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Article

First record of the heteromorph ammonite genus *Parapatoceras* Spath, 1924 from the lower Callovian (Middle Jurassic) of Algeria

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With 3 figures

Abstract: Heteromorph ammonites of the genus *Parapatoceras* Spath, 1924 are described herein for the first time from Algeria (northwestern Africa), from the lower Callovian Kheneg Formation exposed in the El Bayadh area, central Saharan Atlas. This is also the second record from the African continent of *Parapatoceras* cf. *tuberculatum* (Baugier & Sauzé); the previous record figured as *Parapatoceras pinatum* (Baugier & Sauzé) by Collignon from the lower Callovian of Madagascar, is herein considered as *P. tuberculatum*. The occurrence of *Parapatoceras* in Algeria probably coincides with the lower Callovian sea level highstand, JCa2, and supports the previously suggested link between their widespread occurrence and rising sea levels.

Key words: *Parapatoceras*, *Macrocephalites*, lower Callovian, Middle Jurassic, Algeria.

1. Introduction

The heteromorph ammonites of the genus *Parapatoceras* Spath, 1924 are rare but have a widespread distribution pattern (e.g., Dietl 1978; Mitta & Seltzer 2006; Bert & Courville 2016; Jain 2018; Dietl 2020), possibly facilitated by rising sea levels (Jain 2018) and its epiplanktic mode of life (Lukeneder 2015). Its stratigraphical range is also broad, with its first occurrence in the lower Bathonian (Zigzag Zone in Hungary; Galácz 1980) to the upper Callovian (Collotiformis Subzone, Athleta Zone in France; Bert & Courville 2016).

Algeria (Fig. 1A–C), due to its prolific Jurassic exposures, and an intermediate paleobiogeographic location between Europe and western Indian records, provides an excellent opportunity to bridge the geographic gap along the southern margin of the Tethys (see Fig. 1D).

2. Previous work in Algeria

Cornet (1952: 15) reported the presence of *Macrocephalites macrocephalus* (Schlotheim, 1813) from the central Saharan Atlas (see Fig. 1A–C; the study region) and dated the strata as lower Callovian. Lucas (1942: 18) and Arkell (1956: 276) also noted the occurrence of *Macrocephalites* Zittel, 1884 from the Tlemcen (Déglène locality) and Saïda mountains (Djebel Ben Kmer locality) and also dated these strata as lower Callovian (see Fig. 1B). Mangold (1971) noted the occurrence of *Macrocephalites* s. str. (large forms) together with *Oxycerites* sp., *Bullatimorphites bullatus* (Orbigny), *Homoeplanulites* (*Parachoffatia*) *funatus* (Oppel), *Choffatia* (*Choffatia*) aff. *tilli* Mangold and several specimens of "*Nautilus*". Cariou et al. (1967) and Mangold (1971) assigned this assemblage to the lower Callovian Bullatus Zone; this is coeval with the level of Cornet (1952) with-

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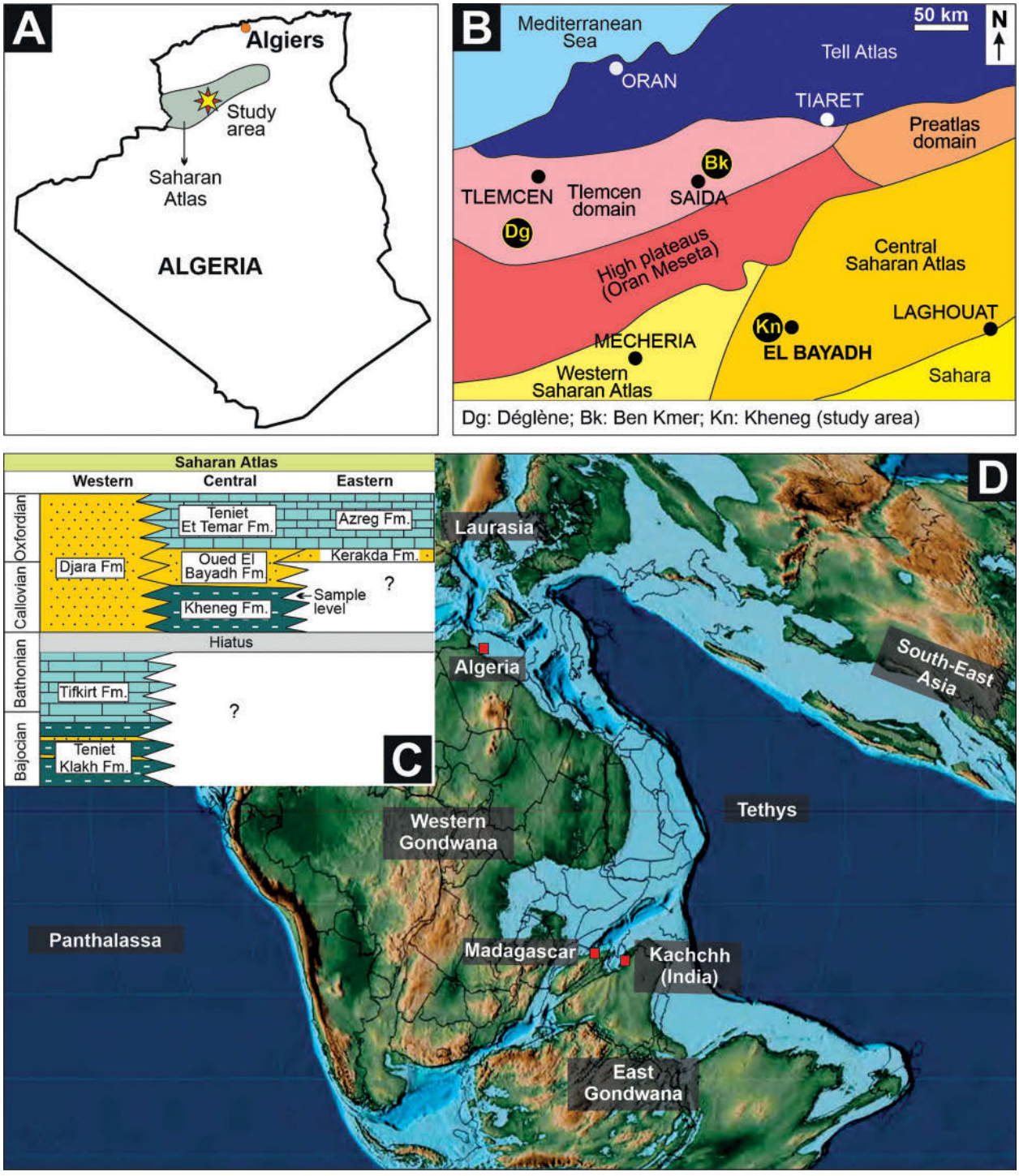

Fig. 1. **A** – Location map of the study area in Algeria. **B** – Major geological domains of northwestern Algeria. **C** – Callovian–Oxfordian lithostratigraphic units of the Saharan Atlas. **D** – Callovian palaeogeography with the location of the study area (after Scotese 2013).

in the Saharan Atlas. Later, Elmi (1971) investigated both localities (Déglène and Djebel Ben Kmer in the Tlemcen Domain; see Fig. 1B) and also reported the occurrence of *Macrocephalites* s. str. associated with *Parachoffatia* cf. *funata* (Oppel) from a condensed reddish-colored limestone facies (ooidal at Déglène; see Fig. 1B).

In the present study, from coeval strata of the El Bayadh area (central Saharan Atlas; see Fig. 1A C), *in situ* samples of *Parapatoceras* (s. str.) are recorded which are associated with *Macrocephalites* sp. from the bedding plane of a carbonate-cemented sandstone, equivalent to the reddish-colored limestones of the Déglène locality (see Fig. 1B).

3. Geological setting

The studied outcrop is situated in the locality Kheneg, 2 km west from El Bayadh city, north-western Algeria (Figs. 1A, B). The studied area is located in the Djebel Amour Mountains, the central sector of the Saharan Atlas Chain (see Fig. 1B). The stratigraphy of the region is dominated by Middle to Upper Jurassic formations. The Callovian–Oxfordian interval comprises three formations: Kheneg, Oued El Bayadh and Teniet Et Temar (Mahboubi 2021; Mahboubi et al. 2021, 2023a, 2023b). The majority of the series is characterised by a dominance of fossiliferous fluvial and/or deltaic siliciclastic deposits (Mahboubi et al. 2021).

The Kheneg Formation is partially equivalent of the siliciclastic-dominated Djara Formation outcropping in the western Saharan Atlas (Fig. 1C). However, there seems to be no equivalent deposits in the eastern part of the basin. The Djara Formation is composed of channel sandstone bodies alternating with claystones and scarce dolomite beds, indicating a deltaic and prodeltaic setting (Bassoullet 1973; Delfaud 1974). Above the Kheneg Formation, this deltaic regime is widespread throughout the Saharan Atlas Basin, with the overlying siliciclastic deposits corresponding to the formations of Oued El Bayadh and Kerakda, attributed classically to the Callovian–Oxfordian (see Mahboubi 2021). During mid-Oxfordian times a transgression related to the subsidence of the northern Gondwanan fringe made the sedimentary environment deeper and a peri-reefal complex developed within a relatively deep inner shelf (Mahboubi et al. 2023b). This complex is recorded by the Theniet-Et-Temar and Azreg formations, in the central and eastern Saharan Atlas, respectively (Fig. 1C), exhibiting a diminishing thickness towards the southwest and eventually terminating between the Arbaouat and Ain Ouarka regions in the western Saharan Atlas, where the prograding deltaic regime persisted until the Early Cretaceous (Bassoullet 1973).

The lower Callovian Kheneg Formation constitutes the oldest lithostratigraphic unit in the El Bayadh area (Mahboubi 2021) (Fig. 1B). It only outcrops in the locality of Kheneg at the exit of the El Bayadh gorges and is composed mainly of dark claystone-sandstone alternations (Fig. 2). On top, there are two thick sandstone beds containing gastropods, brachiopods, and ammonites (Fig. 2A, B). The ammonites described herein come from the top part of Unit 2 of the upper part of the Kheneg Formation that is exposed in the locality Kheneg. The first 5 m-thick unit (Unit 1) is composed of tight alternations of silty clays, ranging in colour from greyish to blackish, exhibiting small- to medium-scale slump folds (Fig. 2C) and olistoliths and fine, greenish millimetres to centimetre-thick sandstone beds, showing parallel laminations, flute casts, and ripple-marks (Fig. 2D). The thickness of the sandstone beds increases upward in the sequence. The 2.5 m-thick Unit 2 (Fig. 2B) consists of two metric beds of carbonate-cemented sandstone. At the top of Unit 2, the studied ammonites were recorded. This ammonite-bearing bed is overlain by the detrital beds of the Oued El Bayadh Formation (Fig. 2B).

4. Material and repository

The 7.5-m-thick interval (i.e., units 1 and 2) of the Kheneg Formation was analysed bed-by-bed with special attention to fossiliferous levels (Fig. 2A, B). The ammonite samples come from a hard and massive carbonate-cemented sandstone at the top of Unit 2 (Fig. 2A, B). The specimens are stored in the Laboratoire de Paléontologie Stratigraphique et Paléoenvironnement (LPSP), Université d'Oran 2 (Algeria) under the sample numbers Kng32-001 to Kng32-005 (indeterminable perisphinctids; not illustrated). Some specimens (Kng-ist-001 to Kng-ist-008) have been photographed *in-situ* (Fig. 3A–I).

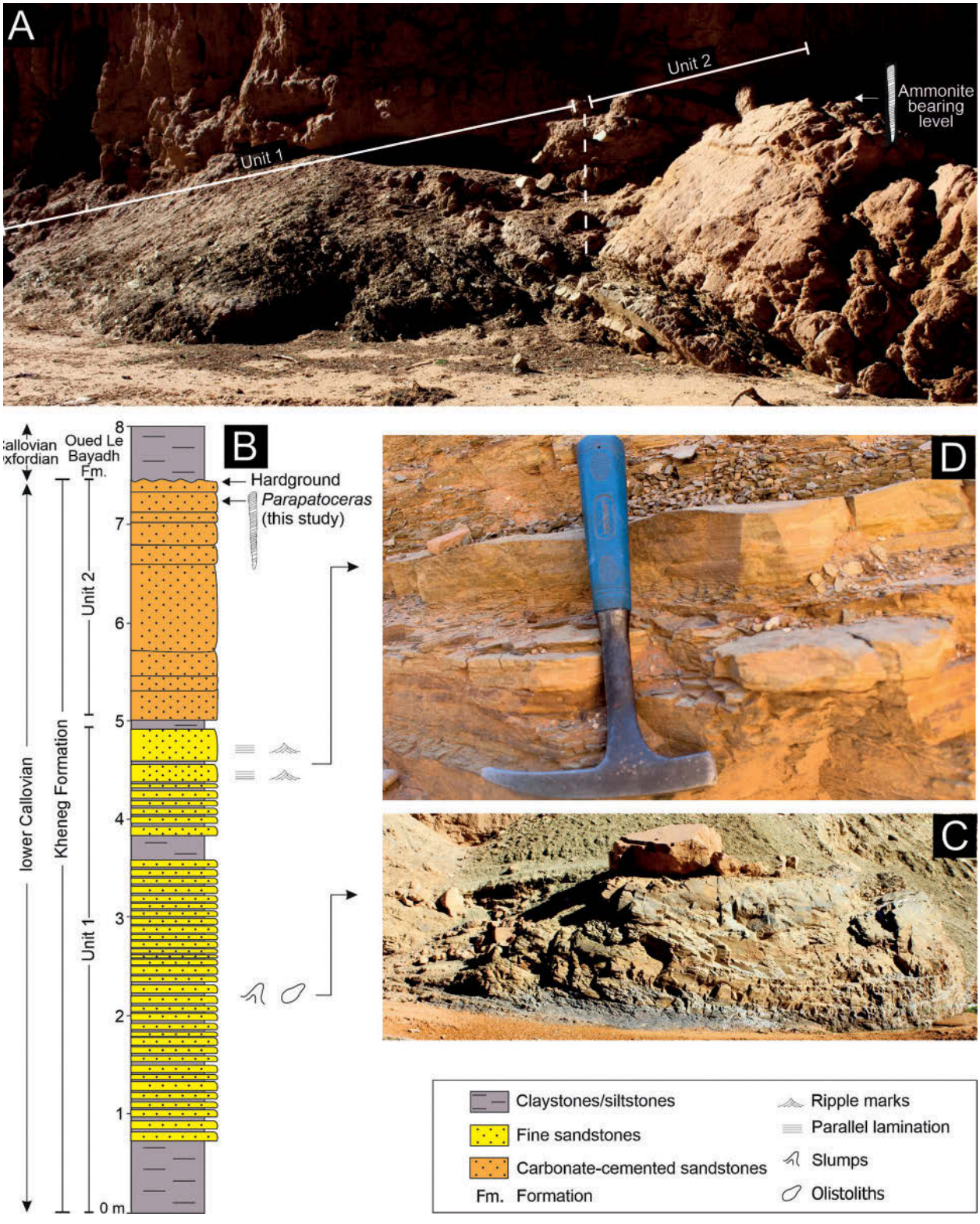

Fig. 2. Lithological characteristics of the Kheneg section (N 33° 41′ 32″; E 0° 59′ 21″; elevation 1268 m). **A** – Panoramic overview of the Kheneg Formation cropping out in the Kheneg area (El Bayadh, central Saharan Atlas). **B** – Lithostratigraphic column of the studied section showing the position of the *Parapatoceras*-bearing level. **C** – Medium-scale slump fold affecting a set of beds from Unit 1. **D** – Fine-grained sandstones from the upper part of the Unit 1 with parallel laminations and ripple marks. Hammer length: 32 cm.

5. Systematic palaeontology

Order Ammonoidea Zittel, 1884
Superfamily Stephanoceratoidea Neumayr, 1875
Family Perisphinctoidea Steinmann, 1890 in Steinmann & Döderlein, 1890
Subfamily Parapatoceratinae Buckman, 1926

Genus *Parapatoceras* Spath, 1924

Type species: *Ancyloceras calloviense* Morris, 1845, by original designation.

Parapatoceras cf. *tuberculatum*
(Baugier & Sauzé, 1843)
Fig. 3A–C

Material studied: Two poorly preserved specimens (Kng-ist-001–Kng-ist-002; see Fig. 3A) from the lower Callovian, top of the Kheneg Formation, central Saharan Atlas (Algeria); N 33° 41′ 32″, E 0° 59′ 21″, elevation 1268 m (see Fig. 2A, B).

Description: The two specimens with a straight shell are large, 53.5 mm and 42 mm in length (Fig. 3A–C). The flanks bear strong, inclined, regular and well–spaced simple ribs. The ribbing does not change throughout the preserved portion of the shell. Whorl section, as estimated from Fig. 3C, is oval. Suture line is not preserved.

Remarks: Based on the shell morphology and ribbing pattern, the present specimens (although not well-preserved) show typical characters of *Parapatoceras tuberculatum* (see Dietl 1978, 2020; Jain 2018). This is the first record of the genus from Algeria and the second one from the African subcontinent, after Madagascar (Collignon 1958).

The present specimens closely resemble the lower Bathonian (Zigzag Zone) Hungarian specimen described by Galácz (1980: 99, pl. 22, fig. 4a, b) as *Parapatoceras* sp. (refigured in Jain 2018, fig. 4.3), and with the uppermost lower Callovian *P. tuberculatum* from Khavda (Pachchham Island, Kachchh, western India; see Pandey et al. 1994, figs. 2d and 4d; refigured in Jain 2018, figs. 4.19 and 4.13, respectively). The lower Callovian Koenigi Zone Russian specimens from Kostroma (Gulyaev 2002) are also large (45 mm in length) (see also Jain 2018, figs. 5.5–5.8) but differ in possessing a wide-spaced ribbing pattern with a cyrtoconical shell. Arp (2001: 216, pl. 7, fig. 1) from Neumarkt i. d. Opf. (Franconian Alb, Bavaria; lower Callovian, Koenigi Zone) also recorded a large specimen (55 mm in length) of *P. tuberculatum*. However, this specimen is marked by a much wider spaced ribbing pattern and with less inclined but equally strong ribs; the shell is also almost straight. The variations in these characters (ribbing pattern and shell morphology) are due to intraspecific variation (see Dietl 1978).

Parapatoceras tuberculatum differs from the morphologically similar *P. tenue* (Baugier & Sauzé, 1843) in possessing more prominent and widely spaced ribs and from *P. distans* (Baugier & Sauzé, 1843) in the cyrtoconical shell and regularly raised ribs (see also Dietl 1978; Jain 2018).

From Madagascar Collignon (1958, pl. 25, fig. 103) illustrated "*Parapatoceras pinatum* (Baugier & Sauzé)" from the "Niveau à *Pseudoclydonic-eras* de Bemadiro"; this level is above the "couches à *Macrocephalites*" of which it characterizes the upper level (based on the *Macrocephalites chariensis* and *Notocephalites semilaevis* zones of the lower Callovian). The Semilaevis Zone has been assigned to the uppermost lower Callovian (Jain & Pandey 1997; Jain 2018). This "*Parapatoceras pinatum* (Baugier & Sauzé)" was not included in by Dietl (1978: 44) under his synonymy for *P. tuberculatum*. It very closely resembles *P. tuberculatum* and is here so considered. Thus, this is the only other African record (except the present one) of *P. tuberculatum*.

Stratigraphical occurrences: Lower Bathonian (Zigzag Zone): Hungary; lower–middle Callovian: Germany, France, England, Spain, Italy, central Russia, and northern Argentina; middle Bathonian (Bremeri Zone)–lower Callovian (middle of the Gracilis Zone): Kachchh (western India); lower Callovian, Gracilis Zone: Madagascar and Algeria (present study); upper Callovian (Athleta Zone): France. Thus, the range of *P. tuberculatum* (Baugier & Sauzé) is from the lower Bathonian (Zigzag Zone) up to the upper Callovian (Athleta Zone).

6. Discussion

The present material is the first record of the genus *Parapatoceras* from Algeria, north western Africa and the second record of *P.* (cf.) *tuberculatum* from the African subcontinent, after Collignon (1958) from Madagascar (see Fig. 1D); both records are from

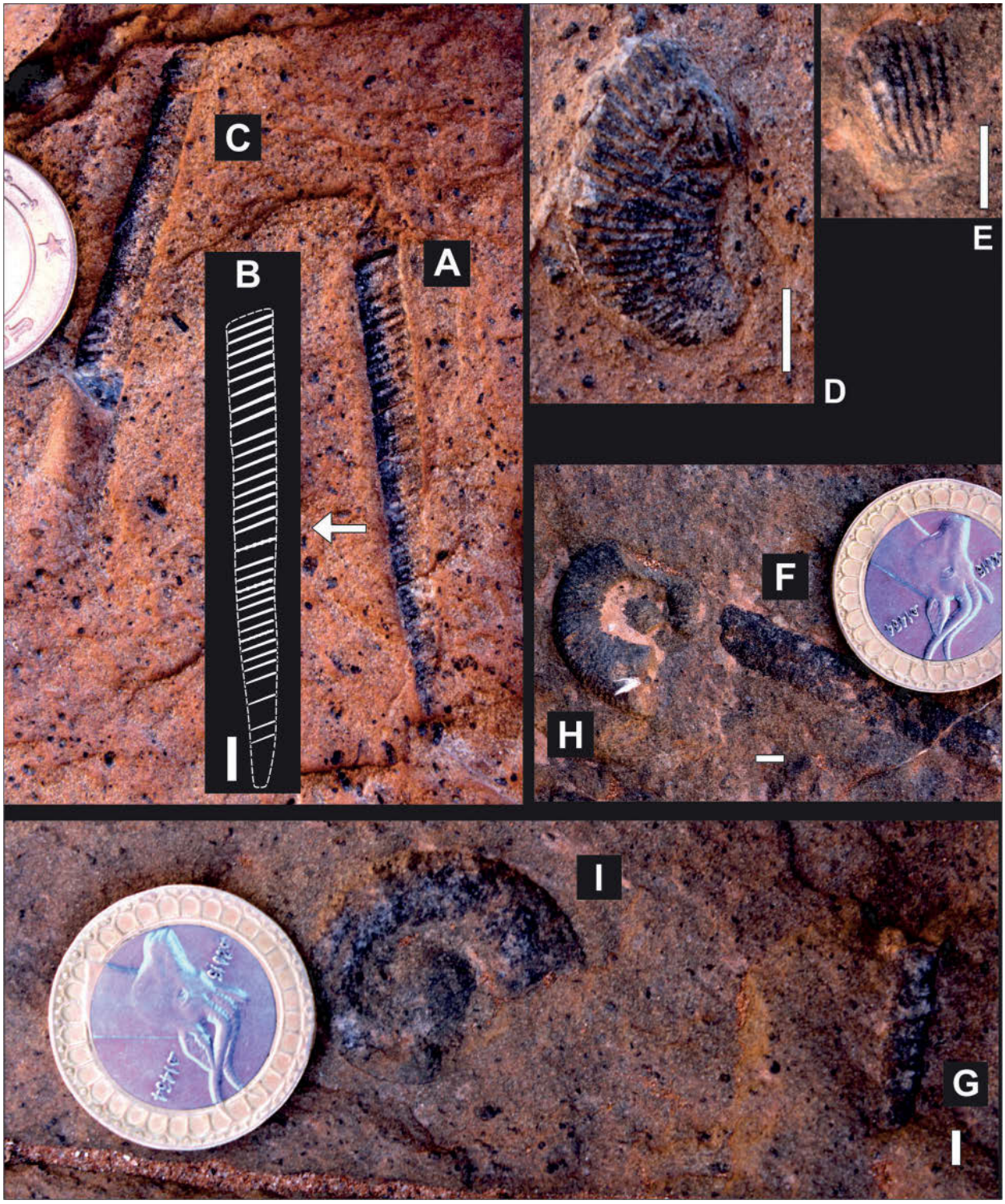

Fig. 3. Faunal assemblage from Unit 2. **A–C** – *Parapatoceras* cf. *tuberculatum* (Baugier & Sauzé 1843), sample nos. Kng-ist-001 to Kng-ist-002, respectively. **B** – Reconstructed from A to show ribbing pattern. **D, E** – *Macrocephalites* sp., sample nos. Kng-ist-002 to Kng-ist-004, respectively. **F, G** – *Parapatoceras* sp., sample nos. Kng-ist-005 to Kng-ist-006, respectively. **H, I** – Indeterminable perisphinctids, sample nos. Kng-ist-007 to Kng-ist-008, respectively. Bar equals 5 mm.

the lower Callovian. Recently, Jain (2018), while reviewing the relationship and occurrences of *Parapatoceras* Spath and *Epistrenoceras* Bentz in Kachchh (western India; see Fig. 1D), suggested a close link between their stratigraphic occurrences and relative sea level rise. Interestingly, the Algerian occurrence of *Parapatoceras* also probably coincides with the lower Callovian sea level highstand, JCa2 (see Haq 2017). However, more sampling is needed to corroborate this link.

7. Conclusions

The present study reports the first occurrence of *Parapatoceras* Spath from Algeria, and is the second record of *P. tuberculatum* (Baugier & Sauzé) from the African subcontinent, after Madagascar. The Algerian record (this study) of *Parapatoceras* probably coincides with the lower Callovian highstand, JCa2, and corroborates the previously suggested link between their widespread occurrence and rising sea level. The genus *Macrocephalites* Spath is also documented for the first time from the El Bayadh area, central Saharan Atlas.

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References

Arkell, W.J. (1956): Jurassic Geology of the World. – 806 pp.; Edinburgh & London (Olivier & Boyd).

Arp, G. (2001): Fazies, Stratigraphie und Ammonitenfauna des Mittleren und Oberen Dogger bei Neumarkt i. d. Opf. (Bajocium–Oxfordium, Süddeutschland). – Berliner geowissenschaftliche Abhandlungen, **E36** : 189–241.

Bassoullet, J.P. (1973): Contribution à l'étude stratigraphique du Mésozoïque de l'Atlas Saharien Occidental (Algérie). – Ph.D. thesis, Université de Paris VI, France: 497 pp.

Baugier, A. & Sauzé, M. (1843): Notice sur quelques coquilles de la famille des ammonoïdees. – Mémoire de la Société de Statistique, **1843**: 1–16.

Bert, D. & Courville, P. (2016): First record of Late Callovian to Early Oxfordian heteromorph ammonites. – Annales de Paléontologie, **102**: 117–121. doi: 10.1016/j.annpal.2016.05.004

Buckman, S.S. (1909–1930): (Yorkshire) Type Ammonites, vols. I–VII + 1–790; London (Wheldon & Wesley).

Collignon, M. (1958): Atlas des fossiles caractéristiques de Madagascar. No. 2. (Bathonien–Callovien). – Tananarive (Service Géologique, République Malgache).

Cornet, A. (1952): L'Atlas Saharien Sud-Oranais. – XIX^{e} International Geological Congress, Algiers, Regional Monographs, **12**: 1–51.

Delfaud, J. (1974): La sédimentation deltaïque ancienne – exemples nord-sahariens. – Bulletin du Centre de Recherche Pau – SNPA, **8**: 241–262.

Dietl, G. (1978): Die heteromorphen Ammoniten des Dogger (Stratigraphie, Taxonomie, Phylogenie, Ökologie). – Stuttgarter Beiträge zur Naturkunde, Serie B, **33**: 1–97.

Dietl, G. (2020): Über heteromorphe Ammoniten aus dem Mitteljura des Gebiets der oberen Donau und der Wutach-Region. – Jahreshefte der Gesellschaft für Naturkunde in Württemberg, **176**: 77–93.

Elmi, S. (1971): Les zones d'Ammonites dans la série Bajocien supérieur–Callovien de l'Oranie (Ouest Algérien). – Bulletin de la Société géologique de France, **S7-XIII**: 28–37. doi: 10.2113/gssgfbull.S7-XIII.1-2.28

Galácz, A. (1980): Bajocian and Bathonian ammonites of Gyenespuszta, Bakony Mts., Hungary. – Geologica Hungarica, Series Palaeontologica, **39**: 1–151.

Gulyaev, D.B. (2002): The first find of heteromorph ammonites in the Lower Callovian of European Russia. – Paleontological Journal, **6**: 38–40.

Haq, B.U. (2017): Jurassic sea-level variations: a reappraisal. – GSA Today, **28** (1): 1–7.

Jain, S. (2018): Genus *Parapatoceras* Spath from Kachchh and the likely ancestor of *Epistrenoceras* Bentz. – Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, **288**: 255–272. doi: 10.1127/njgpa/2018/0740

Jain, S. & Pandey, D.K. (1997): Revision of the age of heteromorph ammonite *Parapatoceras* from Kachchh, Western India. – Journal of Palaeontological Society of India, **42**: 133–139.

Lucas, G. (1942): Description géologique et pétrographique des monts de Ghar Rouban et du Sidi-el-Abed. – Bulletin du Service Géologique de l'Algérie **16**: 1–539.

Lukeneder, A. (2015): Ammonoid Habitats and Life History. – In: Klug et al. (eds.): Ammonoid Paleobiology: From Anatomy to Ecology. – Topics in Geobiology, **43**: 689–791; Dordrecht (Springer). doi: 10.1007/978-94-017-9630-9_18

Mahboubi, C.Y. (2021): Les indices de fluides et diagenèse dans les terrains du Jurassique de la région d'Aïn-Ouarka et d'El-Bayadh (Atlas saharien, Algérie). – Ph.D. thesis, Université d'Oran 2, Algeria : 156 pp.

Mahboubi, C.Y., Radulović, B.V., Ouali Mehadji, A., Ayoub-Hannaa, W. & Munnecke, A. (2021): Late Jurassic (Oxfordian–Kimmeridgian) brachiopods of the El Bayadh Area (Central Saharan Atlas, Algeria): bio-

stratigraphy, stratigraphic revision, paleobiogeography and paleoecology. – Historical Biology **33**: 3260–3280. doi: 10.1080/08912963.2020.1861609

Mahboubi, C.Y., Naimi, M.N., Ouali Mehadji, A., Garah, A., Langer, M.R. & Limam, H. (2023a): First evidence of the benthic foraminifera *Alveosepta jaccardi* from the Oxfordian of the Saharan Atlas (Algeria): Palaeoenvironmental and palaeoecological implications. – Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, **307**: 91–100. doi: 10.1127/njgpa/2023/1115

Mahboubi, C.Y., Naimi, M.N., Simmons, M. & Bidgood, M. (2023b): Algal microfacies in the Theniet Et Temar Formation (middle Oxfordian), Central Saharan Atlas, Algeria. – Proceedings of the Geologists' Association (in press).

Mangold, C. (1971): Stratigraphie des étages Bathonien et Callovien du Jura Méridional. – Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon, **41**: 1–376.

Mehl, J.M. (1978): *Parapatoceras tuberculatum* (Baugier & Sauzé 1843), ein heteromorpher Ammonit aus dem Callovium von Kandern/Südbaden. – Berichte der Naturforschenden Gesellschaft zu Freiburg im Breisgau, **68**: 95–101.

Mitta, V.V. & Seltzer, V.B. (2006): On the Middle Jurassic heteromorph ammonites from European Russia. – In: Barskov, I. & Leonova, T. (eds.): Contribution to Current Cephalopod Research: 25–28; Moscow (Paleontological Institute).

Morris, J. (1845): Description of some species of the genus *Ancyloceras*. – The Annals and Magazine of Natural History, **15**: 31–34. doi: 10.1080/037454809495243

Munk, C. (1979): Heteromorphe Ammoniten aus dem Unter-Callovien ("Macrocephalen-Schichten") vom Westrand der Nördlichen Frankenalb (S-Deutschland). – Paläontologische Zeitschrift, **53**: 220–229. doi: 10.1007/BF02986586

Neumayr, M. (1875): Die Ammoniten der Kreide und die Systematik der Ammonitiden. – Zeitschrift der Deutschen Geologischen Gesellschaft, **27**: 854–892.

Pandey, D.K., Callomon, J.H. & Fürsich, F.T. (1994): On the occurrence of the Callovian ammonite *Parapatoceras tuberculatum* (Baugier & Sauzé 1843) in Kachchh, Western India. – Paläontologische Zeitschrift, **68**: 63–69. doi: 10.1007/BF02989433

Potonié, R. (1929): Die ammonitischen Nebenformen des Dogger (*Apsorroceras, Spiroceras, Parapatoceras*). – Jahrbuch der Preußischen Geologischen Landesanstalt, **50**: 217–261.

Schlotheim, E.F. v. (1813): Beiträge zur Naturgeschichte der Versteinerungen in geognostischer Hinsicht. – Leonhards Taschenbuch für die gesammte Mineralogie, **7** (1): 3–134.

Scotese, C.R. (2013): Atlas of Jurassic Paleogeographic Maps, PALEOMAP Atlas for ArcGIS, volume 3, The Jurassic and Triassic, Maps 32–42, Mollweide Projection, PALEOMAP Project, Evanston, IL.

Steinmann, G. & Döderlein, L. (1890): Elemente der Paläontologie. – XIX + 848848 pp.; Leipzig (Engelmann).

Spath, L.F. (1924): On the Blake collection of ammonites from Kachh, India. – Memoirs of the Geological Survey of India, Palaeontologia Indica, New Series, **9** (1): 1–29.

Spath, L.F. (1927–1933): Revision of the Jurassic Cephalopod fauna of Kachh (Cutch). – Memoirs of the Geological Survey of India, Palaeontologia Indica, New Series, **9** (2): 1–945.

Zittel, K.A. v. (1884): Handbuch der Paläontologie, 2 vols. – 893 pp.; München & Leipzig (Oldenbourg).

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