



The occurrence of a shallow-water *Ammobaculoides* assemblage in the Middle Jurassic (Bajocian) Dhurma Formation of Central Saudi Arabia

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Abstract. We report the occurrence of an *Ammobaculoides*-dominated assemblage in the lowermost member of the Middle Jurassic Dhurma Formation exposed west of Riyadh, Saudi Arabia. The new species *Ammobaculoides dhurmaensis* n.sp. is described from the green shale of the D1 unit (also known as the Balum Member) of the Dhurma Formation, which has been assigned an early Bajocian age based on ammonites. Our new finding constitutes the oldest reported worldwide occurrence of the agglutinated foraminiferal genus *Ammobaculoides* Plummer, 1932.

The Dhurma Formation was deposited during the Middle Jurassic transgression (Vaslet et al., 1983) and is a part of the petroleum-rich Jurassic succession of Saudi Arabia. The formation is named after the town of Dhurma situated northwest of Riyadh (Fig. 1). The Dhurma Formation belongs to the Jurassic Shaqra Group, which is the most prolific stratigraphic petroleum producer in the world. The Shaqra Group contains 12 reservoirs in seven formations that are exploited in the Ghawar Field, which is the world's largest onshore oil field. The Dhurma Formation lies in the lower portion of the Shaqra Group and is assigned a Middle Jurassic (Bajocian–Bathonian) age based on ammonites (Arkell, 1952; Enay et al., 1987). The Dhurma Formation was subdivided into three units, including lower, middle and upper, by Bramkamp and Steineke (1952) and Arkell (1952). These units have been further subdivided by Vaslet et al. (1983), who proposed seven informal units (D1 to D7) based mainly on sedimentology and biostratigraphy (ammonites). Units D1 and D2 correspond to the lower Dhurma Formation sensu Bramkamp and Steineke (1952) and have been assigned informal names. The lowermost D1 unit, also called the Balum Member, has been assigned an early Bajocian age based on ammonites (Discites, *Laeviuscula* European zones of Enay et al., 1987; Enay and Mangold, 1994).

The first micropalaeontological study of the Dhurma Formation was carried out by Powers et al. (1966), who described eight foraminiferal zones. The lower part of the formation was assigned to the Haurania Zone based on two species: *Haurania amiji* and *Haurania deserta* of late Bajocian age (Powers et al., 1966). Subsequent work on foraminifera was performed by Hughes (2004, 2006, 2009), who reported the following 13 species from the Dhurma Formation: *Ophthalmidium* spp., “*Pfenderina*” *trochoidea*, *Satorina apuliensis*, *Trocholina elongata*, *Ammobaculites* spp., *Nautiloculina oolithica*, “*Pfenderina*” *salernitana*, *Redmondoides lugeoni*, *Redmondoides* sp. cf. *rotundata*, *Valvulina* sp., *Trochamijiella gollestanehi*, *Parurgonia caelinensis* and *Pseudocyclammina* sp. cf. *lituus*. Al-Dhubaib (2010) additionally reported *Riyadhella elongata*, *Pseudomarrssonella bipartita*, *Trocholina aptiensis*, *Meyendorffina bathonica*, and several species of *Neotrocholina* and *Andersenolina* from the upper part of the Dhurma Formation.

The foraminifera from the limestone reservoirs of the Dhurma Formation have been studied by several Saudi Arabian Oil Company (Aramco) micropalaeontologists (e.g. Redmond, 1964; Hughes, 2009), but the microfauna from the lower shaley members has not been previously reported. The purpose of this study is to report a new finding of an

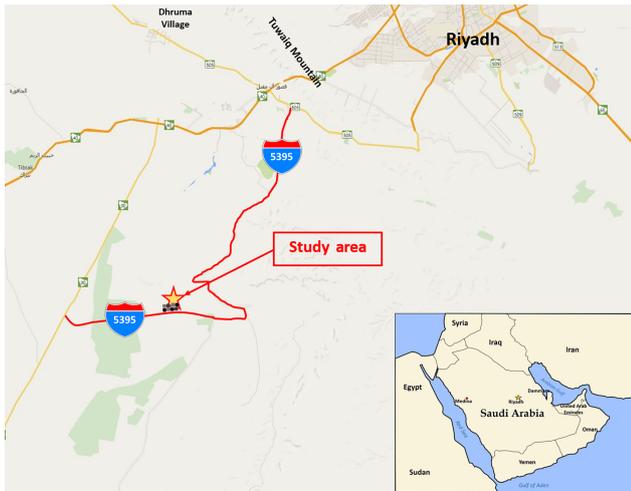


Figure 1. Location of the studied section.



Figure 2. Road cut along Route 5395 at N24°09'45", E46°07'41", looking east. Arrow points to the green shale exposure.

assemblage of smaller agglutinated foraminifera present in the green shale of the basal D1 unit (Balum Member) of the Dhruma Formation.

1 Material and methods

The main emphasis of the study is the green shale of the lower Dhruma Formation belonging to the basal Balum (D1) Member. The green foraminifera-rich shale is exposed near the Dhibi limestone quarries located west of Riyadh (Fig. 1). A road cut along Road 5395 off Highway 30 (N24°09'45", E46°07'41") provides a fresh outcrop of green shale with interbedded brecciated limestone (Fig. 2). The basal member of the Dhruma Formation contains vuggy limestone collapse breccia that was formed as a result of the dissolution of evaporites, and therefore the depositional palaeoenvironment is here interpreted to be very shallow marine with hypersaline pools or lagoons.

The samples were disaggregated, washed over a 63 µm sieve, and dried at the Center of Petroleum & Minerals of the Research Institute, King Fahd University of Petroleum & Minerals (KFUPM). To accelerate the disaggregation and washing process, samples were boiled with industrial soap, which helps in the dispersal and removal of muddy particles from the sand-size grains. The foraminifera were separated into faunal slides and photographed using a Nikon-1500 photomicroscope. Representative specimens were imaged using a model JSM-5900LV scanning electron microscope in the GeoSciences Department at KFUPM.

2 Results

The foraminiferal assemblage recovered from the green shale of the lower Dhruma Formation consists entirely of small agglutinated forms dominated by the genus *Ammobaculoides*, accompanied by rare specimens of *Ammobaculites* aff. *agglutinans* (d'Orbigny) and small trochamminids. *Ammobaculoides* specimens comprise >97% of the total assemblage. Such an *Ammobaculoides*-dominated assemblage has not been previously reported from the Jurassic of Saudi Arabia. The entirely agglutinated nature and low diversity of the assemblage along with the presence of evaporates in the D1 Unit suggest restricted and stressed environmental conditions. The new species *Ammobaculoides dhrumaensis* n.sp. is described below.

3 Systematic palaeontology

The supra-generic classification of the agglutinated foraminifera follows Kaminski (2014).

Class **Foraminifera** d'Orbigny

Subclass **Globothalamana** Pawlowski, Holzmann & Tyszka

Order **Lituolida** Lankester

Suborder **Spiroplectamminina** Mikhalevich

Family **Spiroplectamminidae** Cushman

Genus *Ammobaculoides* Plummer, 1932

Type species: *Ammobaculoides nararroensis* Plummer, 1932.

Ammobaculoides dhrumaensis n.sp. (Figs. 3, 4: 1–3)

Material: over 350 specimens.

Derivation of name: named after the Dhruma Formation of Saudi Arabia.

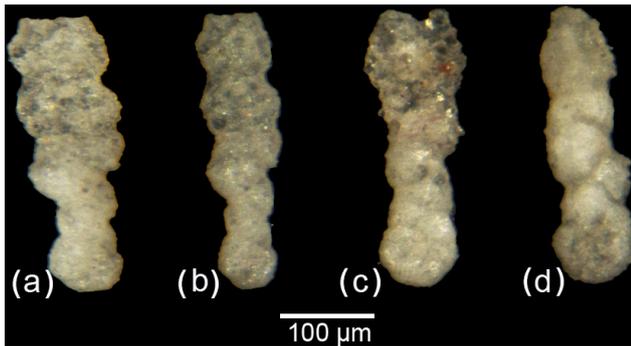


Figure 3. Light microscope images of paratypes of *Ammobaculoides dhrumaensis* n.sp.

Description: Test free, small, elongate, slightly compressed. Early chambers planispirally enrolled, consisting of two whorls with six chambers in the final whorl. The uncoiled part contains up to six chambers: initially with a pair of biserial to loosely biserial chambers, next becoming lax-uniserial, and finally uniserial. Sutures depressed. Wall agglutinated, silicified, insoluble in acid, surface smooth. Aperture terminal, central, oval, on a low shoulder on the final rectilinear chambers.

Remarks: Our specimens of *Ammobaculoides dhrumaensis* n.sp. most closely resemble the species *Ammobaculoides primoris* Komissarenko, 1977, from the upper Callovian of Western Siberia. The specimens illustrated by Komissarenko (1977) are morphologically variable, with about 11 to 12 chambers in the planispiral part (7–8 chambers in the final whorl), followed by an uncoiled portion that may be initially biserial, loosely biserial, or even lax-uniserial (sensu Kaminski et al., 2011). The Siberian form also includes specimens consisting only of a planispiral coil, and complete specimens display a distinct apertural neck. The largest of the specimens illustrated by Komissarenko has only four chambers in the uncoiled part. Our specimens from Saudi Arabia differ in possessing one fewer chamber in the final whorl of the planispiral part, lack an apertural neck, and have an uncoiled portion with as many as six chambers (Fig. 4: 1). Similar to the specimens from Siberia, the uncoiled portion may be initially biserial (Fig. 4: 2), loosely biserial (Fig. 4: 1), or lax-uniserial (Fig. 4: 3). Our specimens from Saudi Arabia differ in possessing lower chambers in the uncoiled portion, whereas the Siberian specimens may have chambers that are more elongated and may be higher than wide.

Type level: lower Bajocian, lowermost D1 (Balum) member, Dhruma Formation.

Type locality: road cut along Road 5395 off Highway 30 (N24°09'45", E46°07'41"), Riyadh District, Saudi Arabia.

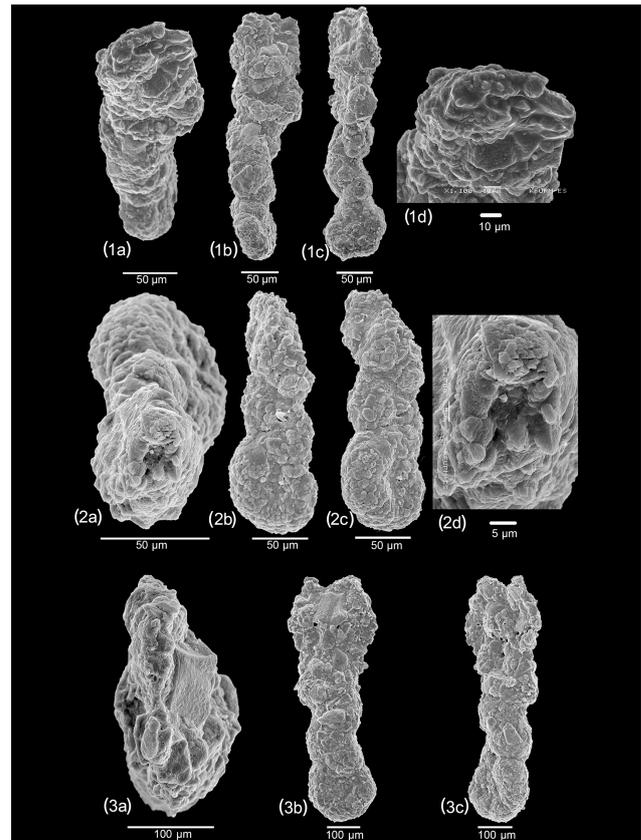


Figure 4. Scanning electron micrographs of *Ammobaculoides dhrumaensis* n.sp., from the basal D1 member of the Dhruma Formation, west of Riyadh. **(1a–d)** Paratype (EMRC 7/7C-9), loosely biserial specimen: **(a)** oblique terminal view; **(b)** edge view; **(c)** lateral view; **(d)** detail of aperture; scale bar 50 µm. **(2a–d)** Paratype (EMRC 7/7C-9), biserial specimen: **(a)** oblique terminal view; **(b)** lateral view; **(c)** oblique edge view; **(d)** detail of aperture; scale bar 50 µm. **(3a–c)** Holotype (EMRC 7/7C-8), lax-uniserial specimen: **(a)** terminal view; **(b–c)** lateral views; scale bar 100 µm.

Dimensions: Holotype – length 650 µm, maximum width 245 µm, width of spiral part 200 µm.

Type specimens: The holotype and figured paratypes have been deposited in the European Micropalaeontological Reference Centre (EMRC Cabinet 7, drawer 7) at Micropress Europe, AGH University of Science & Technology, in Kraków, Poland.

4 Discussion and conclusions

Our finding of an *Ammobaculoides*-dominated assemblage in the lower Bajocian D1 (Balum) Member of the Dhruma Formation in Saudi Arabia constitutes the oldest reported occurrence of this genus. The oldest previously published report of *Ammobaculoides* is from the upper Callovian of

Western Siberia (Komissarenko, 1977; Azbel and Grigalis, 1991). Our specimens bear some resemblance to *Ammobaculoides primoris* Komissarenko, but taking into account the geographical separation from Siberia and older stratigraphic occurrence, they are here described as a new species.

Data availability. The microscope slides have been deposited in the European Micropalaeontological Reference Centre (EMRC Cabinet 7, drawer 7) at Micropress Europe, AGH University of Science & Technology, in Kraków, Poland. Access to the EMRC collections is by appointment. See www.micropresseurope.eu.

Competing interests. The authors declare that they have no conflict of interest.

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