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Fast Track Article

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New Middle and Upper Jurassic ammonites from the Binalud Mountains (Mashhad region, NE Iran)

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With 4 figures

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Abstract: A small collection of ammonites from the Middle to Upper Jurassic (Bathonian to Oxfordian) Dalichai Formation of the eastern Binalud Mountains (southern Koppeh Dagh, northeastern Iran) yielded several taxa that were previously unknown from Iran, i.e. *Lingulaticeras nudatum* (OPPEL), *Hecticoceras (Rossiensiceras)* aff. *metomphalum* BONARELLI, *Horioceras* sp., *Collotia* sp., ?*Homoeoplanulites* sp. (with in situ aptychus), and *Euaspidoceras* aff. *douvillei* (COLLOT). These records are described and figured herein and significantly extend our knowledge of the geographical distribution of these taxa. Palaeobiogeographically, the described taxa are related to the Submediterranean Province.

Key words: ammonites, Middle to Late Jurassic, Binalud Mountains, Iran, palaeobiogeography.

1. Introduction

The ammonite fauna described here comes from a section in the Dalichai Formation situated in the Binalud Mountains to the north of the village Fraizi (N 36 29 34, E 58 58 60), approximately 60 km northwest of the town of Mashhad (Fig. 1). The specimens have been selected from a larger collection of ammonites that come from multiple levels of this section, and comprise those taxa that were previously unknown from the area. The Binalud Mountains represent the easternmost extension of the Alborz Range, reaching from southeast of Bojnurd to the region of Mashhad, and are part of the Iranian Koppeh Dagh. The Koppeh Dagh s. l. embraces two parallel mountain chains (AFSHAR HARB 1994). The northern chain comprises the Koppeh Dagh s. str. and Hezar Masjed Mountains, while the southern chain includes the Golestan, Aladagh and Binalud mountains. The Binalud Mountains expose a thick succession of Jurassic and Cretaceous strata, which are generally considered intermediate in lithology between the strata of the eastern Alborz to the northwest and the Koppeh Dagh s. str. to the north and northeast (Fig. 1). While the Middle and Upper Jurassic strata of the western and central Alborz are termed the Dalichai and Lar formations, the same successions are known as Chaman Bid and Mozduran formations in the Koppeh Dagh (Fig. 2). Although minor lithological changes and a slight increase in thickness occur towards the eastern Alborz, the strata from both regions do not show significant differences. For the Binalud Mountains, both nomenclatures have been applied in the literature. Herein, the names introduced for the Alborz Mountains are used.

Apart from a few small contributions, the geological investigation and detailed mapping of the Koppeh

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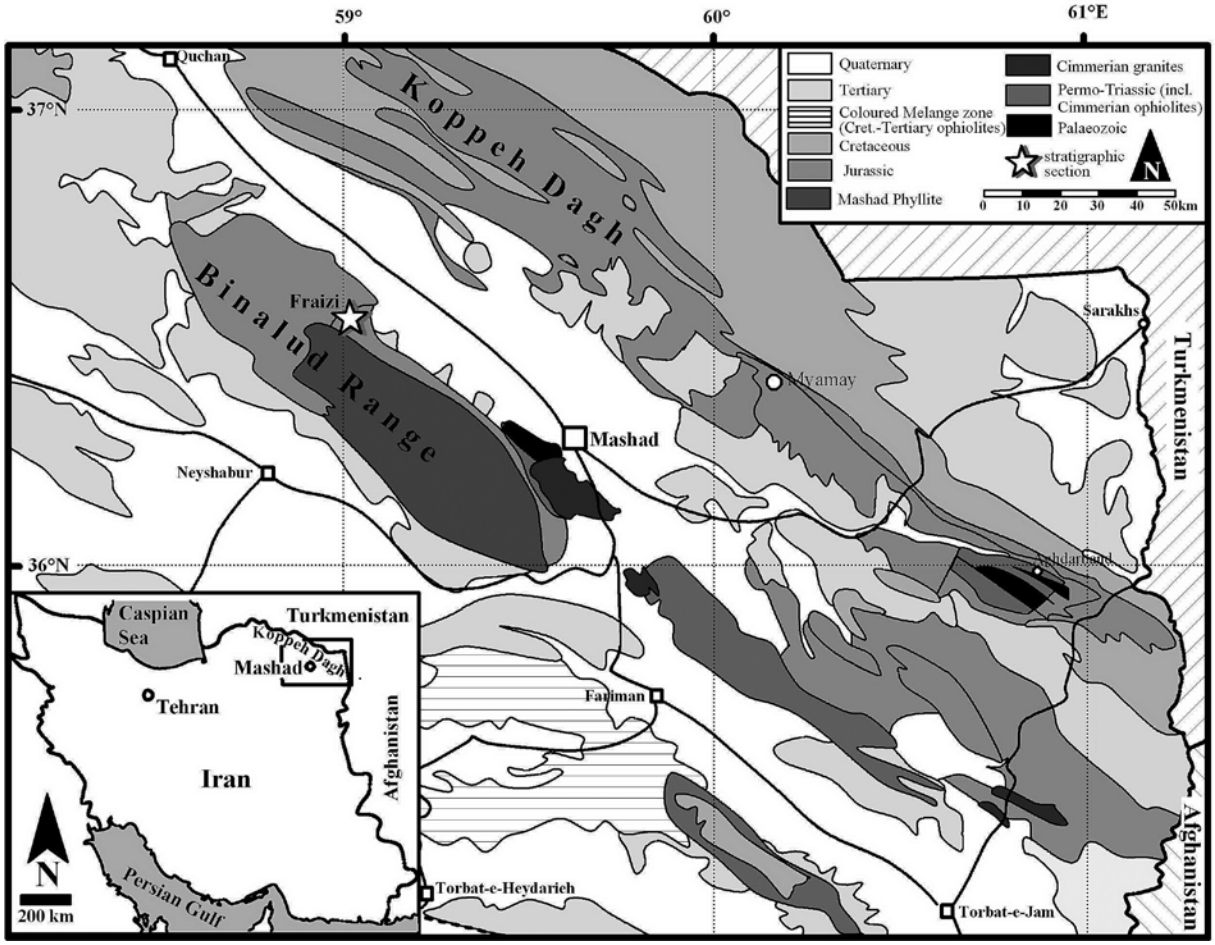

Fig. 1. Geographic overview showing the position of the Fraizi section (prepared by M. Wilmsen, Dresden).

Dagh basins was predominantly carried out by Afshar-Harb (1979, 1994). The official geological map of the study region was prepared by Aghanabati & Shahrabi (1987). Systematic studies on the Jurassic succession of the Binalud Mountains that began in the 1990s as part of the ongoing Iranian-German collaboration resulted in a number of publications (Seyed-Emami et al. 1998; Schairer et al. 1999; Taheri et al. 2009; Wilmsen et al. 2009) on the lithology and stratigraphy of these sediments and their ammonite faunas, including an unpublished MSc thesis (Mehdifar 2000).

2. Geological setting

To the North of Fraizi, the Dalichai Formation (= Chaman Bid Formation) is approximately 400 m thick (Mehdifar 2000) and disconformably overlies the Shemshak Group (Wilmsen et al. 2009). The basal 20

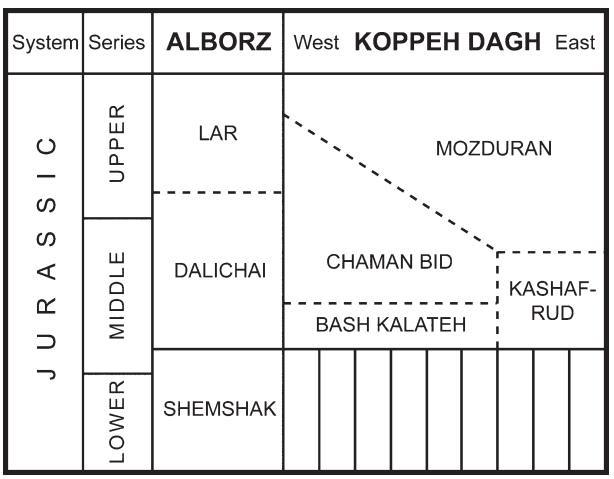

Fig. 2. Lithostratigraphy of the Jurassic rocks in the Alborz and Koppeh Dagh basins.

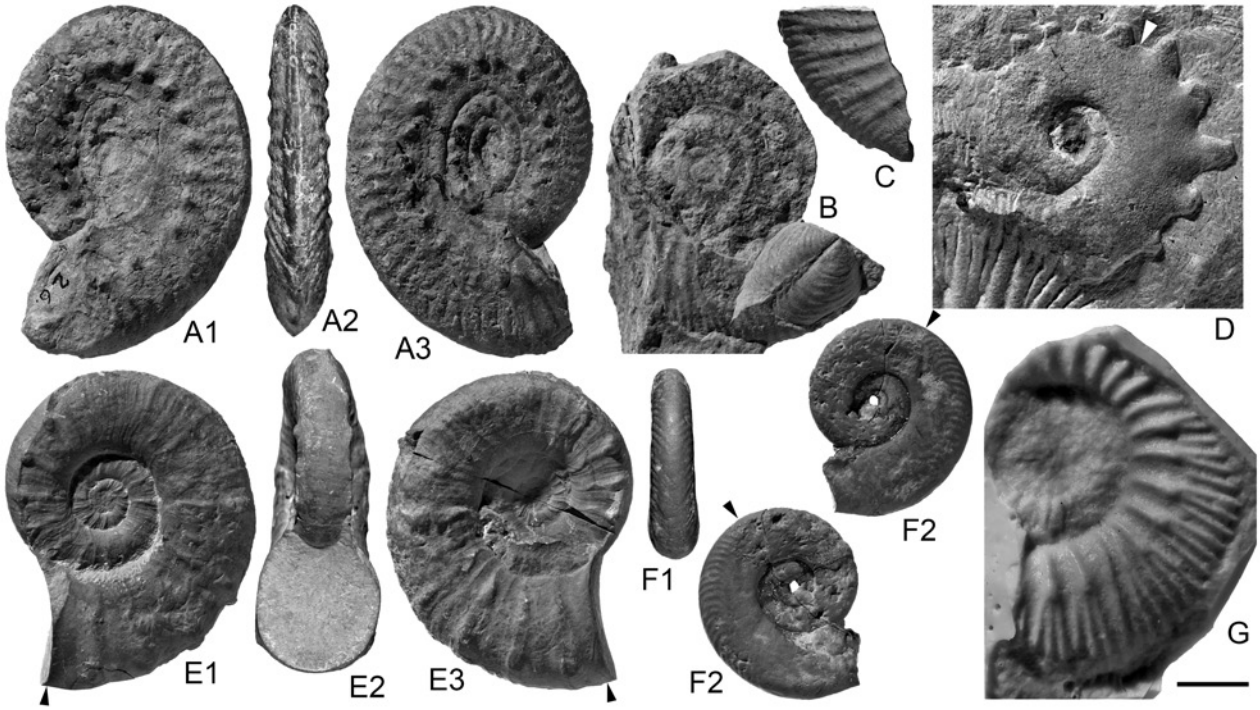

Fig. 3. Ammonites from the Dalichai Formation at Fraizi. **A** – *Hecticoceras* (*Rossiensiceras*) aff. *metomphalum* Bonarelli, 1894 (BSPG 2011 II 1). **B**-**C** – ?*Homoeoplanulites* sp. [m] with aptychus (BSPG 2011 II 2). **D** – *Horioceras* sp. (BSPG 2011 II 3). **E** – *Euaspidoceras* aff. *douvillei* (Collot 1917) (BSPG 2011 II 4). **F** – *Lingulaticerass nudatum* (Oppel, 1858) (BSPG 2011 II 5). **G** – *Collotia* sp. (BSPG 2011 II 6) [plaster cast]. Scale bar = 10 mm.

m of the Dalichai Formation are composed of cross-stratified marine sandstones with trace fossils. These layers are followed by approximately 180 m of dark greyish-green silty marls with *Palaeodictyon* trace fossils and ammonites of the genus *Cadomites*. The latter indicates a late Bajocian to early Bathonian age. These marls are overlain by a 200 m thick alternation of greenish-grey marls and limestone that is attributed to the Bathonian to Oxfordian based on ammonites. A prominent, thick-bedded limestone bank (8 m) with reineckeids and *Horioceras* occurs approximately 270 m above the base of the section. The top of the Dalichai Formation is overlain by the Lar Formation that is composed of massive, cliff-forming grainstones (= Mozduran Formation) (Fig. 2).

3. 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), all in % of diameter; [m] = microconch.

The ammonites studied herein are deposited in the collection of the Bayerische Staatssammlung für Paläontologie und Geologie (BSPG) in Munich, Germany, under collection numbers BSPG 2011 II 1-6.

Order Ammonoidea Zittel, 1884
Superfamily Haploceratoidea Zittel, 1884
Family Oppeliidae Bonarelli, 1894
Subfamily Taramelliceratinae Spath, 1928
Genus *Lingulaticeras* Ziegler, 1958

Lingulaticeras nudatum (Oppel, 1858)
Fig. 3F

1958 *Glochiceras* (*Lingulaticeras*) *nudatum* (Oppel). – Ziegler, p. 133, pl. 12, figs. 8-11, text-figs. 44-46.
1991 *Glochiceras* (*Lingulaticeras*) *nudatum* (Oppel). – Gygi, p. 21, pl. 6, figs. 1-4.
1994 *Gl.* (*L.*) *nudatum* (Opp.) 1858. – Schlegelmilch, p. 54, pl. 16, fig. 8.

Material: A single, slightly eroded, almost complete internal mould, showing parts of the lappet; collected from ca. 380 m above the base of the Fraizi section (BSPG 2011 II 5).

Dimensions:

	D	U	H	W
F-3 (end of the body whorl)	27	37	36	28
F-3 (end of phragmocone)	21	33	40	28

Description: Nearly completely preserved specimen with parts of the lappet. Rather evolute *Lingulaticeras* with rectangular to ovate whorl cross-section, rounded umbilical margin, and narrow, vertical umbilical wall. Body chamber starts at a diameter of 21 mm, extending to 27 mm at the end. Venter rounded, almost smooth. Ribbing restricted to upper part of flank. Inner part of flank almost smooth, without median sulcus. Ribs on the outer half of flank fine, strongly rursiradiate-concave, occasionally bifurcating. Externally, the ribs bend forward, crossing the rounded venter as very weak chevrons. Parts of the original aperture and onset of the lappet are preserved on one side of specimen.

Remarks: *Lingulaticeras nudatum* is characterised by rather evolute whorls and a fine ribbing pattern, which is mostly confined to the outer half of the flank. Compared to the similar *L. lingulatum*, it is distinguished mainly by the absence of a median sulcus (Ziegler 1958: 134; Gygi 1991: 21).

Age: Upper Oxfordian (Bimammatum/Planula zones).

Subfamily Hecticoceratinae Spath, 1925
Genus *Hecticoceras* Bonarelli, 1894
Subgenus *Rossiensiceras* Gérard & Contaut, 1936

Hecticoceras (*Rossiensiceras*) aff. *metomphalum* Bonarelli, 1894
Fig. 3A

aff. 1894 *Hecticoceras* (*Lunuloceras*) *metomphalum* n.f. – Bonarelli, p. 90.
aff. 2000 *Hecticoceras* (*Rossiensiceras*) *metomphalum* Bonarelli. – Schairer et al., p. 55, fig. 14.
aff. 2009 *Hecticoceras* (*Lunuloceras*) gr. *metomphalum* (Bonarelli, 1894). – Schlögel et al., p. 66, figs. 5.9-5.11, 6.4-6.5.

Material: A single slightly crushed and eroded specimen from the Fraizi section (BSPG 2011 II 1).

Description: Compressed specimen of D = 50 mm; almost fully septate, with a small portion of the body whorl; rather evolute, with an indistinct keel. Inner third of flank almost smooth (partly due to the erosion), sloping gently towards umbilicus. Umbilicus shallow, with steep umbilical wall and distinct, concave umbilical border well developed on the outer whorl. Ribbing pattern consists of densely spaced, rather fine tubercles, just above the umbilicus. Usually two or three rursiradiate outer ribs extend from tubercles, curving forward on the outer part of the flank and ending before the keel. 22 tubercles and 54 outer ribs are visible on last whorl.

Remarks: The specimen clearly belongs to the *Hecticoceras* (*Rossiensiceras*) *metomphalum* group, which shows a great variability with regard to ribbing pattern and umbilical width. The tubercles and ribs present in the specimen from Fraizi are distinctly more densely spaced and more numerous than in *H.* (*R.*) *metomphalum* Bonarelli, 1894. According to the ornamentation, the specimen from Fraizi most closely resembles the subspecies *H.* (*R.*) *m. multicostata* Tsytovitch, 1911 (Tsytovitch 1911: pl.5, fig. 12; Zeiss 1956: pl. 2, fig. 7) and *H.* (*R.*) *m. suevum* Bonarelli in Tsytovitch, 1911 (Tsytovitch 1911: pl. 5, figs. 7, 8, 10). However, the latter is much more evolute. It may be noted that the subgenus *Rossiensiceras* is considered synonymous to *Putealiceras* by Arkell (1956: L277) and Schlegelmilch (1985: 39).

Age: Middle Callovian Jason Zone, equivalent to the Anceps Zone in the Submediterranean Province (Zeiss 1956, 1959; Thierry et al. 1997).

Subfamily Distichoceratinae Hyatt, 1900
Genus *Horioceras* Munier-Chalmas, 1892

Horioceras sp.
Fig. 3D

Material: A single, laterally preserved, slightly eroded internal mould showing a major portion of the body chamber; collected from ~270 m above the base of the Fraizi section (BSPG 2011 II 3).

Dimensions:

	D	U	H	W
F-1 (between the clavi)	33	35	43	-

Description: Almost complete, laterally preserved specimen, showing ¾ of the body chamber. Maximum diameter = 33 mm; the body chamber starts at D = 26 mm. Relatively large, evolute specimen, with slightly convex flank and high ovate whorl cross-section; maximum whorl width occurs at inner third of flank. Umbilical wall steep; umbilical border rounded, transitional to flank. Flank obviously smooth; no ribs discernable. Very shallow, almost indistinct lateral sulcus on external part of the body chamber, just above mid-flank. Nine prominent, tooth-shaped clavi occur on the venter. Clavi are radiate at onset, becoming rursiradiate towards the aperture. Length of clavi initially increasing towards the aperture, but finally decreasing. Egression not observed.

Remarks: Since the opposite side of the specimen is not visible, it cannot be inferred whether there are one or two rows of clavi. A major character of the studied specimen is its large size. Compared to an equally large specimen, figured by Schlögl et al. (2009: 64, figs 5.3, 6.2) and named as *Horioceras* sp. nov. (aff. *depereti* Lemoine, 1932), the specimen from Fraizi differs by its more distant, distinctly higher, and partly rursiradiate clavi. Both specimens differ from *H. depereti* Lemoine in a smaller umbilicus and much

stronger clavi. All other species of *Horioceras* described to date are significantly smaller than those discussed above.

Apart from its large size, the specimen from Fraizi is relatively similar to the Middle Oxfordian *Glochiceras (Coryceras) crenatum* (Brugière) figured by Gygi (1991, pl. 4, figs. 2-6), especially with regard to the prominent clavi. Other similar taxa include the genera *Creniceras* (Oxfordian to Kimmeridgian) and *Cymaceras (Trochiskioceras)* (Kimmeridgian). However, both genera are obviously distinctly smaller and definitely younger. Due to the limited preservation of the single specimen, obscuring details of external morphology, we refrain from a specific assignment.

Age: The specimen was collected together with the reineckeid *Collotia* sp. (see below), indicating a Lower to Middle Callovian age (Gracilis to Athleta zones; Thierry et al.1997).

Superfamily Perisphinctoidea Steinmann, 1890
Family Reineckeidae Hyatt, 1900
Genus *Collotia* Grossouvre, 1917

Collotia sp.
Fig. 3G

Material: A single, incomplete imprint occurring on a single rock sample together with *Horioceras* sp. (see above) (BSPG 2011 II 6).

Description: Relatively evolute reineckeid with equally-spaced ribbing pattern, consisting of radiate, rather distant and coarse umbilical ribs, starting at umbilical seam. Ribs culminating in rounded, small tubercles, and dividing into two or three, slightly prorsiradiate secondary ribs slightly above rounded umbilical border, within the inner third of flank. Narrow, slightly prorsiradiate constriction followed by a simple, oblique and strong rib.

Remarks: Although the ribbing is somewhat coarser and more distant, the specimen from Fraizi can be best compared with *Collotia oxyptycha* (Neumayr, 1870) from the Coronatum Zone. Due to the poor preservation, however, we refrain from a specific assignment.

Age: Lower to Middle Callovian (Gracilis to Athleta zones; Thierry et al.1997).

Family Perisphinctidae Steinmann, 1890
?Genus *Homoeoplanulites* Buckman, 1922

?*Homoeoplanulites* sp. [m]
Fig. 3B-C

Material: A single fragment with aptychus in situ (BSPG 2011 II 2).

Description: Inner whorls of specimen relatively evolute, with rather equally spaced ribbing. Preserved part of body whorl with slightly prorsiradiate, biplicate primary ribs and one or two intercalary ribs. Aptychus preserved inside the whorl, next to onset of body chamber as an internal, bivalved mould (L = 17 mm; W = 10 mm). Nearly triangular in shape, with rather strong, concentric folds.

Remarks: The specimen clearly is a perisphinctid and most similar to microconch forms of *Homoeoplanulites* (e.g., Mangold 1971: pl. 2, figs. 1, 3). Most likely, the aptychus belongs to the same specimen is displaced from its original position to the beginning of the body chamber.

Age: ?Upper Bathonian.

Family Aspidoceratidae Zittel, 1895
Subfamily Euaspidoceratinae Spath, 1931
Genus *Euaspidocers* Spath, 1931

Euaspidoceras aff. *douvillei* (Collot 1917)
Fig. 3E

aff. 1931 *Aspidoceras Douvillei* Collot. – Dorn, p. 35, pl. 26, fig. 4; pl. 27, fig. 1.
aff. 1994 *Euaspidoceras douvillei* Collot 1917). – Schlegelmilch, p. 121, pl. 64, fig. 4.

Material: A single, fairly well-preserved internal mould, with a small portion of the body whorl, starting at D = 45 mm; collected from ~370 m above the base of the Fraizi section (BSPG 2011 II 4)

Dimensions:

	D	U	H	W
F-39	44	37	38	38

Description: Relatively evolute aspidoceratid with almost quadrate to ovate whorl section. Umbilical border rounded, with gradual transition to umbilical wall. Ribbing pattern rather irregular, slightly falcoid. Ribbing on inner whorls rather fine and dense. Usually, three to five very fine, more or less bundled ribs alternating with coarser bispinous ribs. Ribbing becoming much coarser and distant towards outer whorl; finer ribs disappear and only stronger ribs remain. Stronger ribs with radially elongate, fine umbilical and distinctly stronger marginal tubercles. Ribs crossing the slightly rounded venter as indistinct, fine, forward curved striae.

Remarks: The specimen from Fraizi is higly similar to *Euaspidoceras striatocostatum* (Dorn, 1931) (Dorn 1931: 37, pl. 20, figs. 4-7; Bonnot et al. 2009: pl. 7, figs. 4, 6-10) from the Upper Oxfordian Bimammatum Zone. A characteristic of both species is the fine ribbing pattern on the inner whorls (see also Dorn 1931: 37). However, the specimen from Iran is slightly less broad than *E. striatocostatum*. Another similar form is *E. perarmatum* (Sowerby), figured by Jeannet (1951: 208), especially those specimens from the Upper Oxfordian of Herznach, Switzerland (Jeannet 1951: pl. 92, fig. 2; pl. 97, fig. 3).

Age: upper Lower Oxfordian (Cordatum Zone; Schlegel-

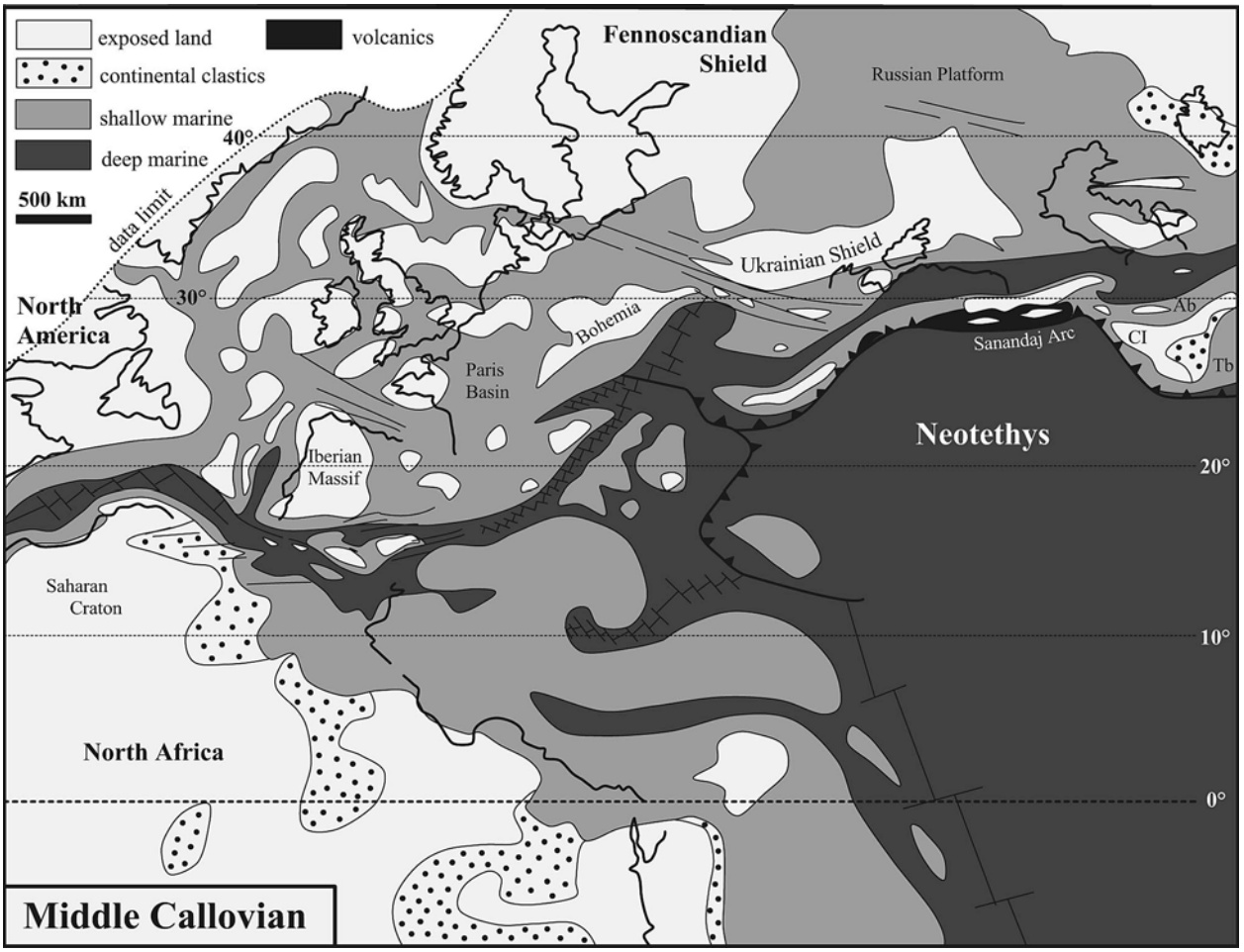

Fig. 4. Paleogeographic map of the western Tethys region during the Middle Jurassic, showing the position of Iran (adopted from Wilmsen et al. 2010). Ab = Alborz; CI = Central Iran; Tb = Tabas Block.

milch 1994) to lower Middle Oxfordian (Transversarium Zone; Dorn 1931: 37).

4. Discussion and conclusions

The ammonites presented herein have been selected from a larger collection of specimens, all derived from the Dalichai Formation to the north of Fraizi. They come from different levels of this section, and indicate a time span from the Bathonian to the Oxfordian. With exception of these newly reported taxa that are recorded for the first time from Iran, the fauna is closely related to those assemblages described from eastern Alborz (Majidifard 2003; Seyed-Emami & Schairer 2010, 2011). The total fauna from Fraizi contains a high percentage of Phylloceratidae and Perisphinctidae, joined by several Reineckeidae and Oppeliidae, and definitely shows a Submediterranean character, similar to other assemblages described from the Middle and Late Jurassic of northern Iran. Tethyan (Lytoceratidae) and Boreal elements (Cardioceratidae) are absent. To date, only two solitary finds of Cardioceratidae have been reported from Iran, i.e. from the Central Alborz (Seyed-Emami et al. 1995) and Central Koppeh Dagh (Majidifard 2003). The new records of ammonites from Fraizi significantly extend our knowledge on the distribution of the respective taxa, and may thus be important for future biogeographic reconstructions (cf. Fig. 4).

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