Orbitolina arcuala sp. nov.
A NEW ORBITOLINID FORAMINIFERA FROM THE CRETACEOUS (ALBIAN) OF IRAQ

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ABSTRACT

A new species of foraminifera related to the family Orbitolinidae, *Orbitolina arcuala* sp. nov., is observed and described from the Late Albian part of the Mauddud Formation (Late Albian – Early Cenomanian) of Iraq. Its identification depends on the morphology and the internal structural features of the test. To achieve this aim, thin sections have been prepared from core samples collected from Kirkuk well 109. Two supplementary thin sections are used, one from Cham Chamal well 1 and the other from Nafatah well 1; to confirm definition and geographic extensions.

This new identified species differs from the other species of the genus *Orbitolina* d'Orbigny, 1850 (subfamily Orbitolininae), by the presence of a depression on one side near the embryonic area and by the presence of a perfect, well-developed periembryonic area, in addition to the differences in the dimensions and other features, all features are within the valid definition of the genus *Orbitolina*.

Orbitolina arcuala sp. nov.
نوع جديد لعائلة الفورامنيفيرا Orbitolinidae
من الطباشيري (الألبيان) في العراق

مأمون عبيد محمد

المستخلص

تم وصف النوع الجديد *Orbitolina arcuala* sp.nov من عائلة Orbitolinidae إحدى عوائل الفورامنيفيرا القاعية من صخور الألبيان المتأخر لتكوين المودود (الألبيان المتأخر- السينومانيان المبكر) في العراق. تم هذا الوصف بالاعتماد على طبيعة الخصائص الخارجية بالإضافة إلى المميزات الداخلية لأصداف النوع الجديد. استخدمت الشرائح الرقيقة التي أعدت من نماذج اللباب المجموع من بئر كركوك 109، إضافةً إلى شريحتين من بئري چم چمال 1 ونفاطة 1 لغرض دعم التعريف والامتداد الجغرافي.

تمت مقارنة هذا النوع مع بقية أنواع جنس الـ *Orbitolina*، حيث يختلف عنهم جميعاً بوجود انخفاض من جهة واحدة قرب المنطقة الجنينية، إضافة إلى وجود تشكيل مميز يحيط بالغرفة الأولية، والى الفروقات في الأبعاد وبقية المميزات، كلها تقع ضمن التعريف النافذ لجنس الـ *Orbitolina*.

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INTRODUCTION

The Mauddud Formation is a shallow-water carbonate with wide-spread distribution of Cretaceous age (Late Albian – Early Cenomanian) in the subsurface of the Arabian Gulf. It was described for the first time by Henson in an unpublished report in 1940 (cited by Bellen *et al*., 1959) from Dukhan 1 well near Ain Mauddud area, north Dukhan, Qatar. It has subsequently been recognized in Iraq, Kuwait, Saudia Arabia, Bahrain, United Arab Emirates and Oman.

In southern Iraq, the reference section of the formation is described from Zubair well 3 by Owen and Nasr (1958). In this well, the Mauddud Formation consists of organic, detrital, occasionally pseudo-oolitic limestone with streaks of green or bluish shale.

In central Iraq, the formation has also been described from a variety of different wells and fields (like Awasil 5, Falluja 1, Makhul 2 and more recently East Baghdad and Ahdab fields). In all these area, the Mauddud Formation is composed of organic detrital limestone with a marly matrix and an *Orbitolina – Trocholina* fauna (Bellen *et al*., 1959).

According to Bellen *et al*. (1959), northern Iraq has a different stratigraphic nomenclature adopted for the Mauddud-equivalent strata. Here, the stratigraphic nomenclatures were based on the fieldwork in the mountain region of the northern Iraq that preceded exploration drilling in that area. In that particular region, the outcrops of the Hauterivian – Albian strata include the exposed, vertical, massive and black to dark-brown dolomites and dolomitic limestones that form the cores of most of the main anticlines of northern Iraq. These strata were assigned to the Qamchuqa Formation by Wetzel (1950) in an unpublished report (Wetzel, 1950 in Bellen *et al*., 1959). Wetzel (1950) divided the Qamchuqa Formation into three limestone units that are separated by three dolomite units (Wetzel, 1950 in Bellen *et al*., 1959).

The Qamchuqa Formation was encountered in the subsurface of the deep test well Kirkuk 109. The formation was divided in that well into the Upper and the Lower Qamchuqa formations; separated by a Shale Unit. The Shale Unit is designated as the Upper Sarmord Formation. This subdivision scheme was then adopted for northern Iraq by Bellen *et al*. (1959).

The rocks of the Mauddud Formation (equivalent to the informal name Upper Qamchuqa Formation) shows a qualitative variability in its fossils content (different algal and foraminiferal families) where the taxa of the family Orbitolinidae form the main constituent (rock building) in Iraq as noted by Mohammed (1981, 2002a and b, and 2003) and Sayyab and Mohammed (1984 and 1985). The most important and abundant are *Orbitolina concava* Henson, *Orbitolina sefini* Henson, *Orbitolina qatarica* Henson, *Mesorbitolina oculata* (Douglass), *Mesorbitolina aperta* (Erman), *Neoiraqia convexa* Danilova, *Naupliella insolita* Decrouez and Moullade, *Paracoskinolina broennimani* (Decrouez and Moullade), and *Orbitolina* spp.

Schroeder (1975) developed an effective key to identify orbitolinids species based on the dimensions and complexity of the embryonic area of the individual. This area consists of protoconch, overlain by deutroconch and underlain by subembryonic area. For orbitolinas, their structures are slightly modified and their dimensions increased (between 0.33 – 0.9 mm) as time progressed. Other features are of subsidiary importance. The species described here displays a unique pattern to this region of the test.

▪ Materials used and Methodology

Materials used in the current study are 120 thin sections prepared from 40 core samples. These samples were collected from the Late Albian sediments of the deep test well Kirkuk 109 (Fig.1).

The terminology adopted in this study is that of Loeblich and Tappan (1988). They defined this group as agglutinated foraminifers that have tests of low conical to discoidal shapes, subdivided by marginal subepidermal partition, with a central zone containing pillars or vertical partitions. The embryonic apparatus either simply consists of protoconch and deutroconch, or it may be made (more complex) by the presence of one or two additional zones. The wall may be trilaminar, with rare disappearance of the middle part (radial zone) in some genera.

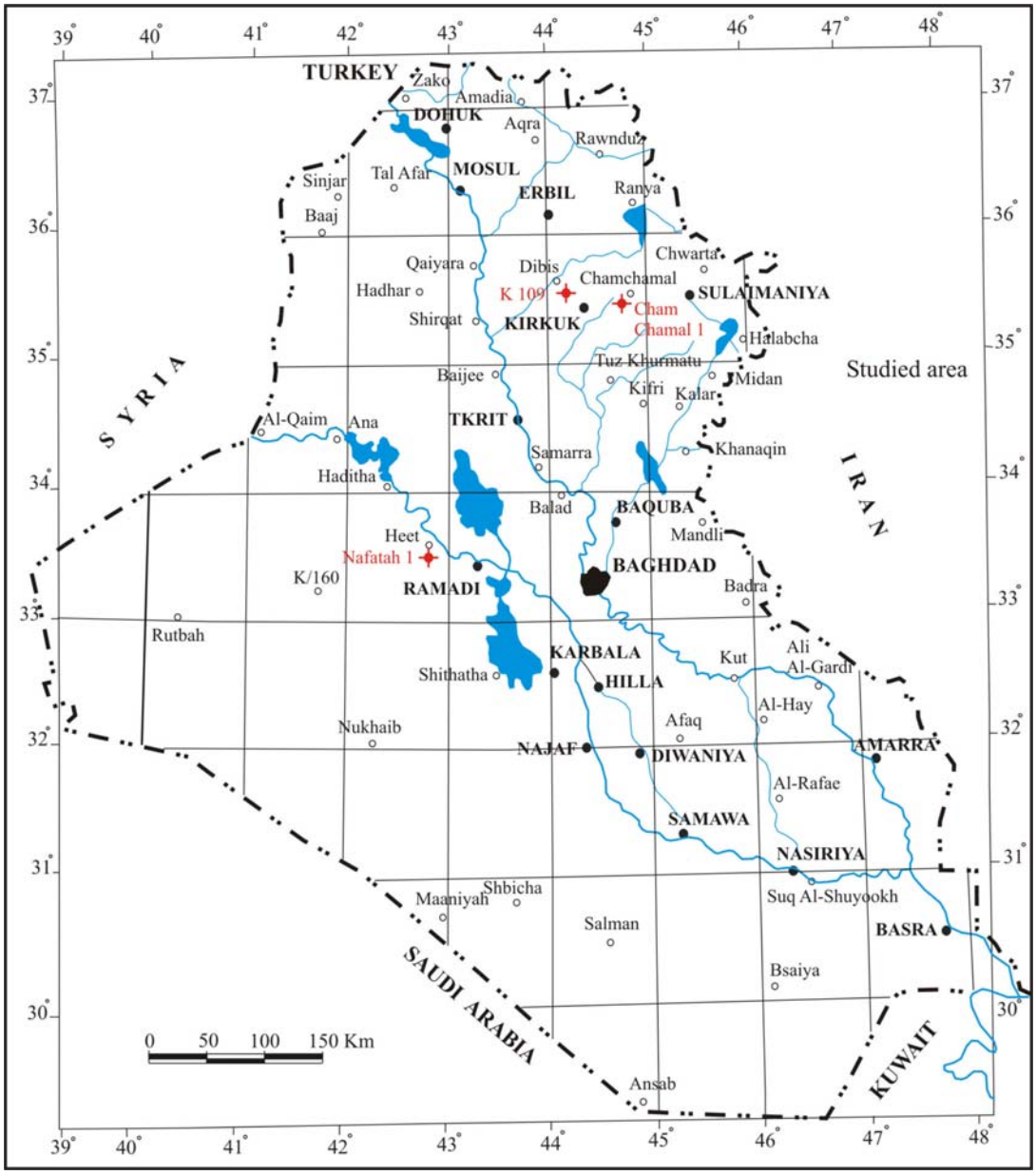


Fig.1: Location map of the studied wells

SYSTEMATIC DESCRIPTION

Order Foraminiferida Echwald, 1830

Suborder Textulariina Delage and Herouord, 1896

Superfamily Orbitolinacea Martin, 1890

Family Orbitolinidae Martin, 1890

Subfamily Orbitolininae Martin, 1890

Genus Orbitolina d'Orbigny, 1850

Type species: *Orbulites concava* Lamarck, 1816

Orbitolina arcuala sp. nov

(Fig.2.1 – 2.6)

Orbitolina concava qatarica Henson; Mohammed, 1981 (Fig.3)

- **Derivation of Name**

arcus (Lat.) = bow + ala (Lat.) = wing, with reference to the bowl shape of elongated chamberlets chain surrounding the protoconch.

- **Holotype**

Axial section through a megalospheric form (Fig.2.1), Repository: Author's collections, Mohammed (1981), Department of Geology, College of Science, University of Baghdad.

- **Paratypes**

Twenty three thin sections (of different orientations) out of one hundred and twenty thin sections prepared from the core samples of the deep test well Kirkuk 109. Two supplementary thin sections from Cham Chamal well 1 and the other from Nafatah well 1 (Figs.2 and 3).

- **Dimensions**

The dimensions of the Holotype and Paratype are mentioned in Table (1)

Table 1: Dimensions of Holotype and Paratype

	Diameter (mm)	Height (mm)	Fig.
Holotype	2.26	1.60	2.1
Paratype	2.09	–	2.3
Paratype	2.19	–	2.4
Paratype	2.44	–	2.5
Paratype	2.06	–	2.6
Paratype	2.26	1.48	3.1

- **Diagnosis**

Megalospheric tests are of low conico-concave shape bearing a sulcus or a depression on one side. The embryonic area possesses elongated chamberlets (five chamberlets, two of them are semi-divided internally by incomplete partitions) completely surrounding the protoconch along its circumference. These elongated chamberlets open into the protoconch by a connecting opening located on the upper third part of their region of contact. No connection present between the chamberlets themselves. Microspheric tests are almost of discoid shape of large diameter.

▪ **Materials**

One hundred and twenty thin sections of different orientations are prepared from core samples taken from the deep test well Kirkuk 109 (Fig.1). Two supplementary thin sections, one from Cham Chamal well 1 and the other from Nafatah well 1, are used to confirm the species definition and its geographic extension.

▪ **Type Locality**

The deep test well Kirkuk 109 (Fig.1), north Iraq, co-ordination
Latitude $35^{o}\ 33^{'}\ 08^{"}$ and Longitude $44^{o}\ 18^{'}\ 55^{"}$

▪ **Type Horizon**

This species came from limestone beds of the middle part of the informal Upper Qamchuqa Formation (= Mauddud Formation) at drilling depth (1409.7 – 1455.42) m; in association with *Orbitolina qatarica* Henson and *Mesorbitolina oculata* (Douglass). The last occurrence of this species (at depth 1409.7 m) is associated with the first appearance of *Orbitolina sefini* Henson. A Late Albian age is suggested for this species on the basis that *Orbitolina sefini* Henson present on the Albian – Cenomanian boundary and that *Orbitolina qatarica* Henson does not exceed the Late Albian age (Fig.4).

DESCRIPTION

▪ **External morphology**

Test calcareous, imperforate and microgranular. Megalospheric tests are of low conico-concave shape showing bilateral symmetry. Apex curved bearing a depression or a sulcus on one side at the top of the test near the embryonic area (Figs.4.1 and 4.2). Apical angle ranges between ($63^{o} – 63^{o}\ 30^{'}$). Base slightly concave so that the last 2 – 3 whorls are of an annular nature; flanks are nearly straight; diameter of the test ranges between 2.06 – 2.26 mm and height ranges between 1.48 – 1.60 mm; the number of the chambers are between 32 – 38. Microspheric tests are discoid in shape with slight convexity of the upper surface and slightly flat base.

▪ **Internal Structure**

The embryonic apparatus is in a central position within the vertex of the test tip (Fig.2.1). It consists of a globular protoconch that almost measures 0.15 mm in diameter (axial sections). The diameter of the embryo, as a whole ranges between (0.33 – 0.44) mm.

Vertical radial beams subdivide both the deutroconch zone and the subembryonic zone. The latter zone is small in comparison to the deutroconch and may be reduced to few chamberlets. In addition, the deutroconch is subject to another subdivision by irregular endoskeletal plates. The most remarkable thing is the presence of an asymmetrical, elongated and concave chamberlets surrounding the circumference of the protoconch (viz. periembryonic ring) (Figs.2.1, 3.4 and Fig.5). The embryonic area is completely surrounded by the first postembryonic chamber (Figs.2.1 and 3.1), and each chamberlet opens on protoconch (Fig.3.3) without any connection between the chamberlets themselves.

The marginal zone is very narrow and clearly visible (Figs.2.5 and 2.6), but is occasionally missing due to abrasion (Figs.2.3 and 2.4). It has first order radial beams and shorter second order one, in addition to the presence of horizontal rafters.

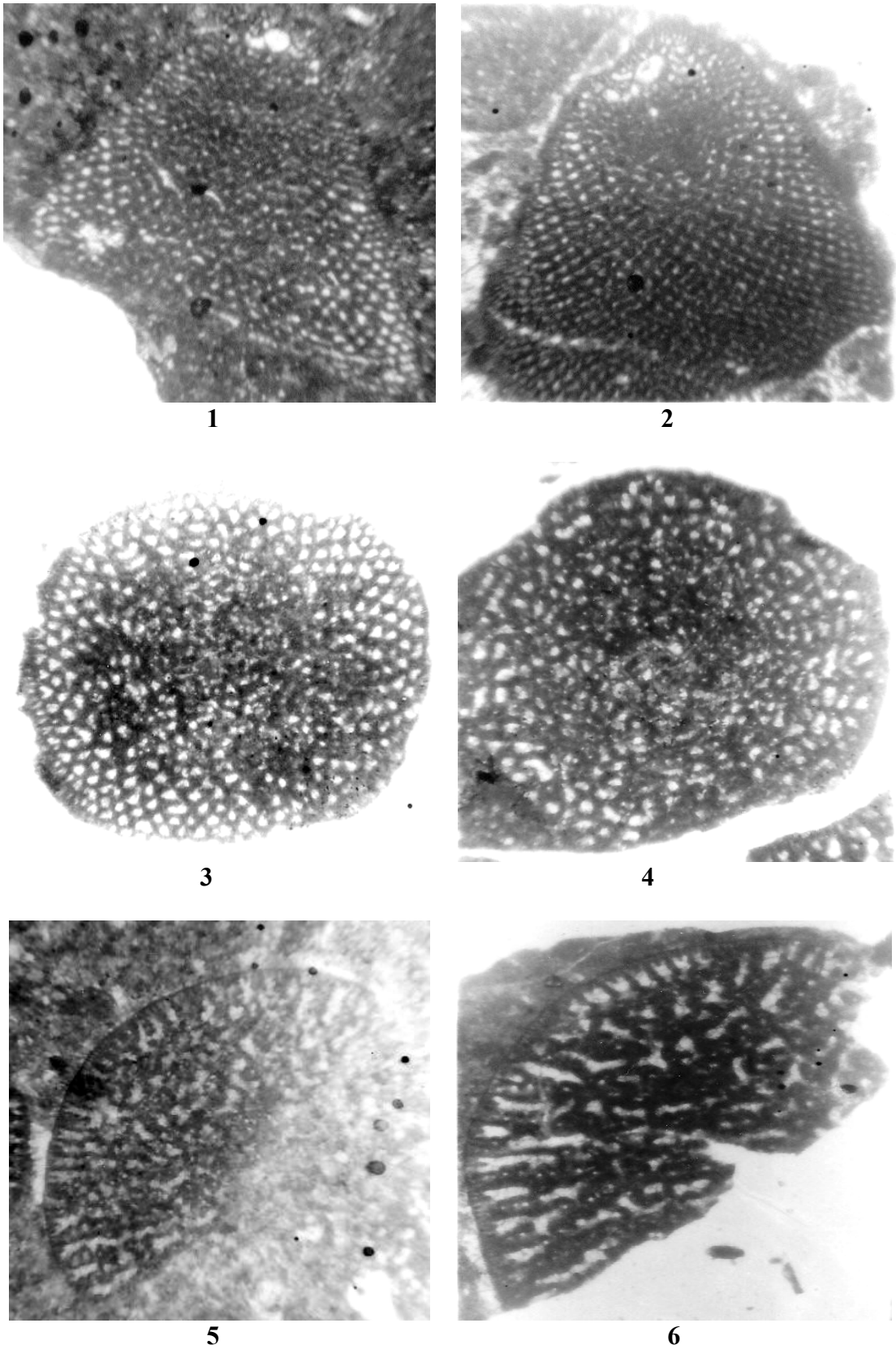


Fig.2

Explanation for Fig.2:

1- *Orbitolina arcuala* sp. nov. Holotype, axial section through a megalospheric form showing a well-rounded protoconch. The longitudinal concave chamberlets represent the periembryonic ring. The base is concave. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth (1409.70 – 1411.22) m, 32.5 X.

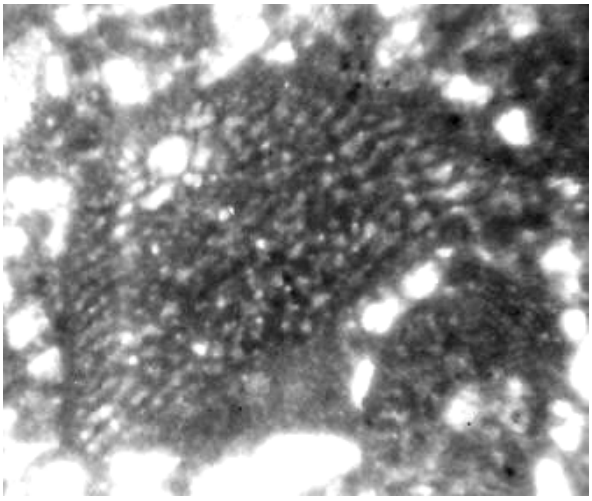
2- *Orbitolina arcuala* sp. nov. Paratype, tangential section goes deeper in the embryonic area of a megalospheric form. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth (1411.22 – 1412.75) m, 32.5 X.

3- *Orbitolina arcuala* sp. nov. Paratype, horizontal section near the base of a megalospheric form. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth (1426.46 – 1427.99) m, 32.5 X.

4- *Orbitolina arcuala* sp. nov. Paratype, oblique section near the base of a megalospheric form. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth (1453.90 – 1455.42) m, 32.5 X.

5- *Orbitolina arcuala* sp. nov. Paratype, random section away from the embryonic area of a megalospheric form. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth 1414.88 m, 32.5 X.

6- *Orbitolina arcuala* sp. nov. Paratype, part of parallel section at the middle portion of the test. See the connected chamber passages. Also see the pores at the reentrant of the undulating partitions. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth (1432.56 – 1434.01) m, 32.5 X.



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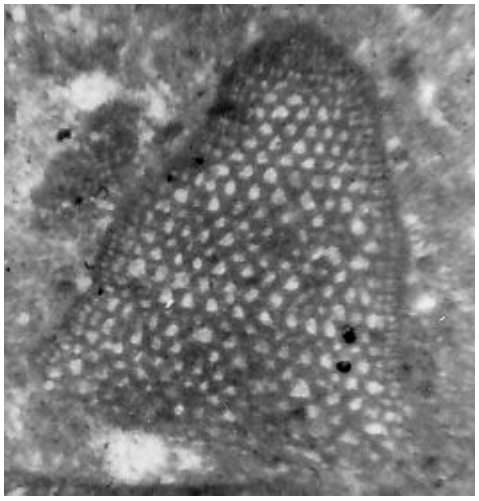

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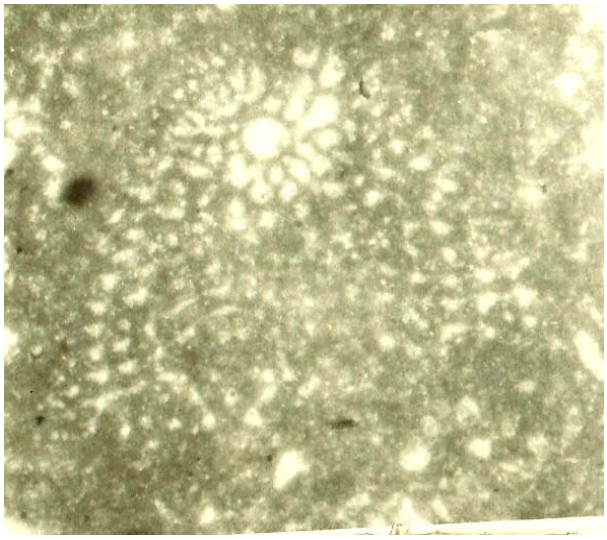

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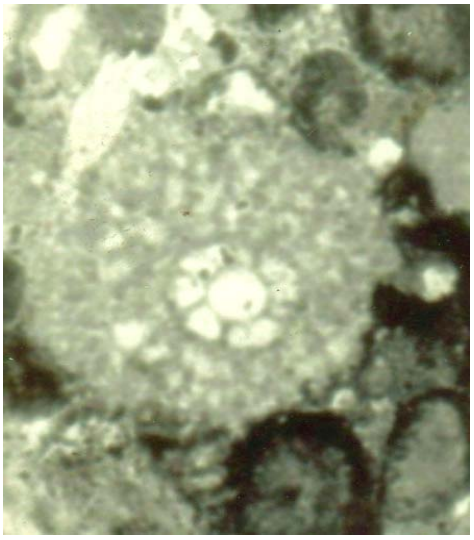

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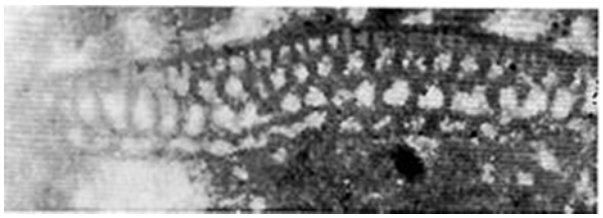

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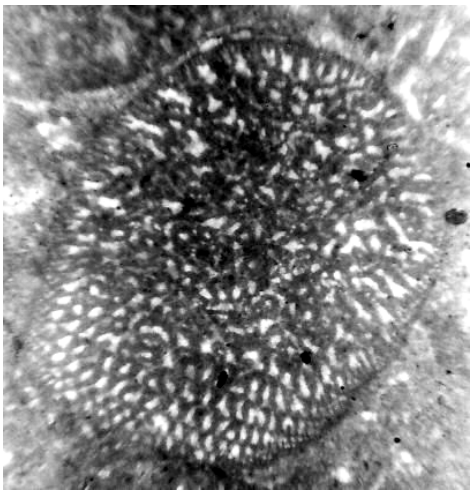

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Fig.3

Explanation for Fig.3:

1- *Orbitolina arcuala* sp. nov. Sub-axial section goes through the embryonic area, showing the complicated deutroconch, rounded protoconch and simple sub-embryonic area. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth 1414.8 m, 32.5 X.

2- *Orbitolina arcuala* sp. nov. Tangential section through a megalospheric form away from protoconch, grazing the periembryonic ring. See the sulcus near the test apex and see the concave base of the test. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth 1417.02 m, 32.5 X.

3- *Orbitolina arcuala* sp. nov. Random section through a megalospheric form showing the details of the embryonic apparatus. See the right wing of periembryonic chamberlets opens directly into protoconch. Mauddud Formation, Nafatah well 1, depth (1050 – 1055.2) m, 32.5 X.

4- *Orbitolina arcuala* sp. nov. Horizontal section of a megalospheric form cutting the embryonic apparatus through the periembryonic region. See the rounded protoconch surrounded by five chamberlets, two of them halved divided internally by incomplete partition. Mauddud Formation (= Upper Qamchuqa Formation), Cham Chamal well 2, depth 2387.8 m, 32.5 X.

5- *Orbitolina arcuala* sp. nov. Tangential sections of part of microspheric form (19 mm) showing the rare occurrence of rectangular shape of chamberlets, while chamberlets of triangular shape are more dominant. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth (1409.70 – 1411.22) m, 32.5 X.

6- *Orbitolina arcuala* sp. nov. Deep random section, slightly tangential near the base of the test. (2 – 4) pairs of chamber passages are connected at the radial zone to form one chamber passage. See the complexity of the reticulate zone. Mauddud Formation (= Upper Qamchuqa Formation), Kirkuk well 109, depth 1417.02 m, 32.5 X.

The radial zone is very prominent in contrast to the marginal zone. The cross section of the chamber passage is almost of rectangular – triangular shape, while the cross section of the chamberlets is mostly rectangular in shape with few triangular shapes, as seen in tangential section (Figs.2.2, 3.2 and 3.5).

The main partitions maintain their thickness throughout the test (Fig.2.5), but sometimes every neighboring pair (sometimes each four pairs, Fig.2.6) are attached and communicate in an irregular manner leaving the radial chamber passages as patches of different shapes; filled with pure calcite forming so-called "calcite eyes". This is common where the radial chamber passages enter the central zone. At this point they (viz. radial partitions) lose their identity, forming an irregular structure. This structure occupies large areas of the central zone. The central zone itself comprises one third the area of the test.

The aperture consists of numerous and disseminated pores situated in the re-entrants of the undulating partitions and areas where these partitions are anastomosing, all through the central part of the septa (Fig.2.6).

- **Stratigraphic and Geographic Distribution**

This species had been previously identified as *Orbitolina concava qatarica* (= *Orbitolina qatarica* Henson) from Ratawi well 2, south Iraq by Mohammed (1981), (Fig.3.3) from the Albian part of the Mauddud Formation. He identified the remarkable difference in the embryonic area and the need for further study (Mohammed, op. cit, p. 113).

To east of the type locality of this species, it is recorded from the Mauddud Formation (= Upper Qamchuqa Formation) of Cham Chamal well 2, and to the southwest from the Mauddud Formation of Nafatah well 1 (Fig.1). To the north and northwest, dolomitization ruins all the features of the fauna, sometimes ghost or relics of them are present.

- **Comparisons and Conclusions**

Orbitolina arcuala sp. nov. shows a close resemblance to the type species *Orbitolina concava* (Lamarck), but the latter has large diameter (6.7 mm), irregular and large protoconch (0.3 – 0.4 mm) and its chamber passages are almost rectangular.

The bell-like shape of the protoconch as well as its project outward with rounded surface is clearly discriminate *Orbitolina qatarica* Henson; from the new species. While *Orbitolina duranddelgai* Schroeder has flat surface of the projected embryonic area and its protoconch is of overturned bell-like shape.

The large diameter of the embryonic area (0.5 – 0.72 mm) and the biconvex shape of the test of *Orbitolina sefini* Henson can be easily distinguished from small diameter of the embryonic area (0.38 mm) and low conical-concave of *Orbitolina arcuala* sp. nov.

Table (2) summarizes the differences between this new species and other species of the genus *Orbitolina*. This comparison is based on the description of the external morphological features as well as the internal structure characteristics of A-generation tests (megalospheric form).

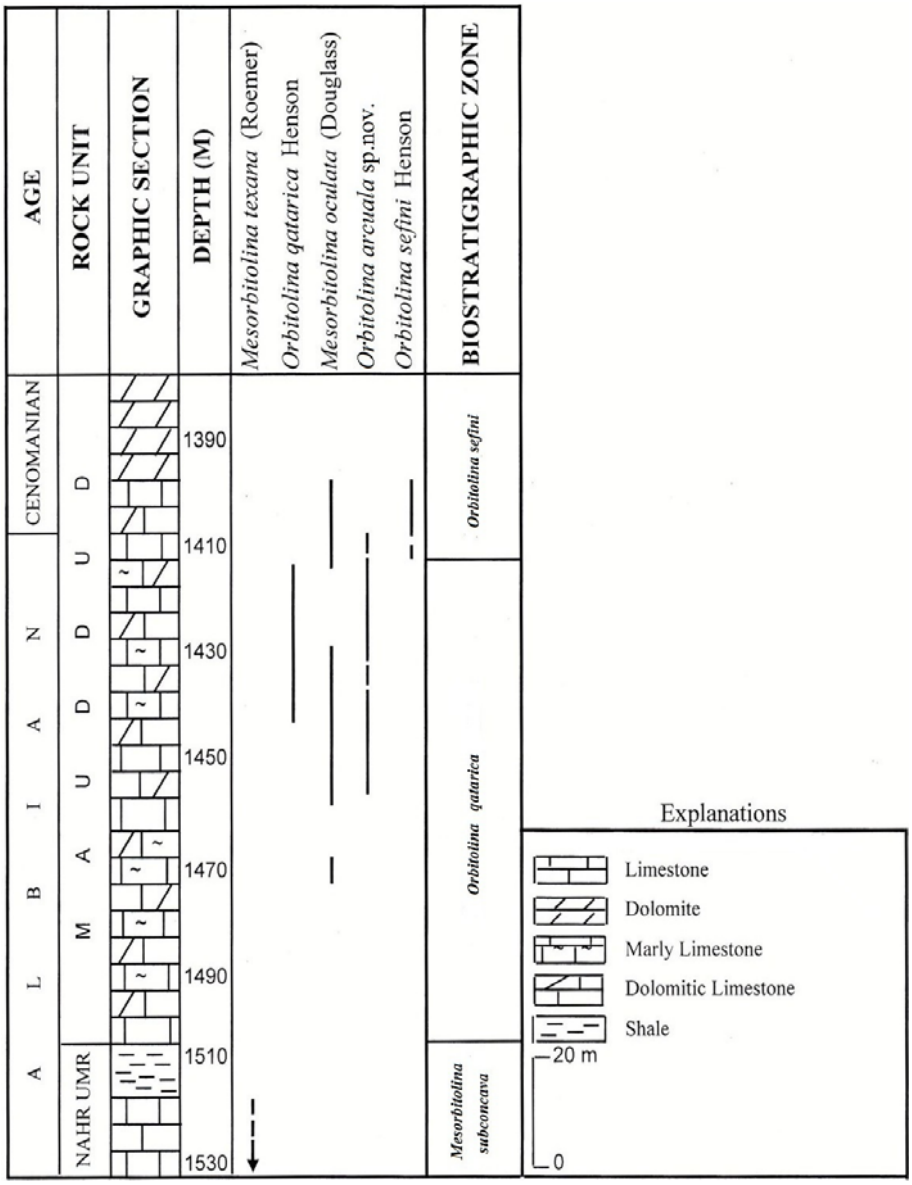

Fig.4: Biostratigraphic range chart of the orbitolinids present in the studied section (Kirkuk well 109)

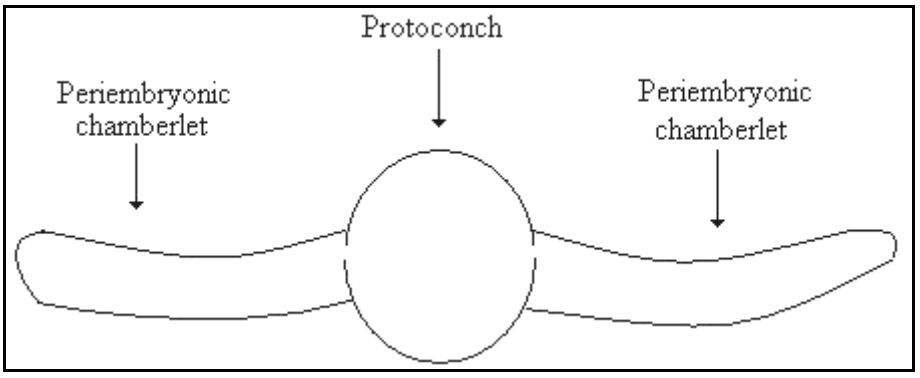

Fig.5: Schematic axial section goes through the embryonic area of the new species

Table 2: Comparison between *Orbitolina arciala* sp. nov. and the other species of the genus Orbitolina.
(*) After Schroeder and Neumann (1985)

Species	**Height (mm)**	**Diameter (mm)**	**Dia. of Protoconch (mm)**	**Dia. oft embryonic area (mm)**	**Apex**	**Number of Chambers**	**Number of Chambers per last mm of test**	**Base of the test**	**Flanks of the test**	**Shape of protoconch**	**Remarks**
* *O. duranddelgai* Schroeder	1.0 – 1.3	4.5	0.25 – 0.3	0.5 – 0.8	Bossed-pustular	40 – 50	22 – 24	Concave	Convex	Overturned bell	Protoconch projected with flat surface
* *Orbitolina qatarica* Henson	0.9 (max. 1.2)	5.8 (max. 6.3)	0.3	0.33 – 0.55	Pustular	Rarely recognized	Rarely recognized	Convex mostly	Regular convex	Bell-like shape	Protoconch projected with rounded surface
* *Orbitolina sefini* Henson	0.5 – 1.5	5.7 (max. 20)	0.2 – 0.25	0.5 – 0.72	Bossed	30 – 40	15 – 19	Convex	Slightly convex	Circular (coupe)	Biconvex disc
* *Orbitolina concava* (Lamarck)	1.1 – 1.4	6.7 (max. 9)	0.3 – 0.4	0.7 – 0.9	Flat	35 – 45	12 – 14	Concave	Regular	Irregular ellipse	Convexo-concave disc
Orbitolina arcuala sp. nov.	1.48 – 160	2.06 – 2.26	0.15	0.38	Rounded	32 – 38	13 – 20	Slightly concave	Straight	Globular	Low conico-concave

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