16	
GZN2011I-CH-6-33	62	43	34	26	25	57
GZN2011I-CH-6-35	59	41	32		25	54
GZN2011I-CH-6-10a	47	40	33	25	25	
GZN2011I-CH-6-25a	54	44	35	28	28	58
GZN2011I-CH-6-27	60	44	34	28	26	54
GZN2011I-CH-6-9	48	40	33	25	25	

Description: Shell relatively evolute, whorl cross-section little higher than wide and oval, flank nearly flat, venter arched, umbilical wall nearly vertical, and umbilical margin broadly rounded. Ribbing on the inner whorls consisting of regular, relatively dense and rectiradiate to prorsiradiate ribs, starting at the seam and bifurcating near the outer part of the flank, with few intercalatory and polygyrate ribs. Close to the body whorl the ribs become coarser and distant and split into three secondary ribs. Towards the outer whorls, the primary ribs rapidly give way to prorsiradiate, irregular bullate ribs starting at the umbilical margin and vanishing about mid-flank. At this stage no secondary ribs are developed and the venter is smooth. Some of the primary ribs may continue towards the venter. A few constrictions can be seen. The body chamber seems to occupy about four-fifth of the outer whorl (Pl. 3, Fig. 6).

Remarks: The large specimen GZN2011I-CH-6-13 is fully grown with D=103 mm. It closely resembles the holotype figured by Spath (1950: pl. 7, fig. 5) but differs in having finer ribs on inner whorls. The body chamber in specimen GZN2011I-CH-6-14 seems to occupy about 2/3 of the outer whorl. It can be compared with the holotype figured by Spath (1950: pl. 7, fig. 5). Some of the specimens, e.g. GZN2011I-CH-6-9, 25a have mainly bifurcating and rarely single and trifurcating ribs whereas others, such as specimen, GZN2011I-CH-6-10a and the one figured by Schairer & Barthel (1981: pl. 3, fig. 3) have mainly bifurcating and rarely single and intercalatory ribs. The present specimens closely resemble Schairer & Barthel's specimen but differ from that in having fairly distant ribs.

Stratigraphic distribution: According to Spath (1950), *Phanerostephanus subsenex* occurs in the upper part of the Lower Tithonian to lower part of the Upper Tithonian of Kurdistan (northern Iraq). The present specimens come from the Lower Tithonian because at the top of its stratigraphic range *Ph. subsenex* co-occurs with abundant *R. richteri* which indicates the Lower Tithonian (Oloriz 1978; Cecca 1986; Fig. 5). Therefore, *Ph. subsenex* is stratigraphically older than *R. richteri* (lower part of Fallauxi Zone, Richteri Subzone). Enay *et al.* (1971) reported *Phanerostephanus* associated with *Pseudinvoluticeras*, *Virgatosphinctes*, *Aspidoceras*, *Hybonoticeras*, and *Aulacosphinctes* in Turkey. The presence of *Hybonoticeras* places this fauna in the Lower Tithonian Hybonotum or Darwani zones Fig. 5. Moreover, *Aulacosphinctes* is also more likely to indicate the Upper Tithonian (Howarth, 1992). In Madagascar, (Collignon, 1960) recorded *Phanerostephanus* from the *Aulacosphinctes hollandi* Zone, which indicates the Upper Tithonian. Thus, this is an Upper Tithonian fauna, not older than the Microcanthum Zone, and is a definite identification of the age of *Phanerostephanus* in Madagascar (Howarth 1992). Verma & Westerman (1984) found *Phanerostephanus* in the Lower Tithonian (Hybonotum Zone) of Kenya, but according to Howarth (1992), these specimens are more evolute and lack the umbilical tubercles of *Phanerostephanus* and belong rather to *Sublithacoceras*. On the other hand, Donze & Enay (1961) reported an example of *Phanerostephanus* from the Lower Tithonian of south-eastern France which also lacks umbilical tubercles. Meanwhile, *Phanerostephanus*, originally known only from northwestern Kurdistan (Spath 1950) has been recorded from Turkey (Enay *et al.*, 1971), Madagascar, (Collignon, 1960), Kenya (Verma & Westermann, 1984), and south-eastern France (Donze & Enay, 1961).

Phanerostephanus aff. *intermedius* Spath, 1950
Pl. 2, Fig. 3

aff. 1950 *Phanerostephanus intermedius* sp. nov. – Spath: 107, pl. 8, fig. 3.

Material: 2 specimens (GZN2011I-CH-6-22, GZN2011I-CH-6-23).

Dimensions: Table 6

specimen	D	U%	H%	W%	PR	SR
GZN2011I-CH-6-22	52	33	40	37	26	55
GZN2011I-CH-6-23	54	33	39	31	28	61

Description: Shell relatively evolute and inflated with an ovate whorl cross-section which is higher than broad. Venter rounded and broadly arched. Primary ribs sharp, coarse and slightly prorsiradiate. They start at the umbilical margin and divide into two or three dense secondaries at around two-thirds of flank height and continue towards the venter. There are three prorsiradiate constrictions on the last visible whorl.

Remarks: The present specimen closely resemble *Phanerostephanus intermedius* Spath, 1950 but differ from holotype by (Spath 1950: 107, pl. 8, fig. 3) in having fairly strong ribs. The species differs from *Phanerostephanus subsenex* and *Phanerostephanus* sp. in being more inflated and

involute.
Stratigraphic distribution: Lower Tithonian (lower part of Fallauxi Zone, Richteri Subzone).

Phanerostephanus sp.
Pl. 2, Fig. 4
Material: 1 specimen and 2 fragments (GZN2011I-CH-6-26a).

Dimensions: Table 7

specimen	D	U%	H%	W%	PR	SR
GZN2011I-CH-6-26a (body whorl)	54	40	36	28	28	

Description: Shells relatively evolute with high-ovate whorl cross-section, low and rounded umbilicus, flatted flanks, and arched, broad venter. The ribbing is slightly prorsiradiate and coarse. The primaries begin at the umbilical margin and split mainly into two, rarely three, secondaries at around two-thirds of flank height, which cross the venter. There are four prorsiradiate, deep constrictions on the last whorl. The body chamber seems to occupy about four-fifth of the outer whorl.

Remarks: The present specimens differ from other specimens of *Phanerostephanus* in having sharp and deep constrictions, relatively coarse ribs and arched, broad venters.

Stratigraphic distribution: Lower Tithonian (lower part of Fallauxi Zone, Richteri Subzone).

Genus *Nothostephanus* Spath, 1950
Nothostephanus aff. *kurdistanensis* Spath, 1950
Pl. 2, Fig. 7, Pl. 3, Fig. 1
aff. 1950 *Nothostephanus kurdistanensis* sp. nov. – Spath: 116, pl. 7, figs. 1–3
Material: 2 specimens and 1 fragment (GZN2011I-Ch-6-9ab, GZN2011I-CH-6-9abc).

Dimensions: Table 8

specimen	D	U%	H%	W%	PR	SR
GZN2011I-CH-6-9ab	54	31	43	31		
GZN2011I-CH-6-9abc	37	32	42	28		

Description: Shell fairly involute with high whorls and ovate whorl cross-section, narrowly rounded venter and nearly flat flank. Venter rounded and arched. The ribbing is prorsiradiate, regular, and dense. The primaries begin close to the umbilical margin and divide into two, rarely into three, secondaries at around two-thirds of flank height. Some ribs remain simple.

Remarks: With regard to its dense ribbing, increasing height of the phragmocone, primary ribs on the umbilical margin fairly thickening and fairly involute coiling, the specimens resemble *Nothostephanus kurdistanensis* Spath (1950: 116, pl. 7, fig. 1) but differ in having somewhat finer ribs. This genus is connected with *Phanerostephanus* by morphological transitions (Spath, 1950). The species differs from *Phanerostephanus* (*Nothostephanus*) *digoi* Verma & Westermann (1984: 53, pl. 10, fig. 2) in having a larger umbilicus and weaker umbilical nodes, finer ribs, a narrower venter and a different branching point of the ribs.

Stratigraphic distribution: *Nothostephanus* aff. *kurdistanensis* co-occurs with *Phanerostephanus subsenex* in the Lower Tithonian (lower part of Fallauxi Zone, Richteri Subzone).

Genus *Nannostephanus* Spath, 1950
Nannostephanus cf. *subcornutus* Spath, 1950
Pl. 2, Fig. 8
cf. 1950 *Nannostephanus subcornutus* sp. nov. – Spath: 111, pl. 10, figs. 7–10.
cf. 1992 *Nannostephanus subcornutus* Spath – Howarth: pl. 1, figs. 3, 4.
Material: 1 specimen (GZN2011I-CH-6-13b).

Dimensions: Table 9

specimen	D	U%	H%	W%	PR	SR
GZN2011I-CH-6-13b	35	52	24	36	16	32

Description: Shell evolute with rectangular whorl cross-section, rounded umbilical shoulder, vertical umbilical wall, and broad rounded venter. The ribbing is coarse, strong and distant on the outer whorls. The prorsiradiate primaries begin at the umbilical margin and end at tubercles near the ventrolateral shoulder, from where they bifurcate. The prorsiradiate ribbing continues towards the venter.

Remarks: The specimen has only slightly denser ribs than the holotype figured by (Spath 1950: pl. 10, figs. 7–10).

Stratigraphic distribution: *Nannostephanus* cf. *subcornutus* co-occurs with *Phanerostephanus subsenex* in the Lower Tithonian (lower part of the Fallauxi Zone, Richteri Subzone).

Nannostephanus sp.
Pl. 3, Fig. 3
Material: 1 specimen (GZN2011I-CH-6-13a).

Dimensions: Table 10

specimen	D	U%	H%	W%	PR	SR
GZN2011I-CH-6-13a	48	43	35		17	

Description: Shell evolute with approximately rectangular whorl cross-section, rounded umbilical shoulder, nearly vertical umbilical wall, and broad rounded venter. The ribbing is coarse, strong and distant on the middle and outer whorls. The prorsiradiate primaries begin at the umbilical margin and end at faint tubercles near the ventrolateral shoulder, from where they bifurcate. The prorsiradiate ribbing continues towards the venter.

Remarks: The single specimen has slightly denser, longer and finer ribs as well as a narrower venter than the holotype of *Nannostephanus subcornutus* as illustrated by (Spath,1950: pl. 10, fig. 7). Thus, it is kept without specific assignment.

Stratigraphic distribution: *Nannostephanus* sp. co-occurs with *Phanerostephanus subsenex* in the Lower Tithonian (older Fallauxi Zone, Richteri Subzone).

Family Ataxioceratidae BUCKMAN, 1921
Subfamily Lithacoceratinae Zeiss, 1968
Genus *Richteria* Oloriz, 1978
Richteria richteri (Oppel, 1865)
Pl. 1, Figs. 4–9; Pl. 3, Figs. 4, 7

1865 *Ammonites richteri* sp. nov. – Oppel: 556.
1868 *Kossmatia richteri* (Oppel) – Zittel: 108, pl. 20, figs. 9a–d.
1889 *Perisphinctes richteri* (Oppel) – Bogdanowitch: 175, pl. 4, figs. 1, 2.
1978 *Richteria richteri* (Oppel) – Oloriz: pl. 51, figs. 8–11.
1979 *Richterella richteri* (Oppel) – Sapunov: 136, pl. 40, fig. 7.
1986 *Richterella richteri* (Oppel) – Cecca: pl. 1, figs. 1, 2, 4, 5, 7, 8, 10–12.
1993 *Richterella richteri* (Oppel) – Schairer: 41, pl. 3, fig. 3.
1999 *Richterella richteri* (Oppel) – Schairer et al.: 27, pl. 2, figs. 3–6.

Material: 16 specimens and 75 fragments (GZN2011I-CH-7-37-39, GZN2011I-CH-7-44-45, GZN2011I-CH-7-52-60).

Dimensions: Table 11

specimen	D	U%	H%	W%	SR	PR
GZN2011I-CH-7-38	58	31	39	15	23	
GZN2011I-CH-7-53	55	35	40	15	28	60
GZN2011I-CH-7-37	51	38	35	15	22	44
GZN2011I-CH-7-39	52	36	35	13	22	49
GZN2011I-CH-7-44	49	34	38	13	24	44
GZN2011I-CH-7-45	46	37	38	12	26	51
GZN2011I-CH-7-52	40	40	38	15	20	40
GZN2011I-CH-7-51	50	30	40	12	22	44
GZN2011I-CH-7-55	46	37	37	11	22	44
GZN2011I-CH-7-57	45	31	40	13	26	54
GZN2011I-CH-7-54	44	34	41	18	24	48
GZN2011I-CH-7-56	37	32	43	13	23	46
GZN2011I-CH-7-60	40	30	43	12	22	45
GZN2011I-CH-7-58	28	36	39	21	17	32
GZN2011I-CH-7-59	29	38	38	17	16	

Description: Shells moderately evolute with high and compressed oval whorl cross-section, rounded umbilical margin, and nearly vertical umbilical wall. The ribbing is relatively dense, regular, fine, and slightly rectiradiate to prorsiradiate. The primary ribs begin at the umbilical margin and divide usually into two (rarely into three) falcoid and prorsiradiate secondaries at around mid-flank to two-thirds of flank height, from where they continue towards the venter. In a few cases the ribs remain simple. There are one or two intercalatory ribs that begin at mid-flank.

Discussion: The specimens correspond well to the material described and figured by Cecca (1986). The specimen GZN2011I-CH-7-37 (Pl. 1, Fig. 4) has coarser and stronger ribs than the other specimens. For this reason it is referred to *Richteria* *richteri* with reservation. Some of the specimens, e.g. GZN2011I-CH-7-37, have only bifurcate ribs whereas others, such as specimen GZN2011I-CH-7-44 and GZN2011I-CH-7-45 have mainly bifurcate and rarely simple ribs. Yet other specimens such as GZN2011I-CH-8-96 have mainly bifurcating and rarely trifurcate ribs. The present specimens differ also in that the secondaries start at mid-flank in some of them (e.g. GZN2011I-CH-7-69) and at around two-thirds of flank height in others (e.g. GZN2011I-CH-7-37, 44). However, all these minor differences fall into intra-specific variability of *Richteria richteri*.

Stratigraphic distribution: Lower Tithonian Fallauxi Zone (Richteri Zone in Oloriz 1978; Cecca 1986), Richteri Subzone (Geyssant, 1997: 98).

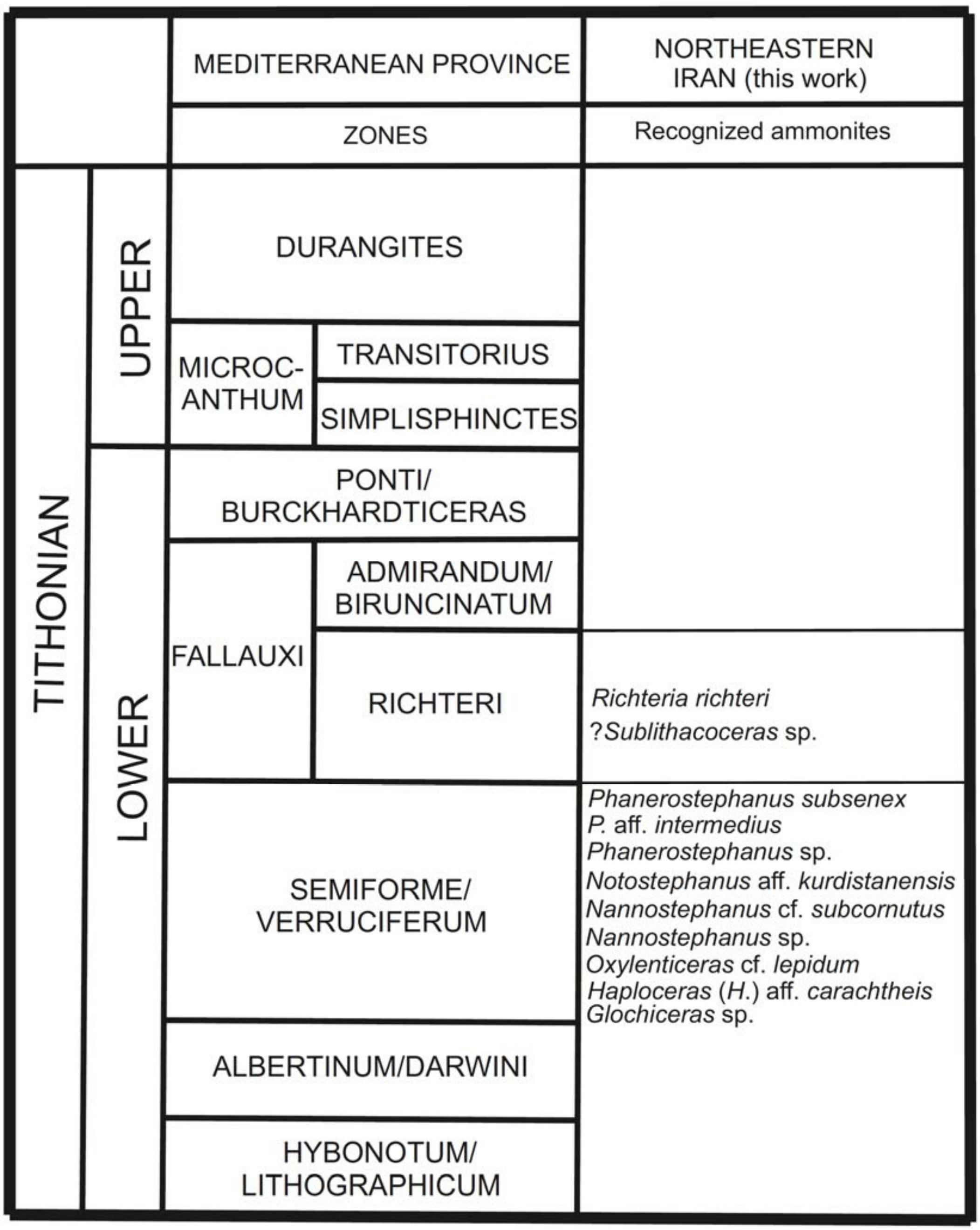

Figure 5. Zonal subdivision of Tithonian sediments of the northeast Iran (Chaman Bid section) and correlation with the standard chart of Mediterranean province, from Villaseñor *et al*. 2005.

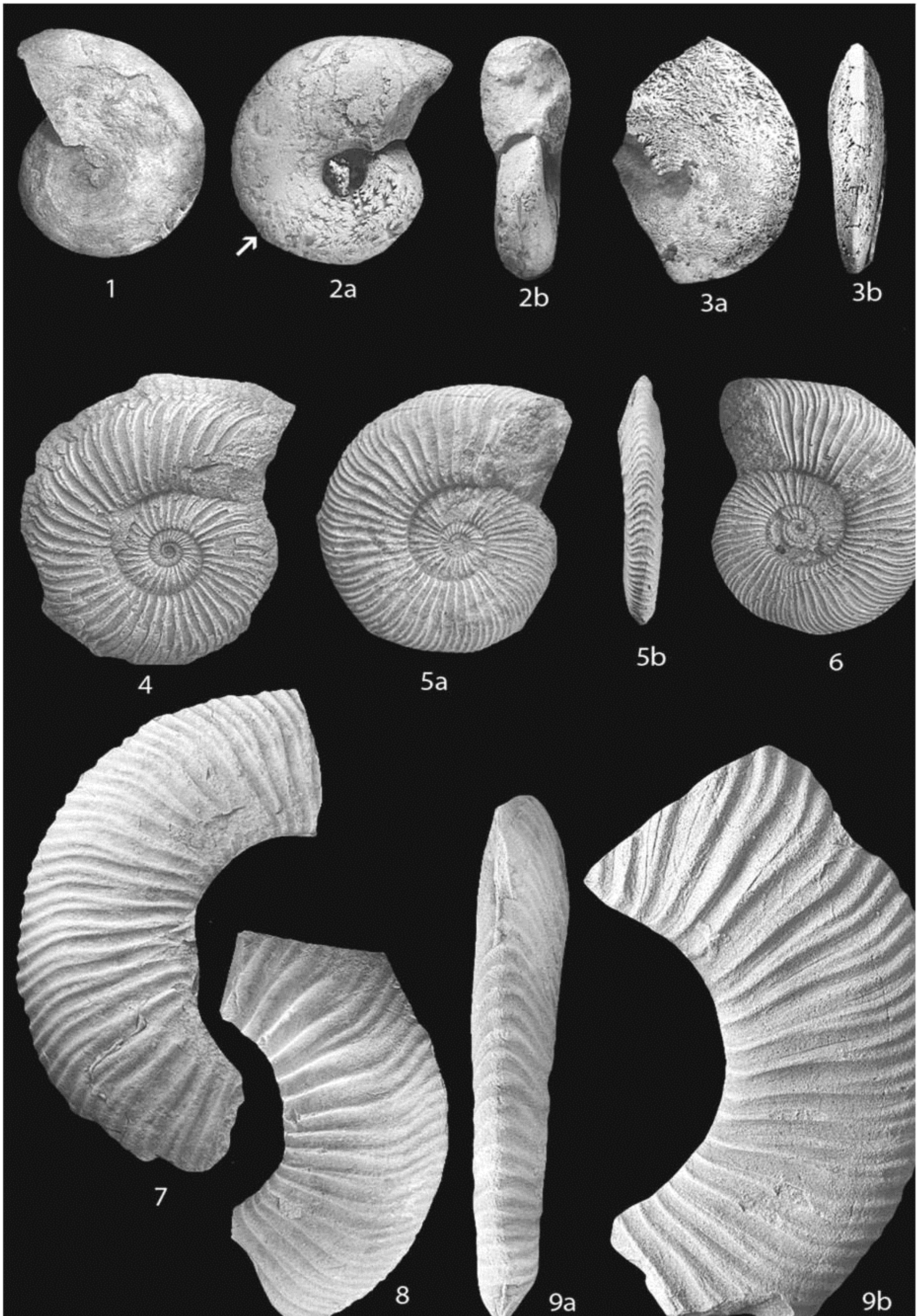

Plate 1. Fig. 1. Glochiceras sp., Lower Tithonian (GZN2011I-CH-6-41), Fig. 2. Haploceras (Haploceras) aff. carachtheis (Zeuschner) , Lower Tithonian (GZN2011I-CH-6-8), Fig. 3. Oxylenticeras cf. lepidum Spath, Lower Tithonian (GZN2011I-CH-6-7), Figs. 4–9. Richteria richteri (Oppel), Lower Tithonian, Fallauxi Zone (4, specimen GZN2011I-CH-7-53; 5, specimen GZN2011I-CH-7-37; 6, specimen GZN2011I-CH-7-45; 7, specimen GZN2011I-CH-7-39, a questionable macroconch, [M]; 8, specimen GZN2011I-CH-7-40; 9, specimen GZN2011I-CH-7-43, macroconch, [M])

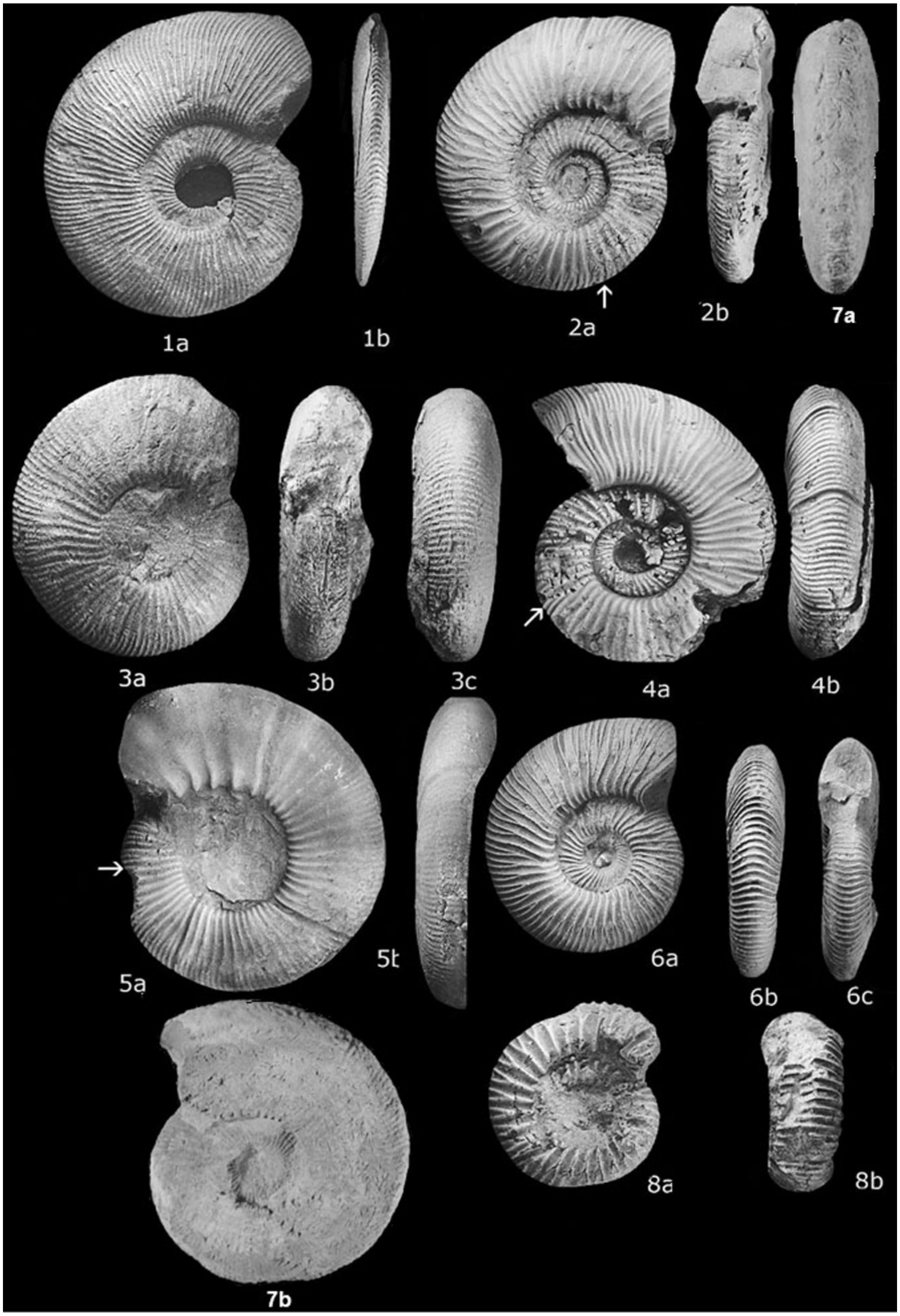

Plate 2. Fig. 1. *?Sublithacoceras* sp., Lower Tithonian (GZN2011I-CH-7-42), Figs. 2, 5, 6. *Phanerostephanus subsenex* Spath, Lower Tithonian (2, specimen GZN2011I CH-6-25a; 5, specimen GZN2011I-CH-6-27, with body chamber; 6, specimen GZN2011I-CH-6-10a), Fig. 3. *Phanerostephanus* aff. *intermedius* Spath, Lower Tithonian (GZN2011I-CH-6-23), Fig. 4. *Phanerostephanus* sp., Lower Tithonian (GZN2011I-CH-6-26a), Fig. 7. *Nothostephanus* aff. *kurdistanensis* Spath, Lower Tithonian, (GZN2011I-CH-6-9ab), Fig. 8. *Nannostephanus* cf. *subcornutus* Spath, Lower Tithonian (GZN2011I-CH-6-13b)

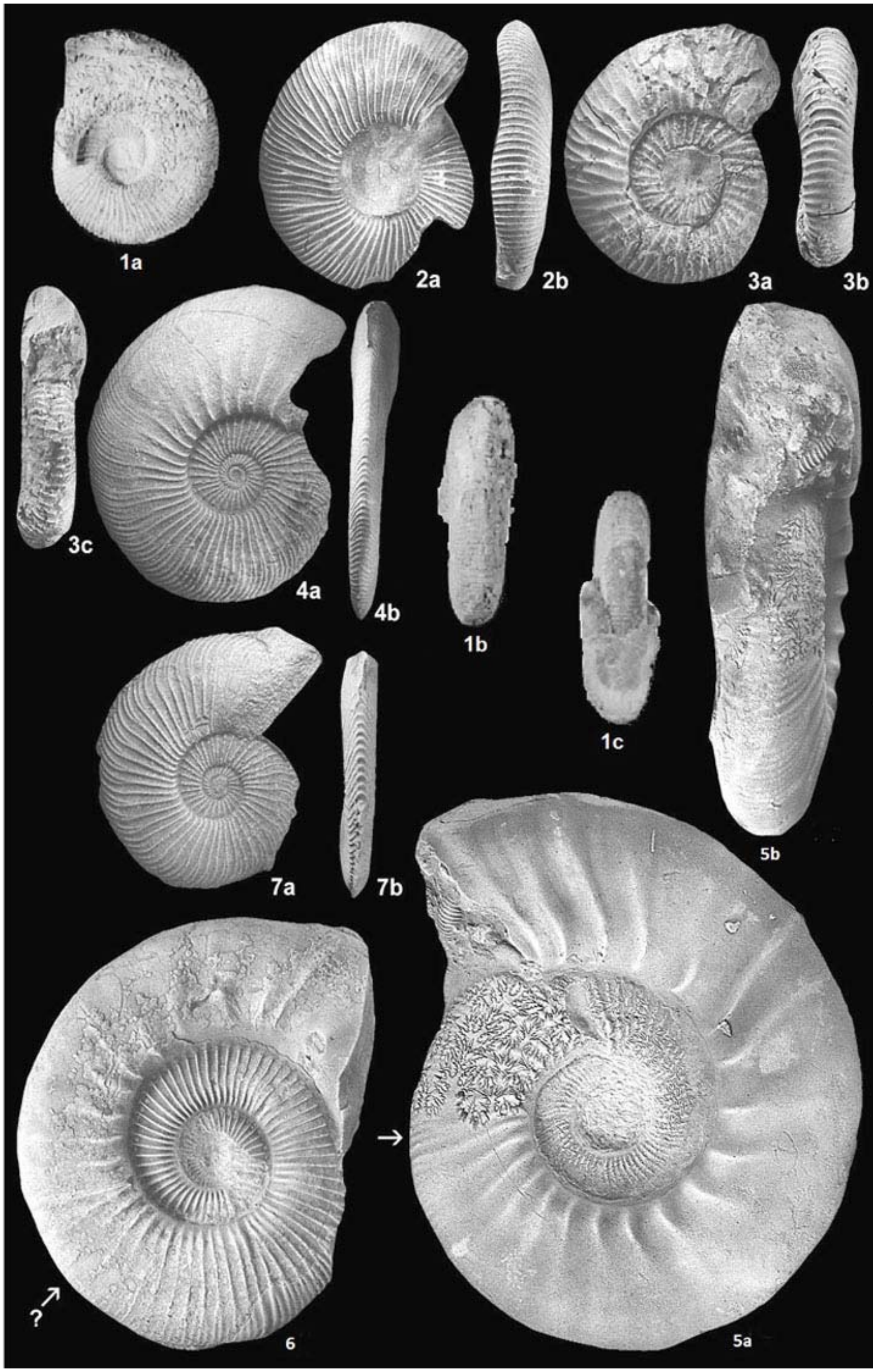

Plate 3. Fig. 1. *Nothostephanus* aff. *kurdistanensis* Spath, Lower Tithonian, ./8x, (GZN2011I-CH-6-9abc), Fig. 2. *Phanerostephanus subsenex* Spath, Lower Tithonian (GZN2011I-CH-6-9), Fig. 3. *Nannostephanus* sp., Lower Tithonian (GZN2011I-CH-6-13a), Figs. 4, 7. *Richteria richteri* (Oppel), Lower Tithonian, Fallauxi Zone (4, specimen GZN2011I-CH-7-38; 7, specimen GZN2011I-CH-7-44), Figs. 5, 6. *Phanerostephanus subsenex* Spath with body chamber, Lower Tithonian (5, specimen GZN2011I-CH-6-13; 6, specimen GZN2011I-CH-6-14)`

Discussion and conclusions

The most abundant families within the studies type section in the upper part of member (D) in the middle part of the Chaman Bid Formation are Ataxioceratidae, followed by Perisphinctidae, Oppeliidae, and Haploceratidae (Majidifard 2003). The Lower Tithonian ammonite fauna is represented by two ammonite assemblages:

The first assemblage contains the ammonites *Haploceras (Haploceras)* aff. *carachtheis Oxylenticeras* cf. *lepidum, Glochiceras* sp., *Phanerostephanus subsenex*, *Phanerostephanus* aff. *intermedius, Nothostephanus* cf. *kurdistanesis*., and *Nannostephanus* cf. *subcornutus.* These ammonites are assigned to the early Tithonian (Semiforme Zone, or even older zones, Fig. 5). The second assemblage contains, *Richterella richteri, Richterella* sp. and *Sublithacoceras* sp. indicating an early Tithonian age (Fallauxi Zone, Richteri Subzone, Fig. 5). The stratigraphic position of the two assemblages (Figs. 2, 5) indicates that the first ammonite assemblage is the older one and older than the lower part of the Fallauxi Zone. The absence of ammonites representing the early Tithonian Hybonotum and Darwini zones in the study section could mean that (1) strata of this age interval are not preserved, (2) fossils of this age interval are absent due to taphonomic processes; (3) unfavorable ecological conditions.

Paleobiogeographically, the Tithonian ammonite faunas of northeastern Iran are mostly of Submediterranean affinity (Seyed-Emami et al. 2001; Seyed-Emami et al. 2013). However elements of the Mediterranean faunal provinces occasionally occur. In order to unravel the origin of the faunal elements and their migration routes, the relationship of the ammonite fauna of Iran to that of other regions need to be analysed in the future. Especially the appearance of several allegedly regionally restricted Ataxioceratidae such as *Phanerostephanus*, *Nannostephanus*, *Nothostephans* and the Oppeliidae as *Oxylenticeras*, which occur in Ethiopian Province (Page 2008, p. 50) is of great palaeobiogeographical interest.

Acknowledgements

I thank to the PD Dr. Markus Wilmsen, for useful comments and corrections which improved our manuscript. I would like to thank late Prof. J.H. Callomon, London, late Prof. F. Cecca, Paris, for useful discussions. The present study was financially supported by the “Deutsche Akademische Austauschdienst (DAAD)”, which I gratefully acknowledge. My appreciation goes also to M. T. Korehie, Head of the Geological Survey of Iran (GSI) and Dr. J. Taheri Director of Geology and Mineral Exploration northeast of GSI and Mrs. M. Hosseiniun for their help and encouragement and for the fieldwork in Iran.

References

Afshar-Harb, A., 1979. The stratigraphy, tectonics and petroleum geology of the Koppeh-Dagh region, northern Iran. Unpublished Ph. D. thesis, University of London.

Afshar-Harb, A. 1994. Geology of Kopet Dagh. In Treatise on the geology of Iran. A Publication of the Geological Survey of Iran, 275 pp. [In Persian]

Ashuri, A., Majidifard, M.R., Vahidinia, M. and Raoufian, A. 2008. Biostratigraphy, lithostratigraphy Late Jurassic rocks in the west of Binalud Range (Dahaneh Heydari-Bojnow) northwest of Neyshabour. Journal of Science, University of Tehran, 34: 25-40.

Ashuri, A**.,** Majidifard, M.R., Vahidinia, M. and Raoufian, A. 2011. Biostratigraphy of the Middle - Late Jurassic Rocks, West of Binalud Range (Baghi) Northwest of Neyshabour. Scientific Quarterly Journal, Geosciences, Geological Survey of Iran, 80; 3-14.

Bogdanowitch, C., 1889. Notes sur la géologie de l‘Asie centrale. I. Déscription de quelques depots sédimentaires de la contrée transcaspienne et d’une partie de la Perse septentrional, 192 pp.

Boughdri, M., Oloriz, F., Marques, B.L., Layeb, M., Matos, J.D., Sallouhi, H., 2005. Upper Kimmeridgian and Tithonian ammonites from the Tunisian Dorsale (NE Tunisia) updated biostratigraphy from the Jebel Oust, Rivista Italiana di Paleontologica e Stratigrafia, 111: 305-316.

Cecca, F., 1986. Le genre *Richterella* Avram Ammonitina, Perisphinctides) dans le Tithonique inférieur de la bordure Ardechoise (sud-est de la France): Dimorphisme et variabilité. Geobios, 19: 33–44.

Collignon, M., 1960. Atlas des fossils characteristiques de Madagascar. VI. Tithonique. Service Geologique, Tananarive, 134–157.

Dabagh Sadr, F., Seyed-Emami, K., Majidifard, M.R., 2012. Biostratigraphy and lithostratigraphy of Middle-Upper Jurassic rocks in Barmahan section based on the ammonite (NW Neyshapour). Scientific Quarterly Journal, Geosciences, Geological Survey of Iran, 85: 33-44.

Donze, P., & Enay, R., 1961. Les cephalopodes du Tithonique inferieur de la Croix-de-Saint-Concors pres Chambery (Savoie). Travaux du Laboratoire de Geologique de la Faculte des Sciences de Lyon, 7: 1–236.

Enay, R., 1971. Tithonique/Portlandien (sen francais). 99-102. In Mouterde, R. et al.. Les zones du Jurassique en France. Compte Rendu Sommaire des Seances de la Societe Geologique de France 6, 99–102.

Enay, R., & Cecca, F., 1986. Structure et evolution des populations tithoniqes du genre d ammonites tethysien Haploceras Zittel, (1868): Commemorazione di Raffaele Piccinini, Atti i Convegno, Pergola 25-28 Ottobre, 1984: 37–53.

Faridani, M., Raisossadat, S. N., Majidifard, M. and Babazadeh, S. A. 2012. Effects of sea level fluctuations on distribution and diversity of ammonites in the middle and upper Jurassic strata northwest of Neyshabur. Stratigraphy and Sedimentology Researches Journal, 28: 81-94.

Geyssanti, J., 1997. Tithonian. In: Cariou, e. & Hantzpergue, P.: Biostratigraphie du Jurassique ouest-européen et mediterranéen. Zonations paralleles distribution des invertébrés et microfossiles. Elf Aquitaine édition, 97-102.

Grigore, D., 2011. Kimmeridgian – Lower Tithonian ammonites assemblages from Ghilcos – Haghimas massif (Eastern Carpathians Romanian), Acta Palaeontologica, 7: 177-189.

Howarth, M.K., 1992. Tithonian and Berriasian ammonites from the Chia Gara Formation in northern Iraq. Palaeontology, 35: 597–655.

Lasemi, Y., 1995. Platform carbonates of the Upper Jurassic Mozduran Formation in the Kopet Dagh Basin, NE Iran facies, palaeoenvironments and sequences. Sedimentary Geology, 99: 151–164.

Majidifard, M.R., 2003. Biostratigraphy, lithostratigraphy, ammonite taxonomy and microfacies analysis of the Middle and Upper Jurassic of northeastern Iran. Unpublished Ph.D. thesis, University of Wuerzburg.

Majidifard, M.R., 2008. Stratigraphy and facies analysis of the Dalichai and Lar formations (Middle-Upper Jurassic) of NNE Iran. Beringeria, 39: 3-49.

Majidifard, M.R. 2015. Late Bajocian–Bathonian ammonits from Northeast Iran, Acta Palaeontologica 11, 25-41.

Motamedalshariati, M., Seyed-Emami, K. and Aryai, A. A. 2006. Stratigraphy and ammonite fauna of Chaman-Bid Formation in the east of Koppeh-Dagh Basin. Journal of Science, University of Tehran, 32: 27-35.

Oloriz Saez, F., 1978. Kimmeridgiense-Tithonico inferior en el sector central de las Cordilleras Beticas (Zona Subbetica). Ph.D. thesis, University of Granada.

Page, N., 2008. The evolution and geography of Jurassic ammonoids. Proceedings of the Geologist’s Association, 119: 35–57.

Parent, H., Raoufian, A. Seyed-Emami, K., Ashouri, A. & Majidifard, M.R. 2014. The Bajocian-Kimmeridgian ammonite fauna of the Dalichai Formation in the SE Binalud Mountains, Iran. Informes del Insitituto de fisiografiay Geologia1, 1-60.

Raisossadat, S.N , Seyed-Emami, K., Majidifard, M.R. 2006. Ammonite palaeobiogeography of the Jurassic deposits in Koppeh-Dagh Basin, north east of Iran. The 7 International Congress on the Jurassic System, Poland, pp. 128.

Raoufian, A., Joly, B., Seyed Emami, K., Ashouri, A., Majidifard, M.R., and Ameri, H. 2014. Phylloceratoides du Jurassique moyen et superieur du Nord-East Iran (Monts Binalud). Annales de Paleontologie, 100: 311-325.

Sapunov, I.G. 1979. Les fossiles de Bulgarie. III. 3. Jurassique supérieur, Ammonoidea, Academie Bulgare des Sciences, 263 pp.

Schairer, G., & Barthel, W., 1981. Die Cephalopoden des Korallenkalks aus dem Oberen Jura von Laisacker Neuburg a. d. Donau. Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie, 21: 3–21.

Schairer, G., 1993. Jura-Ammoniten aus dem "Wildflysch" des Oberndorfer Grabens (Haunsberg, Salzburg). Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie, 33: 31–50.

Schairer, G., Seyed-Emami, K., Majidifard, M.R., & Monfared, M. 1999. Erster Nachweis von Untertithon in der Chaman Bid Formation an der Typuslokalität bei Bash Kalateh (Zentral-Koppeh-Dagh, NE Iran). Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie, 39: 21–32.

Seyed-Emami K., 1988. Jurassic and Cretaceous ammonite faunas of Iran and their paleobiogeographic significance. In: Wiedmann, J. & Kullmann, J. (Eds.) Cephalopods -Present and Past, pp. 599–606.

Seyed-Emami, K., Fürsich, F.T., & Schairer, G., 2001. Lithostratigraphy, ammonite faunas and palaeoenvironments of Middle Jurassic strata in north and Central Iran. Newsletters on Stratigraphy, 38: 163–184.

Seyed-Emami, K., & Schairer, G., Raoufian, A., & Shafeizad, M., 2013. Middle and Late Jurassic ammonites from the Dalichai Formation west of Shahrud (East Alborz, North Iran). Neues Jahrbuch für Geologie und Paläontologie, 267: 43–66.

Spath, L.F., 1923. The ammonites of the Shales-with-Beef. Quarterly Journal Geology Society (London), 79: 66–88l.

Spath, L.F., 1925. Ammonites and Aptychi. I. The collection of fossils and rocks from Somaliland. Monography of the Geology Department Hunterian Museum, 111–164.

Spath, L.F., 1950. A new Tithonian ammonoid fauna from Kurdistan, northern Iraq. Bulletin of the British Museum (Natural History) Geology, 1: 96–137.

Taheri, J., Fürsich, F.T., & Wilmsen, M., 2009. Stratigraphy, depositional environments, and geodynamic significance of the Upper Bajocian-Bathonian Kashafrud Formation (NE Iran). In: Brunet, M.F., Wilmsen, M. & Granath, J. (Eds), South Caspian to Central Iran basins. Geological Society London, Special Publication, 312: 205–218.

Verma, H.M., & Westermann, G.E.G., 1984. The ammonoid fauna of the Kimmeridgian-Tithonian boundary beds of Mombasa, Kenya. Life sciences Contributions, Royal Ontario Museum, 130: 1–124.

Villaseñor, A.B., González-León, C.M., Lawton, T.F.,and Aberhan, M., 2005. Upper Jurassic ammonites and bivalves from the Cucurpe Formation, Sonora (Mexico), Revista Mexicana de Ciencias Geológicas, 22: 65-87

Zeiss, A., 1968. Untersuchungen zur palaeontology der Cephalopoden des Unter-Tithonium der Suedlichen frankenalb. Verlag der Bayerischen Akademie Wissenschaften, pp. 190.

Zeiss, A., Benetti, A., Pezzoni, N. 1994. A new ammonite fauna from the Tithonian (Semiformiceras/Verruciferum Zone) of the Lessinian Alps, Verona Province, Northern Italy, Proceeding, of the 3rd Pergola International Symposium, 367 – 381.

Zittel, K.A., 1868. Die Cephalopoden der Stramberger Schichten. Palaeontogische Mittheilungen aus dem Museum des Königlich-Bayerischen Staates, 2: 33–118.

Zittel, K.A., 1870. Die Fauna der älteren Cephalopoden-führenden Tithonbildungen: Palaeontographica (Stuttgart), Band 1: 119-310.

Zittel, K.A., 1884. Handbuch der Palaeontologie: Abt. 1, Band 2, 893 pp.