Solak A. Darmoian
Iraq National Oil Company
P. O. Box 184
Basrah, Iraq

Planktonic foraminifera from the Upper Cretaceous of southeastern Iraq: Biostratigraphy and systematics of the Heterohelicidae

ABSTRACT

On the basis of stratigraphic ranges of planktonic foraminifera, the Khasib, Tanuma, Sadi and Qurna Formations in southeastern Iraq are divided into five concurrent-range zones and are correlated with the European standard stages and with the similar zones or subzones in North Africa, Central Europe, the Gulf Coast region and the West Indies. Thirty-one species and subspecies of planktonic foraminifera, including one new species, belong to the family Heterohelicidae, and are herein described and illustrated. This is the first detailed account of the Upper Cretaceous foraminifera from Iraq.

INTRODUCTION

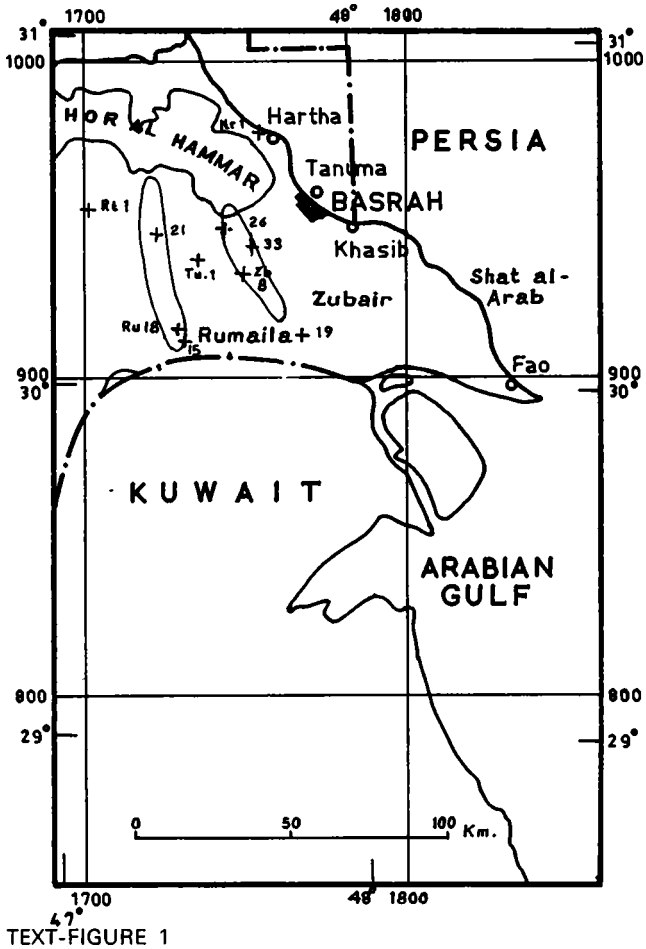
The area under consideration lies to the west of the Shat al-Arab, the river running from the confluence of the Tigris and Euphrates to the head of the Arabian Gulf. It is situated just to the southwest of the village of Zubair and about 25 kilometers southwest of the city of Basrah, in southeastern Iraq approximately between latitudes 30° 10′ and 30° 43′ N., and between longitudes 47° 03′ and 47° 42′ E. Except for the Jabal Sanam, a hill about 1525 meters in diameter at its base and 153 meters high, and the Jal El-Zor escarpment, the surface of the area is flat and is composed of sands and gravels of probable Upper Miocene to Pleistocene age (Macfadyen, 1938; Owen and Nasr, 1958; Al-Naqib, 1967).

Interest in the geology of southeastern Iraq has advanced in step with the increasing demand for oil. To date eighty or more wells have been drilled in the area by the Basrah Petroleum Company. Almost all have penetrated the whole Cretaceous, but nothing of consequence has been published on the micropaleontology of the succession. The only important paper is that of Owen and Nasr (1958), in which A. H. Smout provided a summarized range chart of "typical fossils of Basrah area". The same list of fossils was later repeated by Bellen, Dunnington, Wetzel and Morton (1959) and by Al-Naqib (1967).

The purpose of the present research is to investigate in detail the vertical distribution of the planktonic foraminifera in the Upper Cretaceous of southeastern Iraq and their use for biostratigraphic studies. As the results of the work were extensive, it was decided to present them in two separate papers. The first paper, which is here submitted, deals with the biostratigraphic zonation of the Khasib, Tanuma, Sadi and Qurna Formations on the basis of the planktonic foraminifera, and the systematic descriptions of the species of the family Heterohelicidae that were found in the same area. Descriptions of the species of other families of planktonic foraminifera will be presented in the second paper.

MATERIAL

By the courtesy of the Basrah Petroleum Company (BPC) and the Ministry of Oil and Minerals, Iraq, the writer had the opportunity to study material from ten oil wells drilled in southeastern Iraq by the above-mentioned company. Only BPC wells Zubair no. 8, Rumaila no. 18 and Ratawi no. 1 were used for the detailed micropaleontological studies. About 300 samples of rock cuttings, each weighing 25 grams dry weight, were treated by means of standard techniques differing according to the nature of the rock. In each case the residue was dried and passed through



TEXT-FIGURE 1
Map of southeastern Iraq showing well locations. Degrees are of N. latitude and E. longitude. The coordinates of the 100-km. grid are those of the Universal Mercator Transverse Grid System.

sieves of 30, 60, 90, 100, and 120 meshes, and, in rare cases, 200 mesh. All of the planktonic and benthonic foraminifera, Ostracoda, megafossils (if present), Bryozoa, charophytes and other fossils were picked out, sorted and counted. The planktonic foraminifera were sorted separately, described in detail and figured (except for the very rare and poorly preserved specimens where adequate photographing was found to be impossible). The identification is principally by comparison with previously published figures and descriptions, topotypes and/or holotypes, if available. All illustrations are stereoscan photographs taken by Dr. M. Muir and Mr. P. Grant of the Imperial College of Science and Technology, London, and printed by Studio Thomas, Baghdad.

STRATIGRAPHY OF ARUMA GROUP

The term "Aruma" was first employed by Steineke and Bramkamp (1952) for a single formation of Campanian–Maastrichtian age cropping out in Saudi Arabia. Later, Steineke, Bramkamp and Sander (1958) dated most of this formation as Maastrichtian on the basis of its ammonite content. Beyond the area of the type locality a similar stratigraphic sequence was divided by Owen and Nasr (1958) into several formations and placed together in the Aruma Group. In southeastern Kuwait the group comprised three formations (Gudair, Bahra and Tayarat) and in northeastern Kuwait and southeastern Iraq six formations (Khasib, Tanuma, Sadi, Hartha, Qurna and Tayarat).

The Khasib, Tanuma, Sadi, Hartha and Qurna Formations were first described by Owen and Nasr (*op. cit.*) in the BPC well Zubair no. 3, Universal Mercator Transverse Grid System coordinates 935.284 N. and 1751.649 E. Grid coordinates are shown in text-figure 1. The type locality of the Tayarat Formation is located at Jabal Tayarat in the Rutbah-Gaara area, about 34 kilometers south of the town of Rutbah in the Western Desert of Iraq. The first valuable reference with a detailed description of this formation of southeastern Iraq was that of Owen and Nasr (*op. cit.*). This was followed by those of Bellen, Dunnington, Wetzel and Morton (1959), Al-Naqib (1967) and Darmoian (MS.*a*). The stratigraphic classification proposed by Owen and Nasr (*op. cit.*) in southeastern Iraq is here adopted.

Text-figure 2 shows the stratigraphic succession and biostratigraphic divisions of the Upper Cretaceous rocks in southeastern Iraq, compiled from ten subsurface sections drilled by the Basrah Petroleum Company.

BIOSTRATIGRAPHY

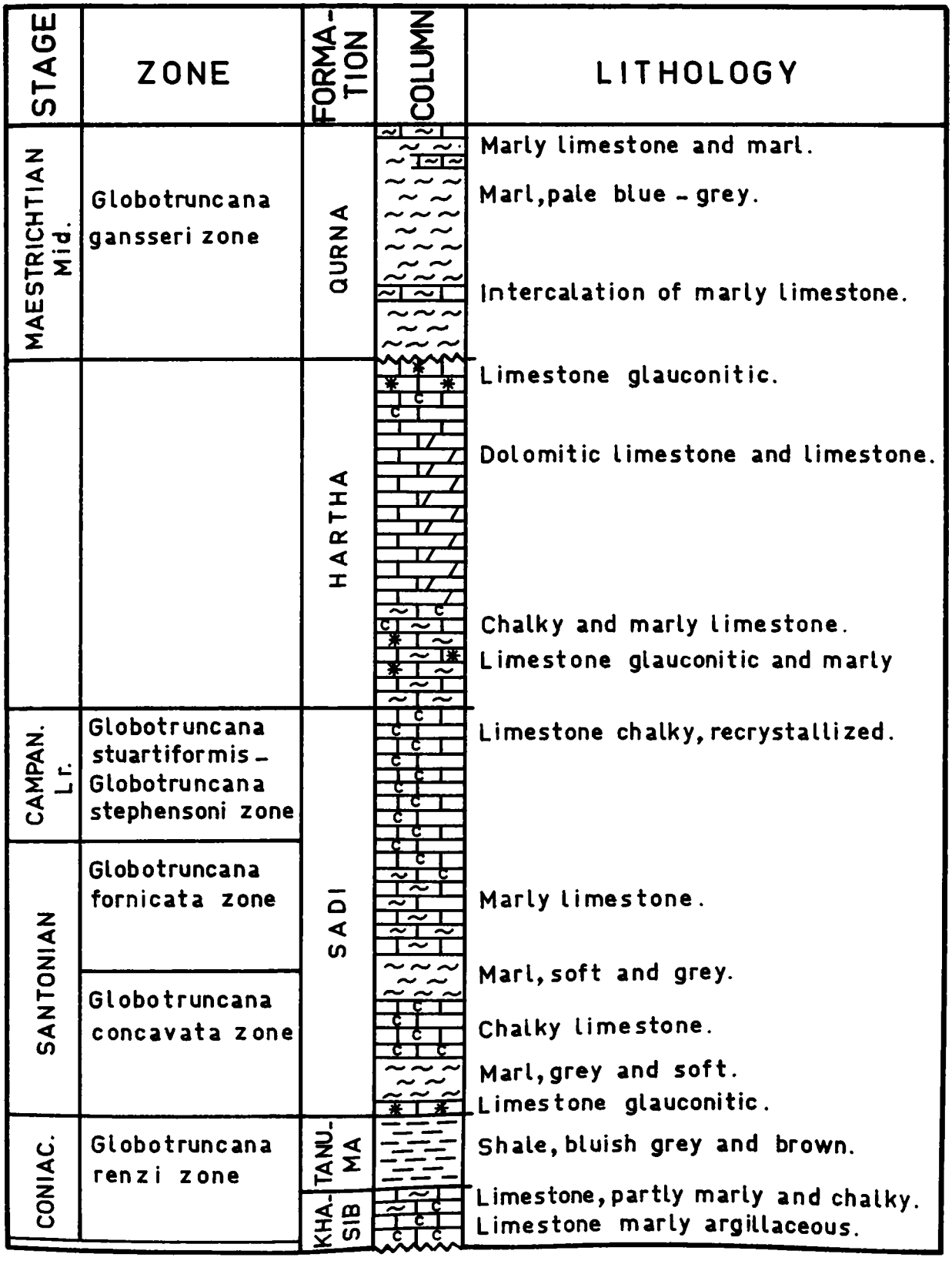
Nomenclature of zones

Darmoian (1972), with comparatively little material available at the time, attempted a micropaleontological zonation of the Upper Cretaceous succession in the Zubair field, southeastern Iraq, on the basis of the planktonic foraminifera. In that study the Khasib, Tanuma, Sadi, Hartha, Qurna and Tayarat Formations were subdivided into the following four concurrent range zones and two subzones:

1. *Globotruncana renzi-Heterohelix pseudoguembeliniformis* Zone
2. *Sigalia carpatica* Zone
   a. *Globotruncana concavata* Subzone
   b. *Globotruncana fornicata* Subzone
3. *Globotruncana stuartiformis-Globotruncana arca*-type *orientalis* Zone
4. *Globotruncana gansseri* Zone

Intervals which are either devoid of fossils, contain no planktonic guide species, or yield a wholly benthonic fauna were placed, according to their positions, among the four zones listed above.

The writer, in his establishment of the first planktonic foraminiferal zones in Iraq, did not consider these zones



TEXT-FIGURE 2
Stratigraphic succession of the Upper Cretaceous in southeastern Iraq compiled from ten subsurface sections drilled by the Basrah Petroleum Company.

worthy of a high level of confidence. With a larger number of samples from an expanded area available, it was later decided to redefine the Upper Cretaceous biostratigraphic zonation with planktonic foraminifera. In the present revised zonation, due to the rare occurrence and limited distribution of the species and subspecies of *Sigalia* Reiss, and the abundant and widely distributed occurrence of *Globotruncana concavata* (Brotzen) and *Globotruncana fornicata* (Plummer), the *Sigalia carpatica* Zone is omitted, and its *Globotruncana concavata* and *Globotruncana fornicata* Subzones are ranked as zones. The species *Heterohelix pseudoguembeliniformis* Darmoian, due to its scanty occurrence in the north and northwest of the area, was also found not sufficiently significant to be a zonal marker. Again, as *Globotruncana orientalis* El-Naggar was found to be different from *Globotruncana stephensoni* Pessagno, the *Globotruncana stuartiformis-Globotruncana arca*-type *orientalis* Zone was changed in name to the *Globotruncana stuartiformis-Globotruncana stephensoni* Zone.

The BPC well Zubair no. 8 is chosen in this study to be the standard section for all zones except the *Globotruncana stuartiformis-Globotruncana stephensoni* Zone. The BPC well Ratawi no. 1 is chosen as the standard section for the excepted zone. The newly revised zones, in ascending order, are as follows:

1. *Globotruncana renzi* Zone
2. *Globotruncana concavata* Zone
3. *Globotruncana fornicata* Zone
4. *Globotruncana stuartiformis-Globotruncana stephensoni* Zone
5. *Globotruncana gansseri* Zone

The term zone is in the sense of concurrent-range zone as defined in the Code of Stratigraphic Nomenclature (1961). The zones are correlated with the European standard stages and with some planktonic foraminiferal zones in North Africa, Central Europe, the western Gulf Coastal Plain and the West Indies.

Descriptions of zones

1. *Globotruncana renzi* Zone

The lower boundary of this zone is marked by the first appearances of *Globotruncana renzi* Gandolfi, *G. concavata primitiva* Dalbiez, *G. imbricata* Mornod, *Heterohelix moremani* (Cushman) and *H. pseudoguembeliniformis* Darmoian, which are restricted to this zone, and the appearance of *Heterohelix pulchra* (Brotzen), *H. reussi* (Cushman), *H. striata* (Ehrenberg), *Pseudotextularia plummerae* (Loetterle), *Globotruncana schneegansi* Sigal, *G. marginata* (Reuss), *G. fornicata fornicata* Plummer, *G. cretacea* (d'Orbigny), *G. bulloides* Vogler, *Praeglobotruncana inornata* (Bolli) and *Globigerinelloides asper* (Ehrenberg), which extend up into younger beds. The *Globotruncana renzi* Zone can be correlated with the Coniacian Stage of the European standard sequence from the joint occurrence of *Globotruncana renzi, G. concavata primitiva* and *G. imbricata*. The zone is correlative with the Coniacian of Tunisia (Salaj, 1969), the southern Alps of Italy (Casati and Tomai, 1969), the West Carpathians (Salaj and Samuel, 1966), Trinidad (Bolli, 1957) and the western Gulf Coastal Plain (Pessagno, 1967, 1969). It includes the whole of the Tanuma Formation and the main part of the Khasib Formation.

2. *Globotruncana concavata* Zone

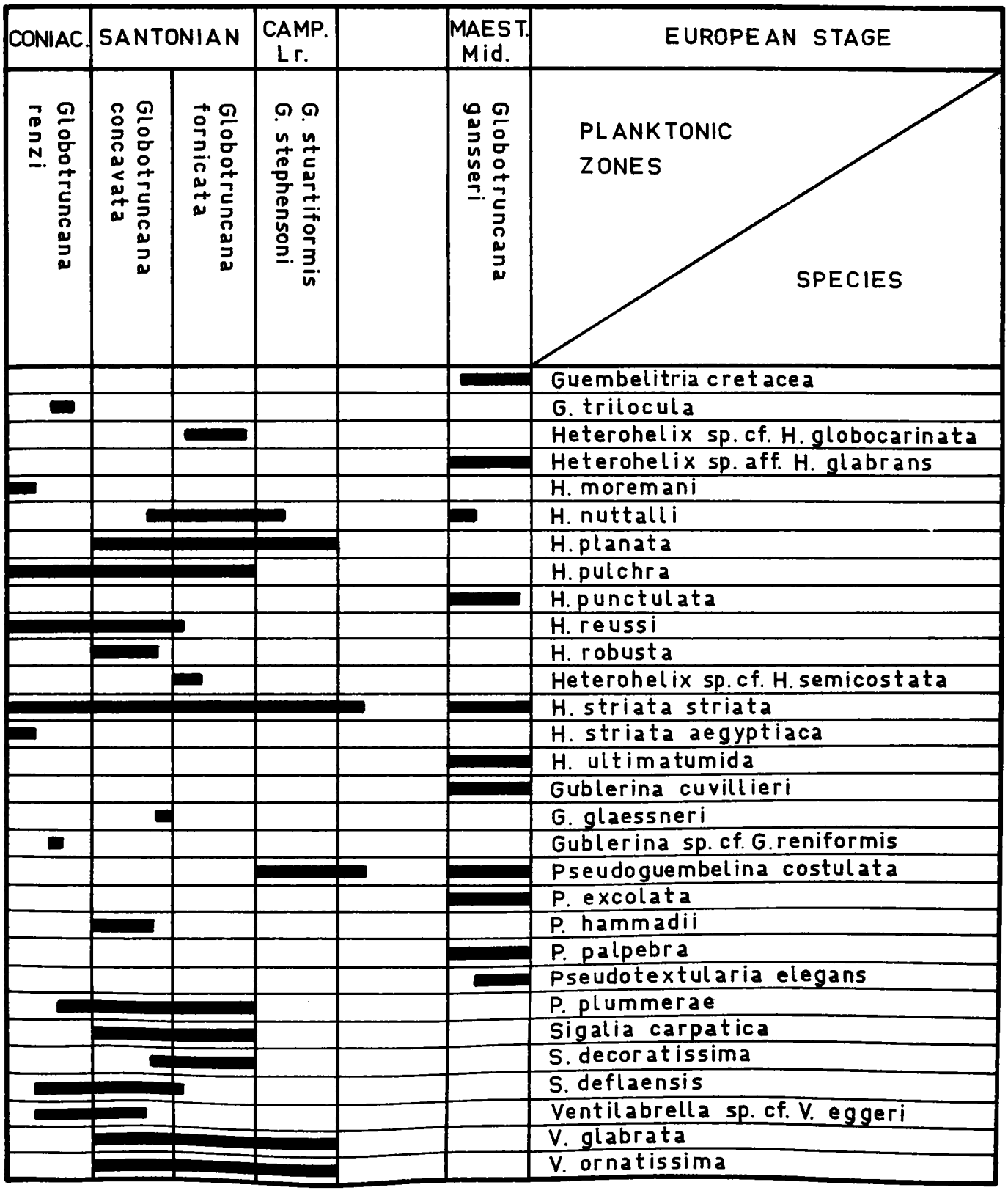
The lower boundary of this zone is marked by the first appearances of *Praeglobotruncana wilsoni* (Bolli) and *Sigalia carpatica* Salaj and Samuel, typically abundant *Globotruncana concavata concavata* (Brotzen) and *Sigalia deflaensis* (Sigal), and rare to common occurrences of *Globotruncana linneiana linneiana* (d'Orbigny), *G. angusticarinata* Gandolfi, *Sigalia decoratissima* (de Klasz), *Ventilabrella glabrata* Cushman, and *V. ornatissima* Cushman and Church.

Following Salaj (1969), Bolli (1957, 1966), van Hinte (1965), Pessagno (1967, 1969), and Casati and Tomai (1969), the *Globotruncana concavata* Zone in Tunisia, Trinidad, the western Gulf Coastal Plain and Italy is considered to be of lower Santonian age and to be succeeded by the *Globotruncana fornicata* Zone of upper Santonian age. In southeastern Iraq, the *Globotruncana concavata* Zone is positively correlated with that of the above-listed areas from the similarity in the appearance and disappearance of *Globotruncana concavata concavata* (Brotzen). The presence of this zone therefore suggests lower Santonian age for the lower part of the Sadi Formation.

3. *Globotruncana fornicata* Zone

The lower boundary of this zone is marked by the first abundant occurrence of *Globotruncana fornicata fornicata* Plummer, at which (or just below it) *Globotruncana concavata concavata* (Brotzen) and *Praeglobotruncana wilsoni* (Bolli) make their last appearances. The species *Sigalia deflaensis* (Sigal), *S. decoratissima* (de Klasz), *Heterohelix reussi* (Cushman) and *Globigerinelloides asper* (Ehrenberg) were found to die out at a short distance above the base of this zone, whereas *Globotruncana austinensis* Pessagno (1967) (not Gandolfi, 1955), *G. fornicata manaurensis* Gandolfi and *G. concavata carinata* Dalbiez make their first appearance at this level.

The extinction of *Globotruncana concavata concavata* (Brotzen) is considered by various authors (see above) as useful to define the top of the *Globotruncana concavata* Zone, which is also the base of the *Globotruncana fornicata* Zone.



TEXT-FIGURE 3
Distribution chart of the species of the foraminiferal family Heterohelicidae in the subsurface Upper Cretaceous of southeastern Iraq.

In southeastern Iraq, the *Globotruncana fornicata* Zone is positively identified with the *Globotruncana fornicata* Zone in Trinidad and the western Gulf Coastal Plain from the similarity in the extinction of *Globotruncana concavata concavata*, the abundant occurrence of *Globotruncana fornicata fornicata* and the first appearance of *Globotruncana stuartiformis* (Dalbiez). Besides, the times of the occurrence and disappearance of *Sigalia carpatica* Salaj and Samuel, *Globotruncana concavata carinata* Dalbiez and *G. fornicata manaurensis* Gandolfi in southeastern Iraq are contemporaneous with those in Tunisia and the West Carpathians.

In the above-mentioned areas, the *Globotruncana fornicata* Zone is considered to correlate with the upper Santonian of the European standard sequence. The zone therefore suggests upper Santonian age for the middle part of the Sadi Formation.

4. *Globotruncana stuartiformis–G. stephensoni* Zone

The lower boundary of this zone is placed at the first appearances of *Globotruncana stuartiformis* Dalbiez and *G. stephensoni* Pessagno. The boundary is also characterized by the first appearances of *Globotruncana rosetta rosetta* (Carsey), *G. gagnebini* Tilev, *G. subcircumnodifer* Gandolfi and *Pseudoguembelina costulata* (Cushman). The species *Globotruncana arca* (Cushman) and *Rugoglobigerina macrocephala macrocephala* Brönnimann were found to make their first appearances at a short distance below this boundary.

The upper boundary is placed at the contact between the Sadi and Hartha Formations. At this boundary *Globotruncana subspinosa* Pessagno and *G.* aff. *calcarata* Cushman first occur, and *Globotruncana bulloides* Vogler, *G. angusticarinata* Gandolfi, *Praeglobotruncana inornata* (Bolli), *Heterohelix planata* (Cushman), *H. pulchra* (Brotzen), *Ventilabrella glabrata* Cushman, and *V. ornatissima* Cushman and Church last occur.

The following planktonic foraminifera were reported by van Hinte (1965) from the lower half of the type Campanian, Aubeterre, France: *Globotruncana arca* (Cushman), *G. cretacea* (d'Orbigny), *G. fornicata* Plummer, *G. linneiana* (d'Orbigny), *G. marginata* (Reuss), *G.* cf. *G. plummerae* Gandolfi, *G. caliciformis* Vogler and *Heterohelix elegans* (Rzehak). He (*op. cit.*) stated: "The Aubeterre fauna with its *Globotruncana cretacea-marginata-linneiana* association and with early *G. caliciformis* in the *G. fornicata* population probably belongs to the *G. stuartiformis* Zone". The statement refers to his *Globotruncana stuartiformis* Zone, which is apparently equivalent to the lower two-thirds of the Campanian Stage. In southeastern Iraq the same planktonic foraminiferal association, with the exception of *Globotruncana caliciformis* Vogler and *Heterohelix elegans* (Rzehak) (= *Pseudotextularia elegans* (Rzehak)), is referred to the *Globotruncana stuartiformis–G. stephensoni* Zone.

Pessagno (1969) discussed the fauna of the type Campanian in detail. Like van Hinte, he arrived at the conclusion that the lowermost part of this stratotype is not older than his *Archaeoglobigerina blowi* Subzone, which is the equivalent of the lower Campanian Stage. He also suggested that *Globotruncana rosetta* (Carsey), *G. stephensoni* Pessagno, *G. stuartiformis* Dalbiez and *Pseudotextularia elegans* (Rzehak) limit the lower boundary of his *Globotruncana fornicata–stuartiformis* Assemblage Zone.

In the area under consideration, all of the above-named forms, except *Pseudotextularia elegans* (Rzehak), make their first appearance at the lower limit of the *Globotruncana stuartiformis–G. stephensoni* Zone. Consequently, the evidence presented above indicates that the zone is correlative with the lower part of the type Campanian. It is also correlative with the lower Campanian of Tunisia (Dalbiez, 1955), the West Carpathians (Salaj and Samuel, 1966), the southern Alps of Italy (Casati and Tomai, 1969), California (Douglas, 1969*a*, *b*), Trinidad (Bolli, 1957, 1966) and the western Gulf Coastal Plain (Pessagno, 1967, 1969). The presence of the *Globotruncana stuartiformis–G. stephensoni* Zone therefore suggests a lower Campanian age for the upper part of the Sadi Formation.

It was found difficult to define, on the basis of planktonic foraminifera, the age of the overlying Hartha Formation, owing to the poorly preserved state or to the complete absence of its planktonic fauna. However, the problem is solved by the presence of some important benthonic species belonging to the genera *Bolivinoides, Globorotalites, Stensioina, Quadrimorphina, Orbitoides* and others; and the position of this formation suggests that it is upper Campanian and lower Maastrichtian (Darmoian, MS.*b*).

5. *Globotruncana gansseri* Zone

The lower boundary of this zone is marked by the first appearance of *Globotruncana gansseri gansseri* Bolli, *G. aegyptiaca duwi* Nakkady and *Pseudoguembelina excolata* (Cushman). It is placed at the contact between the Hartha and Qurna Formations, above which a flood of planktonic foraminifera again occurs.

The *Globotruncana gansseri* Zone is characterized by the presence of *Globotruncana aegyptiaca* var. 1 Nakkady, *G. contusa* (Cushman), *G. leupoldi* Bolli, *Globigerinelloides messinae messinae* (Brönnimann), *Heterohelix punctulata* (Cushman), *H. ultimatumida* (White) and *Pseudotextularia elegans* (Rzehak). It is also char-

acterized by the occurrence of *Guembelitria cretacea* Cushman, *Gublerina cuvillieri* Kikoïne, *Globotruncana convexa* Sandidge and *Trinitella scotti* Brönnimann in its upper part. The *Globotruncana gansseri* Zone can be correlated with the middle Maastrichtian of the European standard stages by the joint occurrence of *Globotruncana gansseri gansseri*, *G. aegyptiaca duwi* Nakkady, *Guembelitria cretacea* Cushman and *Trinitella scotti* Brönnimann, and by the absence of *Abathomphalus mayaroensis* (Bolli), *Pseudotextularia fructicosa* (Egger), *Rugoglobigerina rotundata* (Brönnimann) and *Globigerinelloides messinae subcarinata* (Brönnimann). The zone is correlative with the *Globotruncana gansseri* Zone of the Gulf Coastal Plain (Pessagno, 1967, 1969), Trinidad (Bolli, 1957, 1966), Egypt (El-Naggar, 1966) and Libya (Barr, 1972). It is the equivalent of the Qurna Formation. The upwards extension of the *Globotruncana gansseri* Zone is not clear owing to the barren character (due to dolomitization) of the overlying Tayarat Formation.

SYSTEMATIC PALEONTOLOGY

The classification employed here, with slight modification, is taken from the "Treatise on Invertebrate Paleontology, Part C, Protista", Loeblich and Tappan (1964). Departures from this classification include the recognition of the genera *Sigalia* Reiss, 1957, and, following Brown (1969), *Ventilabrella* Cushman, 1928.

All illustrated specimens will be deposited in the Natural History Museum, Basrah, Iraq.

Order FORAMINIFERIDA Eichwald, 1830

Superfamily GLOBIGERINACEA Carpenter, Parker and Jones, 1862
Family HETEROHELICIDAE Cushman, 1927
Subfamily GUEMBELITRIINAE Montanaro Gallitelli, 1957
Genus GUEMBELITRIA Cushman, 1933

Guembelitria cretacea Cushman
Gümbelitria cretacea CUSHMAN, 1933, pp. 37–38, pl. 4, fig. 12a–b. *Güembelitria cretacea* Cushman. — MONTANARO GALLITELLI, 1957, p. 136, pl. 31, fig. 1a–b. — OLSSON, 1960, pp. 27–28, pl. 4, fig. 8. — PERLMUTTER and TODD, 1965, p. 13, pl. 2, fig. 8. — PESSAGNO, 1967, p. 258, pl. 87, figs. 1–3.

Remarks: A few poorly preserved, triserial, rapidly tapering specimens with highly arched apertures and smooth tests are here referred to *Guembelitria cretacea* Cushman.

Occurrence: Rare in the Qurna Formation, *Globotruncana gansseri* Zone. BPC wells Zubair no. 8 and Ratawi no. 1. *Previous records of occurrence:* Texas and Arkansas, middle Maastrichtian; New Jersey, upper Maastrichtian; New York, Maastrichtian. All reliable records show that the present species ranges throughout the Maastrichtian but is largely confined to its middle and upper parts.

Guembelitria trilocula (Marie)
Plate 1, figure 1

Pseudotextularia trilocula MARIE, 1941, p. 186, pl. 28, fig. 278a–d

Occurrence: Rare in the Tanuma Formation, *Globotruncana renzi* Zone. BPC well Zubair no. 8.

Previous record of occurrence: The Campanian of the Paris Basin.

Subfamily HETEROHELICINAE Cushman, 1927
Genus HETEROHELIX Ehrenberg, 1843

Heterohelix sp. cf. ***H. globocarinata*** (Cushman)
Plate 1, figure 2

Cf. *Gümbelina globocarinata* CUSHMAN, 1938, pp. 10–11, pl. 2, figs. 4a–b, 5.

Remarks: According to Pessagno (1967), who examined the holotype and the two paratype slides, *Heterohelix globocarinata* (Cushman) is characterized by its inflated final chambers, carinate early portion, large and low-arched aperture, and by the finely striate nature of its test. The specimens encountered in this study exhibit all of the above characters except the early peripheral keel.

Occurrence: Rare in the Sadi Formation, *Globotruncana fornicata* Zone. BPC well Zubair no. 8.

Previous records of occurrence: Texas, upper Taylor Marl; Alabama, Arkansas, Mississippi, Austin–Navarro age.

Heterohelix sp. aff. ***H. glabrans*** (Cushman)
Plate 1, figure 7

Aff. *Gümbelina glabrans* CUSHMAN, 1938, p. 15, pl. 13, figs. 1–2.

Occurrence: The species occurs rarely in the Qurna Formation, *Globotruncana gansseri* Zone. BPC well Zubair no. 8.

Heterohelix moremani (Cushman)
Plate 1, figure 3

Gümbelina moremani CUSHMAN, 1938, p. 10, pl. 2, figs. 1a–b, 2 (not fig. 3). — CUSHMAN, 1946, p. 103, pl.44, figs. 15–16. *Heterohelix moremani* (Cushman). — PETRI, 1962, pp. 88–89, pl. 11, figs. 1, 2a–b. — PESSAGNO, 1967, p. 260, pl. 89, figs. 1–2. — BROWN, 1969, pp. 35–36, pl. 1, fig. 8.

Remarks: Cushman (1938) first discovered this species. In his description he pointed out that the surface of *Heterohelix moremani* is smooth. This was confirmed by Pessagno (1967). Brown (1969) showed very faint longitudinal costae in *H. moremani*. He stated: "All Heterohelicids have striae on their test with a possible exception of the most primitive *Heterohelix washitensis* (Tappan) Late Albian–Cenomanian form".

It is possible that all of Pessagno's *H. moremani* specimens were from Cenomanian strata, as were Cushman's holotype and paratypes. Actually, Pessagno (*op. cit.*)

himself stated: "It is conceivable that specimens of *H. moremani* occurring in the Turonian portion of the Eagle Ford group have been reworked from Cenomanian Eagle Ford strata".

A specimen figured and described by Cushman (1938, pl. 2, fig. 3; 1946, pl. 44, fig. 17) as a paratype of *G. moremani* shows an extra chamber between the last two and most probably belongs in *Ventilabrella ventilabrelliformis* (van der Sluis). Furthermore, none of the forms figured by Pessagno (1967, pl. 48, figs. 7–11) is similar to Cushman's holotype. These forms may well belong in *H. pseudoguembeliniformis* Darmoian.

Occurrence: Rare in the Khasib Formation, *Globotruncana renzi* Zone. BPC well Zubair no. 8; BPC well Ratawi no. 1.

Previous records of occurrence: Records from the Gulf Coastal Plain, U.S.A., and Brazil show that *H. moremani* ranges from early Cenomanian to lower Santonian.

Heterohelix nuttalli (Voorwijk)
Plate 1, figures 4–6

Gümbelina nuttalli VOORWIJK, 1937, p. 192, pl. 2, figs. 1–9.
Pseudotextularia nuttalli (Voorwijk). — SALAJ and SAMUEL, 1966, p. 232, pl. 37, fig. 10.

Remarks: Heterohelix nuttalli was originally described by Voorwijk (1937) from Habana, Cuba. He depicted nine poorly drawn specimens but gave neither a definite type locality, type specimens, nor the location of the depository.

H. nuttalli differs from both *Pseudotextularia elegans* (Rzehak) and *P. plummerae* (Loetterle) in its smaller test, the restriction of the compression of the chambers to one side only, and the lack of the *Pseudotextularia* type of reniform chambers in peripheral view.

Occurrence: Rare in the Sadi Formation and in the lower part of the Qurna Formation, upper part of the *Globotruncana concavata* Zone to lower part of the *Globotruncana stuartiformis–G. stephensoni* Zone and lower part of the *Globotruncana gansseri* Zone. BPC well Zubair no. 8.

Previous record of occurrence: West Carpathians, Slovakia, upper Campanian and Maastrichtian.

Heterohelix planata (Cushman)
Plate 1, figure 8

Gümbelina planata CUSHMAN, 1938, p. 12, pl. 2, figs. 13–14. — CUSHMAN, 1946, p. 105, pl. 45, figs. 6–7.
Heterohelix planata (Cushman). — MONTANARO GALLITELLI, 1957, p. 20, pl. 2, figs. 9–10. — PESSAGNO, 1967, p. 261, pl. 86, figs. 3–4; pl. 89, figs. 6–7.
Heterohelix pulchra (Brotzen). — PESSAGNO, 1962, p. 385, pl. 1, fig. 3. — GOVINDAN, 1972, pp. 168–169, pl. 1, figs. 9–10.

Remarks: The supplementary apertures which are clearly observable in most specimens of *Heterohelix planata* are not covered by apertural flaps, and thus the species does not belong in *Pseudoguembelina* Brönnimann and Brown.

Occurrence: Abundant in the Sadi Formation, *Globotruncana concavata* Zone to *Globotruncana stuartiformis–G. stephensoni* Zone. BPC wells Rumaila no. 18 and Ratawi no. 1.

Previous records of occurrence: Texas, upper Campanian and middle Maastrichtian; Puerto Rico, Santonian to lower Maastrichtian; Italy, Campanian and Maastrichtian.

Heterohelix pulchra (Brotzen)
Plate 1, figures 9–15

Gümbelina pulchra BROTZEN, 1936, p. 121, pl. 9, figs. 2a–b, 3a–b.
Gümbelina pseudotessera CUSHMAN, 1938, p. 14, pl. 2, figs. 19–21.
Guembelina pulchra Brotzen. — HOFKER, 1956*b*, p. 77, pl. 9, fig. 69.
Heterohelix pulchra (Brotzen). — MONTANARO GALLITELLI, 1957, p. 134, pl. 31, fig. 20. — TAKAYANAGI, 1965, p. 197, pl. 20, fig. 3a–b. — ANSARY and TEWFIK, 1966, p. 40, pl. 3, fig. 8a–b. — BANDY, 1967, p. 23, text-fig. 12(7). — PESSAGNO, 1967, p. 262, pl. 87, fig. 4 — DOUGLAS, 1969*a*, p. 158, pl. 11, figs. 3, 14.
Heterohelix cf. *planata* (Cushman). — TAKAYANAGI, 1965, p. 197, pl. 20, fig. 2.
Heterohelix dentata STENESTAD, 1969, p. 658, pl. 1, figs. 9–10, 14; pl. 3, fig. 4; text-fig. 12a–c.

Description: Test small to medium, biserial, moderately to strongly compressed, rapidly tapering; maximum breadth at the last pair of chambers; median line usually zigzag and deeply depressed; periphery lobate throughout; chambers in 5–7 pairs, reniform, regularly inflated, wider than high, increasing in width towards the apertural end; last pair of chambers 2½–3½ times wider than high and constricted near aperture; sutures slightly curved, depressed in early part, curved and strongly depressed in last growth stages; wall calcareous, perforate; surface smooth; aperture a high arch on inner margin of last chamber.

Main variations:

1. In apertural view, chambers either narrowly or acutely rounded.

2. Median line either moderately or strongly depressed, in rare cases showing a *Gublerina*-like appearance.

3. Chambers reniform to roughly rectangular, increasing rather rapidly in size, either biserially arranged throughout or last one or two pairs showing a *Ventilabrella*-like appearance.

4. In well-developed specimens, final chambers usually distinctly set apart by large and depressed triangular

areas; in some rare cases, chambers showing flaplike projections.

Remarks: The constant characters of this species are reniform, wider than high, inflated chambers; compressed test; depressed sutures; high-arched aperture and smooth surface.

Heterohelix pulchra was first described by Brotzen (1936) as *Gümbelina pulchra* from the lowermost Senonian of Eriksdal, Sweden. He (*op. cit.*) clearly illustrated both the regularly arranged biserial chambers and the *Gublerina*-like appearance of the last one or two pairs in the microspheric forms. So far, no subsequent authors have recorded forms showing such a peculiar character. Takayanagi (1965, p. 197) was the first to realize that such a tendency can be used for phylogenetic purposes, and he stated: "Thus this species appears to be close to *Gublerina* in morphological character . . . further research on its variation may furnish a key to the genetical interrelationship between *Heterohelix* and *Gublerina*".

Pessagno (1967, p. 262) assigned Brotzen's microspheric *H. pulchra* form to the genus *Planoglobulina* Cushman without comment. In southeastern Iraq, rare specimens showing proliferation of three reniform chambers in the final stage were found, and considered to be abnormal growths of *H. pulchra* (Brotzen).

Cushman (1938) noted small, depressed, triangular areas between the chambers of *Heterohelix reussi* (Cushman), *H. planata* (Cushman) and *Gümbelina pseudotessera* Cushman (= *H. pulchra* (Brotzen)). He also mentioned the presence of lateral flanges in the latter two species. The flanges run out onto the preceding chambers in *H. planata* and are restricted to the aperture in *G. pseudotessera*. Brönnimann and Brown (1953) interpreted these triangular areas as the flaps covering accessory apertures. Pessagno (1967) rejected this interpretation.

Recently, Brown (1969) in "Heterohelicidae Cushman, 1927, amended" removed many of the ambiguities regarding the above features. He came to the conclusion that, "the depressed areas are merely the imperforate flaps of the primary apertures extending down both its sides. Later, in Campanian time in a descendant, *H. pseudotessera* (Cushman), the flaps become relatively enlarged and elongated forming depressed panels or gussets". He added "by tension at the front on faces of the primary chambers a divergent biserial arrangement of primary chambers is produced".

In the area under study, forms with triangular depressed areas, flaplike projections and a strongly deepened *Gublerina*-like median line were found and considered different transitional stages in *H. pulchra's* development. *Heterohelix pulchra* differs from *H. planata* in its well-developed, reniform, much wider than high chambers and smooth test.

The form described by Stenestad (1969) as *Heterohelix dentata*, n. sp., is a synonym of *H. pulchra* (Brotzen). It was said to differ from the latter species in the less compressed nature of its test, the shape of its early and late chambers, the slightly keeled to almost straight initial margins and its surface ornamentation. The writer considers that the degree of compression has neither specific nor taxonomic importance. The initial coiling is induced by physical rather than genetic factors; thus, certain species of *Heterohelix* and *Pseudotextularia* may or may not have initial coils (see also Hofker (1957)). For this reason, *Gümbelina* Cushman is considered a junior synonym of *Heterohelix* Ehrenberg (Montanaro Gallitelli, 1957; Loeblich and Tappan, 1961*b*). Furthermore, in some varieties of *H. pulchra* it is almost usual to find tests showing the last one or two pairs of chambers lying over each other and inclined to the direction of the biseriality, giving the test margins a serrate or (as described by Stenestad) dentate appearance. Such forms are at their extreme limit of variability and occur in various species of *Heterohelix*. Aside from the fact that the keel is not a stable character in *H. pulchra*, and that the surface ornamentation, considered in isolation, is not enough for specific separation, the figured holotype of *H. dentata* lacks surface markings, and its sides are clearly indented throughout.

Occurrence: Abundant in the Khasib and Tanuma Formations and in the lower part of the Sadi Formation, *Globotruncana renzi* Zone to *Globotruncana fornicata* Zone. BPC wells Zubair no. 8, Rumaila no. 18 and Ratawi no. 1.

Previous records of occurrence: Gulf Coastal Plain and Western Interior Basin of U.S.A., Coniacian–Maastrichtian; southern Limburg, Campanian; Italy, Campanian–Maastrichtian; France, Maastrichtian; Sweden, Coniacian–Santonian; Denmark, upper Maastrichtian; Puerto Rico, Santonian–Maastrichtian; Mexico, Campanian–Maastrichtian; Egypt, Maastrichtian.

Heterohelix punctulata (Cushman)
Plate 2, figure 1

Gümbelina punctulata CUSHMAN, 1938, p. 13, pl. 2, figs. 15–16. *Heterohelix punctulata* (Cushman). — ANSARY and TEWFIK, 1966, p. 40, pl. 3, fig. 6a–b. — PESSAGNO, 1967, pp. 262–263, pl. 86, figs. 7–10 (see synonymy).

Remarks: Heterohelix punctulata was first described by Cushman (1938) as *Gümbelina punctulata* from the Taylor Marl of Texas. The species was placed in *Pseudoguembelina* by Brönnimann and Brown (1953) owing to its possession of sutural supplementary apertures covered by tiny valves or flaps.

In southeastern Iraq, the majority of the specimens possess supplementary apertures, but no true apertural flaps were found. Thus, following Pessagno (1967), who stated: "Inasmuch as *Heterohelix* commonly shows sutural supplementary apertures, it is only the possession of such distinctive apertural flaps that separates *Pseudoguembelina* from *Heterohelix*," all forms comparable to this species were placed under *Heterohelix*.

Occurrence: Rare in the Qurna Formation, *Globotruncana gansseri* Zone. BPC wells Zubair no. 8 and Ratawi no. 1.

Previous records of occurrence: Texas, Campanian–Maastrichtian; Cuba, late Maastrichtian; Puerto Rico, Campanian–Maastrichtian; Mexico, Campanian–Maastrichtian; Egypt, Campanian–Maastrichtian.

Heterohelix reussi (Cushman)
Plate 1, figures 16–20

Gümbelina reussi CUSHMAN, 1938, p. 11, pl. 2, figs. 6a–9b. — CUSHMAN, 1946, p. 104, pl. 44, figs. 18a–b, 19.
Heterohelix reussi (Cushman). — ANSARY and TEWFIK, 1966, pp. 40–41, pl. 3, fig. 5a–b. — PESSAGNO, 1967, p. 263, pl. 85, figs. 1–9; pl. 86, figs. 1–2.

Remarks: Heterohelix reussi is distinguished by its slightly compressed chambers, the presence of triangular depressions between the adult chambers, and its finely striate surface.

It was first described by Cushman (1938) from the lower Austin Chalk, Texas, and the Pläner Marl, Bohemia. He stated that its surface is smooth and finely perforate, but Pessagno (1967), who examined the holotype and paratypes, demonstrated the presence of fine costae.

In southeastern Iraq, as in Texas, Arkansas and Mexico, *H. reussi* possesses fine costae wherever it has been observed, except in places where preservation was poor.

Occurrence: Rare in the Khasib and Tanuma Formations and in the lower part of the Sadi Formation, *Globotruncana renzi* Zone to the lower part of the *Globotruncana fornicata* Zone. BPC wells Zubair no. 8, Rumaila no. 18 and Ratawi no. 1.

Previous records of occurrence: All reliable records from Texas, Arkansas, Mississippi, Bohemia, Mexico and Egypt show that *H. reussi* ranges from Turonian to Maastrichtian.

Heterohelix robusta Stenestad
Plate 2, figure 2

Pseudoguembelina palpebra Brönnimann and Brown. — PESSAGNO, 1967, p. 267, pl. 89, figs. 3–4 (not pl. 78, figs. 1–3).
Pseudoguembelina sp. aff. *P. palpebra* Brönnimann and Brown. — PESSAGNO, 1967, p. 267, pl. 89, figs. 5, 12–14.
Heterohelix robusta STENESTAD, 1969, pp. 658–659, pl. 1, fig. 17; pl. 2, fig. 3; text-fig. 13a–c.

Remarks: A few biserial, thick specimens with early slightly and later moderately depressed sutures; large, globular chambers increasing rapidly in size; and coarse longitudinal costae are here assigned to *Heterohelix robusta* Stenestad. Pessagno (1967) described as *Pseudoguembelina palpebra* Brönnimann and Brown, and *P.* sp. aff. *P. palpebra* Brönnimann and Brown, forms which belong in this species. They show no trace of supplementary apertures or apertural flaps, but have large, globular chambers, which increase rapidly in size as added, and coarse, longitudinal costae.

Occurrence: Rare in the lower part of the Sadi Formation, *Globotruncana concavata* Zone. BPC well Zubair no. 8.

Previous record of occurrence: Heterohelix robusta Stenestad was originally described from the upper Campanian and the lowermost part of the Maastrichtian of the White Chalk of the Danish Embayment.

Heterohelix sp. cf. ***H. semicostata*** (Cushman)
Plate 2, figure 3

Cf. *Gümbelina semicostata* CUSHMAN, 1938, p. 16, pl. 3, fig. 6.
Heterohelix sp. cf. *H. semicostata* (Cushman). — RASHEED and GOVINDAN, 1968, p. 80, figs. 10–11.

Remarks: This species is very close to typical *Heterohelix semicostata* (Cushman). However, it shows no trace of a keel in its early growth stages.

Occurrence: Very rare in the lower part of the Sadi Formation, *Globotruncana fornicata* Zone. BPC well Zubair no. 8.

Previous record of occurrence: The typical *Heterohelix semicostata* was described by Cushman (1938) from the upper Taylor Marl, Texas.

Heterohelix striata striata (Ehrenberg)
Plate 2, figures 4–7

Textularia striata EHRENBERG, 1840, p. 135, pl. 4, figs. 1α, 2α, 3α.
Textularia globulosa EHRENBERG, 1840, p. 135, pl. 4, figs. 1β, 2β, 4β, 5β, 7β, 8β.
Gümbelina striata (Ehrenberg). — EGGER, 1900, p. 33, pl. 14, figs. 5–7, 10–11, 37–39 (not Cushman, 1944, p. 91, pl. 14, fig. 4a–b; not Cushman, 1949, p. 7, pl. 3, fig. 24; not LeRoy, 1953, p. 34, pl. 5, figs. 13–14; pl. 6, figs. 6–7.
Not *Guembelina striata* (Ehrenberg). — CUSHMAN, 1931, p. 43, pl. 7, figs. 6a–b, 7.
Pseudoguembelina striata (Ehrenberg). — BRÖNNIMANN and BROWN, 1953, p. 154, text-fig. 6.
Heterohelix striata (Ehrenberg). — OLVERA, 1959, pp. 71–72, pl. 2, figs. 4, 8. — TAKAYANAGI, 1965, pp. 198–199, pl. 20, fig. 4a–b (see synonymy up to 1956). — ANSARY and TEWFIK, 1966, p. 41, pl. 3, fig. 3a–b. — PESSAGNO, 1967, p. 264, pl. 78, figs. 4–5; pl. 88, figs. 3–7. — DOUGLAS, 1969*a*, pp. 159–160, pl. 11, figs. 4, 7–8. — FUNNELL, FRIEND and RAMSAY, 1969, p. 21, pl. 1, figs. 3–4; text-fig. 2a–b. — STENESTAD, 1969, pp. 635–654, pl. 1, fig. 4; pl. 2, figs. 1, 1a–b; text-fig. 1a–c.
Heterohelix globulosa (Ehrenberg). — TAKAYANAGI, 1965, pp.

198–199, pl. 20, fig. 1a–b (see synonymy). — DOUGLAS, 1969*a*, pp. 157–158, pl. 11, fig. 12a–b.

Description: Test small to medium-sized, biserial, expanding moderately; maximum breadth at the last pair of chambers; median line straight to slightly bent; periphery moderately lobate; chambers in 6–9 pairs; early chambers small, subglobular; later chambers increasingly inflated; sutures deeply depressed, almost straight; wall calcareous, perforate; surface ornamented by curved striae; aperture a lunate opening on the inner margin of the last chamber.

Main variations:

1. Chambers either globular throughout or initially subglobular and later globular. The ultimate pair of chambers is either well developed, constituting ¼–⅓ of the test, or reduced to equal to or smaller than the penultimate pair.
2. Striation of the surface either moderate, fine or very delicate; sometimes thickened, giving to the test a *Pseudoguembelina costulata*-like appearance. Ornamentation either confined to the early part of the test or occurring throughout. In some specimens the ultimate pair of chambers is exceptionally smooth.

Remarks: Heterohelix striata striata was first described by Ehrenberg (1840) as *Textularia striata*. His type specimens came from four different geographical locations: (1) Puszkary, opposite Grodno, on the bank of the Memel River, then in Poland; (2) Jutland, Denmark; (3) Rügen Island, Pomerania, Germany; (4) Hamam Farun Mountains, Sinai Peninsula. Neither the type locality nor the type specimen was designated. Pessagno (1967) selected figure 2a and the corresponding specimen as lectotype figure and lectotype specimen of *Textularia striata* Ehrenberg respectively, and figures 1a, 1a′ and 3a, and their corresponding specimens, as paralectotypes.

Pessagno (*op. cit.*) regarded the specimens figured by Berggren (1962, figures 1a–5b) from the Kjolby Gaard Marl, Jutland, Denmark, as topotypes of *Heterohelix striata* (Ehrenberg). He furthermore designated Kjolby Gaard, Jutland, as the type locality and the Kjolby Gaard Marl as the type lithic unit of Ehrenberg's species.

Textularia striata Ehrenberg is much closer to *Heterohelix americana* (Ehrenberg) than to any other species of *Heterohelix*. Both show similar chambers and sutural characters, and parallel surface striation perpendicular to the septa. The only noticeable difference is the lack of early coiling in *T. striata*.

Egger (1900) described *Gümbelina* as a new genus to include *T. striata* Ehrenberg, but Montanaro Gallitelli (1957) affirmed the synonymity of *Gümbelina* with *Heterohelix*. As *Heterohelix* has the priority, she retained it. In fact, *Gümbelina* Egger, 1900, was found to be a junior homonym of *Gümbelina* Kuntz, 1895, and thus doubly invalidated (Loeblich and Tappan, 1961*b*).

Ehrenberg (1840) described as *Textularia globulosa* five other specimens similar to *H. striata striata*. Again, neither the type locality nor the type specimen was designated. His specimens came from five different geographical locations: (1) Jutland, Denmark; (2) Gravesend, England; (3) Meudon, near Paris, France; (4) Mokattam Hills, near Cairo, Egypt; (5) Thebes in upper Egypt, *Nummulites* limestone of the Pyramids. If one judges from the figured specimens, the only noticeable difference between *H. striata striata* and this species is the lack of surface ornamentation in the latter.

Cushman (1938) reported the presence of surface ornamentation in *Heterohelix globulosa* (Ehrenberg). He separated this species from *H. striata striata* by its weakly developed faint surface ornamentation and the smaller size of its test.

Berggren (1962), concerning *H. striata striata* from the Maastrichtian Stage of southern Scandinavia, stated: "This species is very similar to *H. globulosa* (Ehrenberg), differing only in the nature of the ornament. The author has observed an apparent gradation from tests with moderately developed striae to tests with no apparent striae."

McGugan (1964) found that some of the *H. globulosa* specimens from the upper Campanian of British Columbia, Canada, have traces of longitudinally arranged costae or lineation. Takayanagi (1965) found faint striae on the walls of specimens of *H. globulosa* from the Coniacian–Campanian of California. The occurrence of faintly striate *H. globulosa* in California was later confirmed by Douglas (1969*a*).

Brown (1969) stated: "Any ornamentation, fine or coarse, exhibited on the Heterohelicid test is herein referred to as striae." This means that any specimen of *Heterohelix* of *H. globulosa* type with either fine or coarse striate ornamentation is *H. striata*. Specimens showing different strengths of striation were illustrated under *H. striata* (Ehrenberg) in the "Catalogue of Index Smaller Foraminifera, Volume 1," compiled by Ellis, Messina, Charmatz and Ronai (1968).

Stenestad (1969), in "The Genus *Heterohelix* (1843)," found very few Danish Santonian specimens of *Heterohelix* completely smooth. He stated: "The Danish specimens called *H. globulosa* are actually faintly and indistinctly striate specimens of *H. striata* . . . ." He (*loc. cit.*) also examined a few hypotypes of *H. globulosa* from the Kemp Clay, Texas, and found that they all are slightly striate.

In southeastern Iraq, the writer failed to find a morphologic basis for the separation of these two species. Both have globular chambers, small to medium test size, striate surface ornamentation and similar stratigraphic ranges. If entirely smooth forms (*H. striata* forma *globulosa*) are actually present in sequences younger than the Turonian Stage, they most probably represent the early growth stages in the ontogeny leading to the typical striate forms of *H. striata*. This writer believes that lack of surface ornamentation of specimens in their early growth stages fails to represent any taxonomic value. *Heterohelix globulosa* (Ehrenberg) is therefore here regarded as a synonym of *Heterohelix striata* (Ehrenberg).

Nakkady (1949, 1950) recorded the occurrence of *Gümbelina striata* (Ehrenberg), *G. striata* var. *compressa* Nakkady, n. var., and *G. globulosa* (Ehrenberg) from the Maastrichtian–Danian succession of six widely separated sections in Egypt. The examination of these specimens in the British Museum of Natural History, London, showed that (1) the slide labeled *G. striata* (Ehrenberg) contains 15 specimens of Heterohelicidae belonging in 4 different species: *Heterohelix striata* (Ehrenberg), *H. ultimatumida* (White), *Pseudoguembelina excolata* (Cushman) and *P. palpebra* Brönnimann and Brown; (2) the slide labeled *G. striata* var. *compressa*, n. var., contains 16 specimens belonging in 6 different species: *Heterohelix striata* (Ehrenberg), *H. ultimatumida* (White), *Pseudoguembelina excolata* (Cushman), *P. costulata* (Cushman), *P. palpebra* Brönnimann and Brown and *Pseudotextularia elegans* (Rzehak); and (3) the slide labeled *G. globulosa* (Ehrenberg) contains 20 specimens belonging in 2 different species: *Heterohelix striata* (Ehrenberg) with faint surface striation and *H. reussi* (Cushman) with pronounced triangular depressions between the adult chambers.

Occurrence: Abundant in the Khasib and Tanuma Formations and in the lower half of the Sadi Formation. Rare in the lowermost part of the Hartha Formation and in the whole of the Qurna Formation, *Globotruncana renzi* Zone to *Globotruncana fornicata* Zone and also *Globotruncana gansseri* Zone. BPC wells Zubair no. 8, Rumaila no. 18 and Ratawi no. 1.

Previous records of occurrence: According to the above references, *Heterohelix striata* ranges from Campanian to Maastrichtian in various parts of Europe, North America, the Caribbean region, the West Indies, Australia and North Africa; from Santonian to Maastrichtian in the U.S.S.R., Denmark and Iran; from Coniacian to Maastrichtian in the Gulf Coast and the Western Interior Basin of the U.S.A. and in Egypt; from Turonian to Maastrichtian in California; and from the Cenomanian of Egypt.

Heterohelix striata aegyptiaca Ansary and Tewfik
Plate 2, figures 8–9

Heterohelix striata (Ehrenberg) var. *aegyptiaca* ANSARY and TEWFIK, 1966, p. 41, pl. 3, fig. 2a–b.

Remarks: A few rapidly tapering specimens with a slightly compressed test and a rapid increase in size of chambers, the last two of which constitute the greater proportion of the test, are here referred to *Heterohelix striata aegyptiaca* Ansary and Tewfik. The specimens have 5 pairs of inflated chambers and a finely striate test surface.

Occurrence: Limited to the Khasib Formation, *Globotruncana renzi* Zone. BPC well Rumaila no. 18.

Previous record of occurrence: The subspecies was originally described as a variety from the Campanian and Maastrichtian of Ezz El Orban, Egypt.

Heterohelix ultimatumida (White)
Plate 2, figures 10–13

Gümbelina ultimatumida WHITE, 1929, p. 39, pl. 4, fig. 13a–b. *Heterohelix ultimatumida* (White). — PETRI, 1962, pp. 89–90, pl. 11, figs. 3–4, ?5, (not figs. 6–8). — KAVARY and FRIZZELL, 1964, pp. 62–63, pl. 13, fig. 3. — ANSARY and TEWFIK, 1966, pl. 3, fig. 1a–b. — SALAJ and SAMUEL, 1966, p. 225, pl. 37, fig. 19. — PESSAGNO, 1967, p. 264 (no figure) and synonymy.

Remarks: Heterohelix ultimatumida (White) differs from *Heterohelix striata striata* (Ehrenberg) in the greatly inflated and globular nature of the last one or two pairs of chambers; and from *Heterohelix striata* forma *globulosa* in having faint but well-developed striae. The morphologically similar *Heterohelix* sp. cf. *H. globocarinata* (Cushman) is distinguished from *H. ultimatumida* by its compressed initial portion, its compressed and wider than high chambers, and its larger and relatively higher apertural opening.

The writer agrees with Pessagno (1967) in considering that *Gümbelina ultimatumida* White of Cushman (1946, pl. 46, figs. 6a–b, 7) belongs in another species, but not in *Pseudoguembelina palpebra* Brönnimann and Brown.

Occurrence: Rare in the Qurna Formation, *Globotruncana gansseri* Zone. BPC wells Rumaila no. 18 and Zubair no. 8.

Previous records of occurrence: According to the above references, *Heterohelix ultimatumida* is restricted to the Campanian and Maastrichtian beds of the U.S.A., South America, the Caribbean region, the West Carpathians, Egypt and Iran.

Genus GUBLERINA Kikoïne, 1948

Gublerina cuvillieri Kikoïne
Plate 2, figure 16

Gublerina cuvillieri KIKOÏNE, 1948, p. 26, pl. 2, fig. 10a–c. —DE KLASZ, 1953*b*, p. 246, pl. 8, fig. 1a–b. — BETTENSTAEDT and WICHER, 1955, p. 502, pl. 2, fig. 15. — WILLE-JANOSCHEK, 1966, p. 117, text-fig. 8, fig. 11.
Gublerina ornatissima (Cushman and Church). — MONTANARO GALLITELLI, 1957, p. 140, pl. 32, fig. 6 (not figs. 1–5). — BRÖNNIMANN and RIGASSI, 1963, pl. 17, fig. 4.

Remarks: *Gublerina cuvillieri* was first described by Kikoïne (1948) from the Maastrichtian of the French Pyrenees. Kikoïne's figured holotype, analysis of all other figured and described hypotypes, and the samples here studied show the main diagnostic characters of this species to be (1) chamber divergence starting in the early portion of the test, (2) proliferation of chambers (if present) occurring between divergent chambers and sometimes extending up to the top pair (not starting between the top pair), (3) reniform shape of the biserially arranged chambers, (4) the non-septate median portion compressed below the level of the lateral surfaces of the biserially arranged chambers.

Occurrence: Rare in the Qurna Formation, *Globotruncana gansseri* Zone. BPC wells Rumaila no. 18 and Ratawi no. 1.

Previous records of occurrence: Maastrichtian of Austria, Bavaria, northwestern Germany, France and Cuba.

Gublerina glaessneri Brönnimann and Brown
Plate 2, figure 17

Gublerina glaessneri BRÖNNIMANN and BROWN, 1953, pp. 155–156, text-figs. 13–14. — MONTANARO GALLITELLI, 1957, p. 141, pl. 32, fig. 7. — PESSAGNO, 1967, p. 265 (no figure).

Remarks: A single specimen showing six pairs of diverging rows of subrectangular chambers enclosing chambers which are compressed below the level of the lateral surfaces, is assigned to *Gublerina glaessneri* Brönnimann and Brown. The outline is sharply lobate and the sutures are thick and limbate. The uniserially arranged median chambers are different from those of the holotype but similar to those of the figured paratype. A similar *Gublerina* was also figured by Montanaro Gallitelli (1957).

Occurrence: Lower part of the Sadi Formation, *Globotruncana concavata* Zone. BPC well Zubair no. 8.

Previous records of occurrence: Originally described from the Maastrichtian of Cuba. Elsewhere, this species has only been found in the Gulf Coast area at the type locality of the Méndez Shale (Maastrichtian), Tampico Embayment, Mexico.

Gublerina sp. cf. ***G. reniformis*** (Marie)
Plate 2, figure 18

Cf. *Ventilabrella reniformis* MARIE, 1941, p. 185, fig. 277a–b.

Remarks: The present species differs from Marie's holotype in not having early diverging chambers.

Occurrence: A single specimen, in the lower part of the Tanuma Formation, *Globotruncana renzi* Zone. BPC well Zubair no. 8.

Previous records of occurrence: The species with which the specimen is compared was originally described from the Senonian of the Paris Basin.

Gublerina sp.
Plate 2, figure 19

Remarks: A single specimen of a species with a regularly tapering and laterally compressed test, a lobulate periphery, and biserially arranged, slightly divergent and inflated chambers was found. A single chamber occupies the whole central space between the last two pairs of chambers and protrudes strongly on both sides of the test. The sutures are slightly curved and depressed. The wall is calcareous and perforate. The peripheral margins are heavily striate, the lateral surfaces less strongly so, and the last adult chambers are nearly smooth.

Gublerina sp. differs from the similarly compressed *Ventilabrella compressa* van der Sluis, 1950, described from the Maastrichtian of eastern Seram, Indonesia, mainly in lacking limbate sutures, in having the aberrant chamber not compressed below the level of the test surfaces, and in possessing surface striation. From *Ventilabrella ornatissima* Cushman and Church, 1929, it differs in exhibiting inner protruded chambers and in the absence of proliferation of chambers at the top of the test.

Occurrence: Upper part of the Tanuma Formation, *Globotruncana renzi* Zone. BPC well Zubair no. 8.

Genus PSEUDOGUEMBELINA Brönnimann and Brown, 1953
Pseudoguembelina costulata (Cushman)
Plate 3, figures 1–5

Gümbelina costulata CUSHMAN, 1938, p. 16, pl. 3, figs. 7–9.
Pseudoguembelina costulata (Cushman). — BRÖNNIMANN and BROWN, 1953, pp. 153–154, text-fig. 5. — SAID and SABRY, 1964, p. 392, pl. 3, fig. 19. — ANSARY and TEWFIK, 1966, p. 42, pl. 3, fig. 9a–b. — PESSAGNO, 1967, p. 266, pl. 79, fig. 1; pl. 88, figs. 8–9; pl. 90, fig. 3 (see synonymy). — DOUGLAS, 1969*a*, p. 160, pl. 11, fig. 6. — GOVINDAN, 1972, p. 169, pl. 1, figs. 15–16.

Remarks: *Pseudoguembelina costulata* was first described by Cushman (1938) as *Gümbelina costulata*. Brönnimann and Brown (1953) described *Pseudoguembelina* as a new genus and distinguished it from the genus *Guembelina* Egger by its distinctive supplementary apertures along the median line in the lobate stage and, to a lesser extent, by the nature of its costae. They included in this genus *Pseudoguembelina costulata* (Cushman), *P. excolata* (Cushman), *Heterohelix punctulata* (Cushman), *H. striata striata* (Ehrenberg) and their

newly described *Pseudoguembelina palpebra*. Pessagno (1967) distinguished *P. costulata* from *Pseudoguembelina excolata* (Cushman) by its narrow outline and the possession of fine rather than coarse costae.

In southeastern Iraq, *Pseudoguembelina costulata* was found to exhibit some characters of *P. excolata* in early lower Campanian time. Some forms have a small test but coarse costae, others a large test and fine to medium costae, or coarse costae and a narrow outline. Nevertheless, there still remain the striking characters of *P. excolata*, namely, the few, widely spaced, coarse, adult costae, and the smooth to slightly costate early portion.

Occurrence: Rare in the upper part of the Sadi Formation, the lower part of the Hartha Formation and the whole of the Qurna Formation, *Globotruncana stuartiformis–G. stephensoni* Zone and *Globotruncana gansseri* Zone. BPC wells Zubair no. 8, Ratawi no. 1.

Previous records of occurrence: Alabama, Mississippi, Tennessee and Texas, Campanian; southwestern Arkansas, California, Mexico, Puerto Rico, western Spain, Pakistan and Egypt, Campanian–Maastrichtian; Cuba, Maastrichtian.

Pseudoguembelina excolata (Cushman)
Plate 2, figure 20

Güembelina excolata CUSHMAN, 1926, p. 20, pl. 2, fig. 9.
Gümbelina excolata Cushman. — PLUMMER, 1931, pp. 176–177, pl. 8, fig. 10 (not White, 1929, p. 34, pl. 4, fig. 7).
Textularia costata CARSEY, 1926, p. 26, pl. 1, fig. 4.
Pseudoguembelina excolata (Cushman). — BRÖNNIMANN and BROWN, 1953, p. 153, text-figs. 1–4. — HAQUE, 1959, pp. 10–11 (no figure). — ANSARY and TEWFIK, 1966, p. 42, pl. 3, fig. 10a–b. — PESSAGNO, 1967, pp. 266–267, pl. 68, figs. 4–5 (not pl. 90, fig. 5) (see synonymy). — FUNNELL, FRIEND and RAMSAY, 1969, pl. 2, figs. 1–2; text-fig. 7.

Remarks: Pseudoguembelina excolata was first described by Cushman (1926) as *Guembelina excolata* from the Upper Cretaceous of San Luis Potosí, Mexico. Brönnimann and Brown (1953), in their observations on some planktonic Heterohelicidae from the Upper Cretaceous of Habana, Cuba, found that certain species of the striate Heterohelicidae possess minute supplementary apertures situated at the base of each chamber on both sides and covered by tiny valves or flaps. They also noted that these apertures do not appear until the lobate stage. On this basis they established the genus *Pseudoguembelina*. Montanaro Gallitelli's (1957) statement that the supplementary apertures are developed from the very first stage is in error. The specimen figured by her (*op. cit.*) as *Pseudoguembelina excolata* (Cushman) is assignable to *Pseudoguembelina palpebra* Brönnimann and Brown, as it has finer costae and more inflated chambers, and is nearly as wide as high.

Occurrence: Rare in the Qurna Formation, *Globotruncana gansseri* Zone. BPC wells Zubair no. 8, Rumaila no. 18 and Ratawi no. 1.

Previous records of occurrence: Pakistan, the Gulf of Suez and Egypt, Campanian–Maastrichtian; Texas, Arkansas, Colombia, Mexico, Trinidad, Cuba, western Spain and the Farafra Oasis of Egypt, Maastrichtian.

Pseudoguembelina hammadii Darmoian, **n. sp.**
Plate 3, figures 12–15

Description: Test medium-sized, biserial, slightly compressed, rapidly tapering in early portion, gently tapering to nearly parallel-sided in adult; periphery in early stages entire, later slightly to moderately lobate; initial chambers small, slightly compressed, followed by large, inflated, overlapping chambers, slightly wider than high, increasing in height towards the apertural end; biseriality of test terminated by appearance of single, elongate chamber between last pair; elongate chamber with two accessory chambers, one on each side, giving to test a *Ventilabrella*-like appearance; sutures deeply depressed, curved; wall calcareous, perforate; surface ornamented by well-developed striae; a tiny primary aperture at inner margin of last chamber, bordered by a narrow lip (some paratypes showing more than one aperture); sutural supplementary apertures located along median line of adult chambers, covered by flaps.

Dimensions of holotype: Length 0.35 mm., width 0.21 mm., thickness 0.084 mm.

Remarks: Pseudoguembelina hammadii is distinguished by its inflated and overlapping chambers, an elongate and much higher than wide last pair of chambers, the presence of a single central and two small marginal aberrant chambers, the gently tapered to nearly parallel sides of the adult, and the presence of multiple primary apertures.

The species differs from *Ventilabrella carseyae* Plummer in having a compressed test, in the shape and arrangement of the adult chambers, and in possessing sutural supplementary apertures and apertural flaps.

This species is named after Dr. S. Hammadi, Minister of Oil and Minerals and President of Iraq National Oil Company, for his contribution in nationalizing the operations of the Iraq Petroleum Company and in the development of the oil industry in Iraq.

Occurrence: Rare in the lower part of the Sadi Formation, *Globotruncana concavata* Zone. Found only in BPC well Zubair no. 8.

Pseudoguembelina palpebra Brönnimann and Brown
Plate 3, figures 6–11

Pseudoguembelina palpebra BRÖNNIMANN and BROWN, 1953, p. 155, text-figs. 9a–b, 10a–b. — PESSAGNO, 1967, p. 267, pl. 78, figs. 1–3 (not pl. 89, figs. 3–5) (see synonymy).
Pseudoguembelina cornuta SEIGLIE, 1959, pp. 60–61, pl. 4, figs. 1–7.

Remarks: Pseudoguembelina palpebra is distinguished by its as long as broad, compressed test; its large, as high as wide, penultimate chambers; and the usually compressed and flattened chambers of the final pair.

Although Brönnimann and Brown (1953) stated: "In many specimens, the ultimate pair of chambers display strong lateral compression", their text-figure 10b shows only one chamber of the final pair displaying this character. In southeastern Iraq, both variations were observed, but they are not considered to have any taxonomic importance.

A few specimens having fine surface striation, a very slowly tapering adult stage, and a small and compressed ultimate chamber were found to be identical with the form described by Seiglie (1959) as *Pseudoguembelina cornuta*. No striking differences were found between this species and *P. palpebra*, and, following Pessagno (1967), *P. cornuta* Seiglie is included in the synonymy of *P. palpebra* Brönnimann and Brown.

Pseudoguembelina palpebra morphologically is closely related to both *Pseudoguembelina costulata* (Cushman) and *Pseudoguembelina excolata* (Cushman). It differs in having an as long as broad test, as high as wide and inflated chambers, and costae intermediate in character between those of *P. costulata* and *P. excolata*.

Occurrence: Rare in the Qurna Formation, *Globotruncana gansseri* Zone. BPC wells Zubair no. 8, Rumaila no. 18.

Previous records of occurrence: The species was originally described from the upper Maastrichtian of Cuba. It was also reported from the upper Maastrichtian of Mexico and the middle to upper Maastrichtian of Texas and Arkansas.

Genus PSEUDOTEXTULARIA Rzehak, 1891
Pseudotextularia elegans (Rzehak)
Plate 3, figures 16–17

Cuneolina elegans RZEHAK, 1891, p. 2.
Pseudotextularia varians RZEHAK, 1895, p. 217, pl. 7, fig. 1a–b (not figs. 2–3).
Gümbelina elegans (Rzehak). — WHITE, 1929, pp. 34–35, pl. 4, fig. 8.
Gümbelina plummerae Loetterle. — CUSHMAN, 1938, pp. 15–16, pl. 3, figs. 3a–b, 4, 5a–b. — WESSEM, 1943, p. 45, pl. 1, figs. 37–38. — SELLIER DE CIVRIEUX, 1952, p. 270, pl. 6, fig. 11a–b (not fig. 12). — NAGAPPA, 1959, p. 163, pl. 7, figs. 5, 6a–b.
Güembelina plummerae Loetterle. — SAID and KENAWY, 1956, p. 139, pl. 3, fig. 33a–b.
Bronnimannella plummerae (Loetterle). — MONTANARO GALLITELLI, 1956, p. 35, pl. 7, figs. 1–2.
Pseudotextularia elegans (Rzehak). — MONTANARO GALLITELLI, 1957, p. 138, pl. 33, fig. 6a–c. — SALAJ and SAMUEL, 1966, p. 232, pl. 37, fig. 11. — PESSAGNO, 1967, pp. 268–269, pl. 75, figs. 12–17; pl. 85, figs. 10–11; pl. 88, figs. 14–16 (not pl. 89, figs. 10–11).
Pseudotextularia elegans elegans (Rzehak). — BANDY, 1967, p. 24, text-fig. 12 (12).

Remarks: White (1929) designated the specimen figured by Rzehak (1895, pl. 7, fig. 1a–b) as *Pseudotextularia varians* Rzehak the lectotype of *Pseudotextularia elegans* Rzehak.

Pseudotextularia elegans is very closely related to *Pseudotextularia plummerae* (Loetterle), its separation depending on the intensity of the surface striation and the length/breadth ratio of the test.

Pseudotextularia elegans is distinguished from *Heterohelix* sp. cf. *H. globocarinata* (Cushman) of the author by having the chambers strongly compressed in a direction perpendicular to the peripheral margins, a coarsely striate surface and reniform chambers which are much wider than high in the peripheral view, and by the lack of an early entire margin.

Occurrence: Rare in the Qurna Formation, *Globotruncana gansseri* Zone. BPC wells Zubair no. 8, Ratawi no. 1.

Previous records of occurrence: Texas, Arkansas, Mexico, Cuba, Puerto Rico, Czechoslovakia and Venezuela, Campanian and Maastrichtian; India and Egypt, Maastrichtian.

From its stratigraphic occurrence *Pseudotextularia elegans* seems to be a good Campanian–Maastrichtian index fossil in the Tethyan regions, although there are records from the Boreal regions also.

Pseudotextularia plummerae (Loetterle)
Plate 3, figures 18–19

Gümbelina plummerae LOETTERLE, 1937, p. 33, pl. 5, figs. 1–2.
Pseudotextularia elegans (Rzehak). — PESSAGNO, 1967, pp. 268–269, pl. 89, figs. 10–11 (not pl. 75, figs. 12–17; pl. 85, figs. 10–11; pl. 88, figs. 14–16).
Pseudotextularia plummerae (Loetterle). — BROWN, 1969, pp. 56–57, pl. 4, figs. 6–7.

Remarks: The specimens here described as *Pseudotextularia plummerae* (Loetterle) are similar to the holotype, originally designated as *Gümbelina plummerae*. They differ from *Pseudotextularia elegans* (Rzehak) in having faint instead of strong surface striation and a low length/breadth ratio of the test.

Occurrence: Rare in the Tanuma Formation and in the lower half of the Sadi Formation, *Globotruncana renzi* Zone to *Globotruncana fornicata* Zone. BPC wells Zubair no. 8, Ratawi no. 1.

Previous records of occurrence: The species was originally described from the Upper Cretaceous of Kansas,

Nebraska and South Dakota. It was also reported from the lower Campanian of Texas. According to Brown (1969), *P. plummerae* ranges from Coniacian to Santonian.

Genus ***Sigalia*** Reiss, 1957

Type species: Gümbelina (*Gümbelina, Ventilabrella*) *deflaensis* Sigal, 1952 (top figure).

Description: Test compressed; sides flattened or nearly so; periphery moderately to strongly lobate or serrate; in apertural view periphery subrounded or truncate, and in mature specimens truncate periphery with two parallel keel-like thickenings enclosing a depressed band which often extends along both peripheral margins of test, joining sutural extensions and giving test a peripherally serrate appearance; chambers biserially arranged almost to top of test; well-developed individuals show more than two chambers added in a single plane on last pair, or an abundant proliferation of rounded, compressed chambers. The latter form frequently has a larger test size but a shorter biserial chamber arrangement (five pairs maximum as opposed to nine in the non-proliferate form). The early *Guembelina*-type chambers are followed by rectangular to subrectangular or reniform, flat or slightly inflated chambers. Sutures slightly curved, distinct, slightly depressed or flush in early portions, raised, slightly curved, moderately to strongly thickened, limbate or covered by prominent granular beads in last stages; wall calcareous, perforate, except for the imperforate granular beads and truncate margins; surface coarsely ornamented, nodose or faintly to moderately striate in early part; less rough to nearly smooth in adult stages. Aperture a low opening, single in biserial forms, two or more in proliferate ones.

Remarks: Gümbelina (*Gümbelina, Ventilabrella*) *deflaensis* was originally described by Sigal (1952) from the Coniacian of northern Algeria. He depicted two forms in his text-figure 41 without designating the holotype. Later (1955*a*), he concluded that these two forms belong in the two different genera, *Gümbelina* and *Ventilabrella*.

Bettenstaedt and Wicher (1955) considered *G.* (*G., V.*) *deflaensis* Sigal to belong in *Ventilabrella* Cushman.

Reiss (1957) examined Sigal's topotype material from the Santonian (Coniacian, *fide* Sigal, 1952) of northern Algeria and assemblages containing *G.* (*G., V.*) *deflaensis* Sigal from the *Globotruncana concavata* Zone of Palestine and from the various deposits of the eastern Tethys region, including Europe. He concluded that this species shows certain characters different from those of all of the other genera of Heterohelicidae and is distinctive enough to be placed in a new genus, for which he proposed the name *Sigalia*.

Although Reiss was quite justified in erecting *Sigalia*, unfortunately he did not state which of Sigal's two figures represents the type species. However, Salaj and Samuel (1962) selected one of the specimens figured by Sigal (1952, p. 36, text-fig. 41, top figure) as lectotype of *Sigalia deflaensis* (Sigal), which is the type species of *Sigalia* Reiss by original designation.

Sigalia Reiss is distinguished from *Ventilabrella* Cushman by the shape of the chambers, the surface ornamentation, and the sutural and peripheral characters (see under description). It is differentiated from *Gublerina* Kikoïne by the absence of divergence of the chambers, the presence of proliferate chambers at the terminal end of the test, and the raised, limbate and granular sutures. The status of *Gublerina acuta* de Klasz is doubtful, its chambers show no divergence with growth, and it may possibly belong in the *Heterohelix pulchra* group.

Sigalia deflaensis (Sigal) may have possibly evolved from *Heterohelix striata* (Ehrenberg), through an as yet unknown species of *Heterohelix* during late Coniacian time, by the development of compressed chambers; slightly limbate, thickened sutures; and early striate ornamentation. The serrate and truncate peripheral margins were not well developed at this stage. *S. deflaensis* is believed to have evolved into *Sigalia carpatica* Salaj and Samuel during very early lower Santonian time by development of more regularly flattened, subrectangular chambers; strongly raised, limbate, granular sutures; serrate margins with a depressed band; and coarse ornamentation in the early part. *S. carpatica* evolved into *Sigalia decoratissima* (de Klasz) through *Sigalia carpatica sayyabi* Darmoian during lower Santonian time by the development of longitudinal, more strongly granular ornamentation covering the early and middle parts of the test; a series of semicircular, compressed chambers, proliferating on the top of the last biserial ones; and multiple apertures.

It is not certain whether *S. decoratissima* is the ancestor of *Sigalia alpina* (de Klasz), the latter species being absent from southern Iraq.

Sigalia carpatica Salaj and Samuel
Plate 3, figure 20; plate 4, figures 1–4

Ventilabrella deflaensis (Sigal). — BETTENSTAEDT and WICHER, 1955, pl. 11, pl. 1, fig. 2. — WICHER and BETTENSTAEDT, 1957, p. 30, text-fig. 3a–c.
Sigalia deflaensis (Sigal). — WILLE-JANOSCHEK, 1966, pp. 123–125, text-fig. 8, fig. 5 (not fig. 6).
Sigalia carpatica SALAJ and SAMUEL, 1966, pl. 37, fig. 2.
Gublerina deflaensis (Sigal). — SCHEIBNEROVÁ, 1969, pp. 55–56, pl. 6, fig. 6a–b (not fig. 5).

Remarks: Sigalia carpatica Salaj and Samuel morphologically resembles *Sigalia deflaensis* (Sigal). It is dis-

tinguished by its much more compressed test; flat, subrectangular chambers (as against the moderately inflated chambers of *S. deflaensis*); serrate and truncate periphery; heavier ornamentation in the early portion of the test surface; and strongly raised, granular and beaded sutures.

Occurrence: Abundant in the lower part of the Sadi Formation, *Globotruncana concavata* Zone to *Globotruncana fornicata* Zone. Only found in BPC well Zubair no. 8.

Previous records of occurrence: Austria, Bavaria, France and Morocco, Coniacian–Santonian; Palestine, North Africa and West Carpathians, Santonian.

Sigalia decoratissima (de Klasz)
Plate 4, figures 6–8

Ventilabrella decoratissima DE KLASZ, 1953*a*, p. 228, pl. 4, fig. 5a–b. — BETTENSTAEDT and WICHER, 1955, p. 11, pl. 1, fig. 3.
Gublerina decoratissima (de Klasz). — ESKER, 1969, p. 212, pl. 1, figs. 7–8.
Gublerina deflaensis (Sigal). — SCHEIBNEROVÁ, 1969, pp. 55–56, pl. 6, fig. 5a–b (not fig. 6).

Remarks: Sigalia decoratissima was first described by de Klasz (1953*a*) as *Ventilabrella decoratissima* from the lowermost part of the Santonian Bucheck beds of southeastern Germany. He noted its close relation to *Sigalia deflaensis* (Sigal) and stated that *S. decoratissima* differs from the latter in having knobs arranged longitudinally on the sutures of the biserial stage and in lacking striae on the chambers. However, according to Esker (1969), who had opportunity to examine topotypes of *S. decoratissima*, specimens of this species have rather large nodes (knobs) or costae, while *S. deflaensis* shows finer costae or striae.

The present work suggests that the final chamber proliferation, raised, strongly thickened, granular sutures, and a serrate and truncate periphery supply further criteria for distinguishing this species from *S. deflaensis* and other similar forms. The proliferation of chambers begins early in *S. decoratissima*, whereas in *S. deflaensis* there is biserial chamber arrangement but not proliferation. The "rare proliferation forms (1–2 additional chambers in last pair)" mentioned by Esker (*op. cit.*) are transitional either to *S. decoratissima* or to a yet undescribed form.

Bettenstaedt and Wicher (1955) considered *S. decoratissima* and *Sigalia alpina* (de Klasz) as synonymous with *S. deflaensis* (although their figured forms carried the name *Ventilabrella decoratissima* de Klasz). They stated: "In 1953, de Klasz designated two species from the same stratigraphic range in Bavaria as *V. decoratissima* and *V. alpina* . . ., in reality the correct name of these species is *V. deflaensis*." Montanaro Gallitelli (1957) placed this species in the genus *Gublerina*. Her figured paratype from the Santonian of Bavaria is actually different from de Klasz's original figures and herein is assigned to *S. decoratissima* with some doubt, for it shows no perfect and complete proliferation of chambers, the test is thick rather than compressed, and its final growth stage does not seem to be in a single plane. This form is probably transitional between *S. carpatica* and either a *S. decoratissima*-shaped, undescribed variety or some other form. Montanaro Gallitelli (*op. cit.*) herself remarked on the difference in the character of the chambers and surface ornamentation of this paratype.

Occurrence: Rare in the lower part of the Sadi Formation, *Globotruncana concavata* Zone to *Globotruncana fornicata* Zone. BPC wells Zubair no. 8, Ratawi no. 1 (single specimen).

Previous records of occurrence: Lower Santonian of southeastern Germany, Palestine and Mexico; Santonian of Bavaria and Austria; late Coniacian and early Santonian of Jamaica.

Sigalia deflaensis (Sigal)
Plate 4, figures 10–12

Gublerina (*Gublerina, Ventilabrella*) *deflaensis* SIGAL, 1952, pp. 36–37, text-fig. 41 (top figure).
Ventilabrella deflaensis (Sigal). — BETTENSTAEDT and WICHER, 1955, p. 11, pl. 1, fig. 1 (only first and second figures).
Sigalia deflaensis (Sigal). — SALAJ and SAMUEL, 1966, p. 227, pl. 37, fig. 1.
Gublerina deflaensis (Sigal). — ESKER, 1969, p. 213, pl. 2, figs. 4–5 (not Loeblich and Tappan, 1964, pp. 654–655, text-fig. 525 (3).

Description: Test small, compressed, biserial; periphery lobate, slightly serrate; in apertural view subrounded; sutures curved, flush to slightly raised, limbate; chambers in about 7 pairs, increasing rather rapidly in size, wider than high, roughly rectangular, last pair more compressed than early pairs; wall calcareous, finely perforate; surface in early stages striate, later nearly smooth; aperture on inner side of last chamber.

Remarks: The specimens figured as *Gümbelina* (*Gümbelina, Ventilabrella*) *deflaensis* by Sigal (1952, text-fig. 41, lower figure), as *Ventilabrella deflaensis* (Sigal) by Wicher and Bettenstaedt (1957, fig. 10), and as *Gublerina deflaensis* (Sigal) by Loeblich and Tappan (1964, text-fig. 525 (3)) are probably transitional from *Sigalia carpatica* Salaj and Samuel to *Sigalia decoratissima* (de Klasz). Forms of this type have been found in the present material.

Occurrence: Rare in the upper part of the Khasib Formation; abundant in the Tanuma Formation and in the lower part of the Sadi Formation, *Globotruncana renzi* Zone to *Globotruncana concavata* Zone. BPC well Zub-

air no. 8, abundant; BPC well Ratawi no. 1, rather abundant; BPC well Rumaila no. 18, rare.

Previous records of occurrence: Coniacian of Algeria; Coniacian–Santonian of Austria, Bavaria, France, Morocco, West Carpathians and Jamaica. All other ranges given by different authors refer to *Sigalia carpatica* or to transitional forms.

Genus VENTILABRELLA Cushman, 1928

Ventilabrella sp. cf. ***V. eggeri*** Cushman
Plate 4, figure 13
Cf. *Ventilabrella eggeri* CUSHMAN, 1928, p. 2, pl. 1, figs. 10–12.

Remarks: The specimens here described as *Ventilabrella* sp. cf. *V. eggeri* differ from the holotype in having strongly appressed chambers in the proliferation stage. Cushman's holotype shows globular chambers in the proliferation stage. It differs from *Ventilabrella carseyae* Plummer in having only small and narrow apertural openings, as against large, lunate apertural openings in Plummer's holotype.

Occurrence: Rare to abundant in the Khasib and Tanuma formations and in the lower part of the Sadi Formation, *Globotruncana renzi* Zone to *Globotruncana concavata* Zone. BPC wells Zubair no. 8, Rumaila no. 18.

Ventilabrella glabrata Cushman
Plate 4, figures 14–16

Ventilabrella eggeri var. *glabrata* CUSHMAN, 1938, p. 26, pl. 4, figs. 15–17. — CUSHMAN, 1946, p. 111, pl. 47, figs. 20–22. — FRIZZELL, 1954, p. 111, pl. 16, figs. 11–12.
Planoglobulina glabrata (Cushman). — MONTANARO GALLITELLI, 1957, p. 142, pl. 32, figs. 10–12.
Planoglobulina acervulinoides (Egger). — OLSSON, 1960, pp. 28–29, pl. 4, fig. 11.
Ventilabrella glabrata Cushman. — SALAJ and SAMUEL, 1966, p. 231, pl. 37, fig. 7.
Planoglobulina acervulinoides glabrata (Cushman). — BANDY, 1967, p. 25, text-fig. 12 (7).

Remarks: Ventilabrella glabrata was first described by Cushman from the upper part of the Taylor Marl, Texas, as a variety of *Ventilabrella eggeri* Cushman. He stated that this variety differs from *V. eggeri* in having only slightly costate early growth stages and is smooth in the adult. He added that the perforations sometimes appear in lines, whereas *V. eggeri* has longitudinal costae which are heavier on the biserial portion.

In southeastern Iraq, forms of *V. glabrata* either with faint or heavy costae on either the early chambers or over the whole surface of the test were found.

The specimen figured by Olsson (1960) as *Planoglobulina acervulinoides* (Egger) belongs in *V. glabrata* Cushman. It possesses large numbers of small chambers and a fan-shaped, compressed test.

Occurrence: Rare to abundant in the Sadi Formation, *Globotruncana concavata* Zone to *Globotruncana stuartiformis-G. stephensoni* Zone. BPC wells Zubair no. 8, Ratawi no. 1.

Previous records of occurrence: Coniacian–Campanian of Texas and Arkansas; Santonian of Jamaica; Santonian–Campanian of Puerto Rico; Campanian of the West Carpathians; and Coniacian–Maastrichtian of Pakistan.

Ventilabrella ornatissima Cushman and Church
Plate 4, figures 17–20

Ventilabrella ornatissima CUSHMAN and CHURCH, 1929, p. 512, figs. 12–14 (not fig. 15). — CUSHMAN, 1938, p. 27, pl. 4, fig. 11a–b (not Kikoïne, 1948, pp. 25–26, pl. 2, fig. 8a–c.
Gublerina ornatissima (Cushman and Church). — MONTANARO GALLITELLI, 1957, p. 140, pl. 32, fig. 6 (not figs. 1–5). — GRAHAM, 1962, p. 105, pl. 19, fig. 16a–c. — GRAHAM and CHURCH, 1963, p. 61, pl. 7, fig. 10a–b. — MARTIN, 1964, p. 86, pl. 11, fig. 3a–c (not Brönnimann and Rigassi, 1963, p. 17, fig. 4; not Takayanagi, 1965, p. 200, pl. 20, figs. 6–8; not Bandy, 1967, p. 25, text-fig. 11 (3)).
Planoglobulina ornatissima (Cushman and Church). — DOUGLAS, 1969*a*, p. 160, pl. 2, figs. 1–2.

Description: Test medium-sized, compressed; early biserial stage followed by rhomboid adult proliferate stage; peripheral outline in early stage entire, later moderately lobate; periphery in apertural view rounded; chambers added in a single plane; initial 3 pairs of chambers small, appressed, followed by distinct, inflated, globular to subglobular chambers, increasing gradually in size as added, proliferating on top of the last pair, alternating in position; early sutures flush; later sutures very deeply depressed, limbate; in rare cases, sutures flush throughout; wall calcareous, perforate; surface striate; ornamentation heaviest on the peripheral margins, fading out towards the last chambers.

Remarks: Ventilabrella ornatissima Cushman and Church differs from *Ventilabrella glabrata* Cushman and other similar forms in its comparatively long biserial stage; globular to subglobular, moderately inflated, similar-sized chambers, and deeply depressed, limbate sutures in the proliferation stage.

Kikoïne (1948) described the new genus *Gublerina* from the Maastrichtian of the French Pyrenees, with *Gublerina cuvillieri* as type species. Montanaro Gallitelli (1957) considered this species as a junior synonym of *Gluberina ornatissima* (Cushman and Church).

Douglas (1969*a*), in a revision of *V. ornatissima* from the northern California Upper Cretaceous, stated: "In complete adult specimens of *V. ornatissima* (the holotype and paratype are broken), the fan-shaped portion of the test is composed of numerous small globular chambers. The test frequently breaks at a line of weakness just

above the biserial portion . . ., this damage producing a form which superficially resembles *G. cuvillieri* (for example, the paratype illustrated by Montanaro Gallitelli, 1957, pl. 32, fig. 6). The species is, however, completely multi-chambered and can not be assigned to *Gublerina*". He also added: "the California species exhibits a rapid increase in width following the earlier biserial portion, which gives the test a distinct flare. The two taxa should be considered as different, with *G. cuvillieri*, not *V. ornatissima*, as type species of *Gublerina*."

The present study substantiates Douglas's observations. However, specimens of *V. ornatissima* showing a slow increase in width and of *G. cuvillieri* showing a rapid increase in width were found, although rarely, in the area studied. Moreover, the paratype of *G. cuvillieri*, illustrated by Montanaro Gallitelli (*op. cit.*, pl. 32, fig. 4; see above) shows rapid increase in width which gives the test, as in *V. ornatissima*, a "distinct flare".

The present work suggests that the proliferation of chambers at the top of the test and the absence of divergence of the chambers are the best criteria in distinguishing this species from *G. cuvillieri* Kikoïne.

Occurrence: Abundant in the lower part, rare in the upper part of the Sadi Formation, *Globotruncana concavata* Zone to *Globotruncana stuartiformis–G. stephensoni* Zone. BPC wells Zubair no. 8, Rumaila no. 18, Ratawi no. 1.

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PLATE 1

1 *Güembelitria trilocula* (Marie)
x 150, Tanuma Formation, BPC well Zubair no. 8.

2 *Heterohelix* sp. cf. *H. globocarinata* (Cushman)
x 110, Sadi Formation, BPC well Zubair no. 8.

3 *Heterohelix moremani* (Cushman)
x 135, Khasib Formation, BPC well Zubair no. 8.

4–6 *Heterohelix nuttalli* Voorwyck
4, x 100, Qurna Formation, BPC well Zubair no. 8.
5, x 115, Sadi Formation, BPC well Zubair no. 8.
6, x 108, Qurna Formation, BPC well Zubair no. 8.

7 *Heterohelix* sp. aff. *H. glabrans* (Cushman)
x 135, Qurna Formation, BPC well Zubair no. 8.

8 *Heterohelix planata* Cushman
x 100, Tanuma Formation, BPC well Zubair no. 8.

9–15 *Heterohelix pulchra* (Brotzen)
9–12, x 125, Khasib Formation, BPC well Zubair no. 8.
13–14, x 165, Tanuma Formation, BPC well Rumaila no. 18.
15, x 125, Tanuma Formation, BPC well Rumaila no. 18.

16–20 *Heterohelix reussi* (Cushman)
16, x 125, Sadi Formation, BPC well Zubair no. 8.
17, x 100, Sadi Formation, BPC well Zubair no. 8.
18, x 115, Khasib Formation, BPC well Rumaila no. 18.
19, x 150, Khasib Formation, BPC well Rumaila no. 18.
20, x 180, Khasib Formation, BPC well Rumaila no. 18.

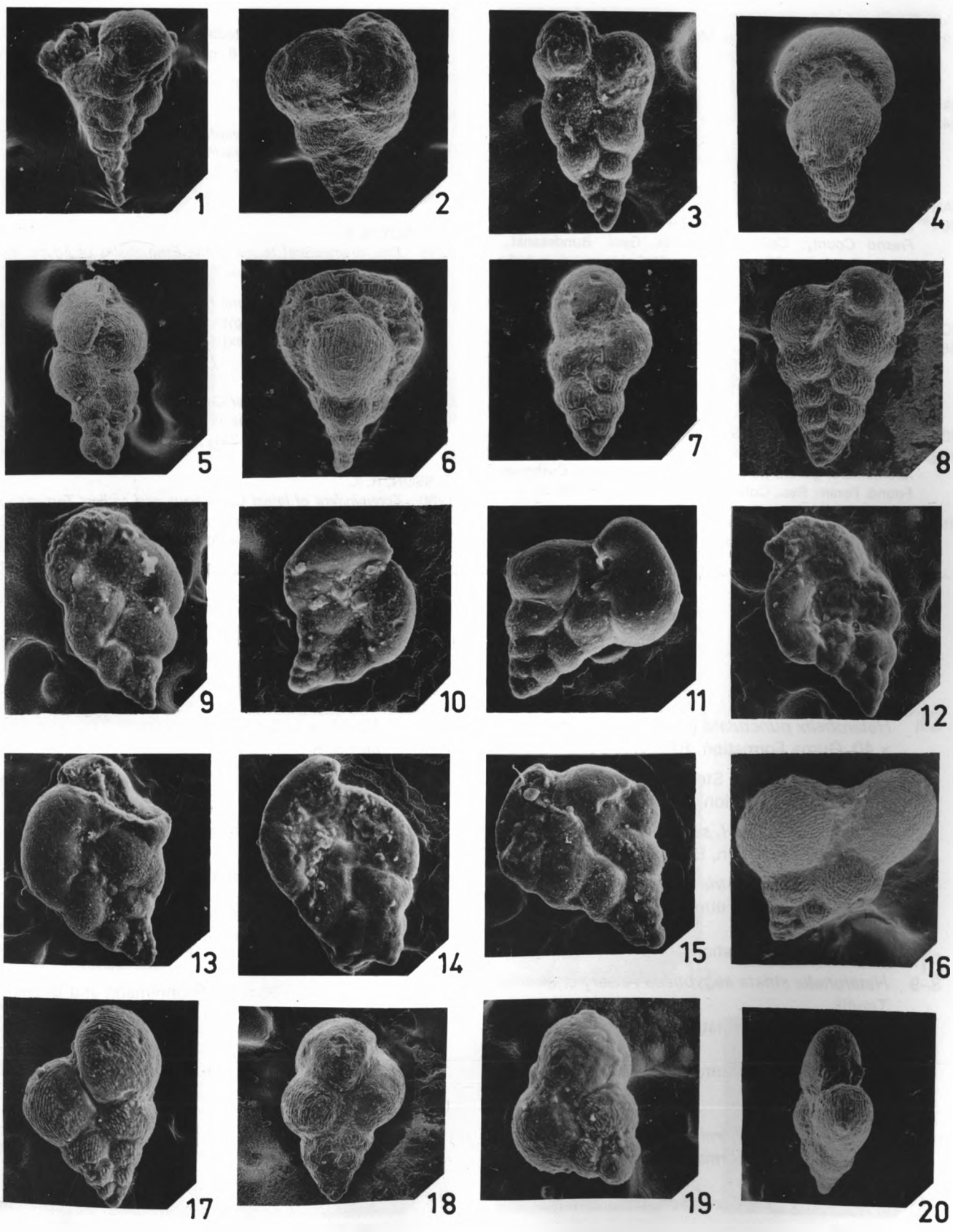
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PLATE 2

1 *Heterohelix punctulata* (Cushman)
x 40, Qurna Formation, BPC well Zubair no. 8.

2 *Heterohelix robusta* Stenestad
x 185, Sadi Formation, BPC well Zubair no. 8.

3 *Heterohelix* sp. cf. *H. semicostata* (Cushman)
x 70, Sadi Formation, BPC well Zubair no. 8.

4–7 *Heterohelix striata striata* (Ehrenberg)
4–6, x 155, Sadi Formation, BPC well Zubair no. 8.
7, x 135, Sadi Formation, BPC well Zubair no. 8.

8–9 *Heterohelix striata aegyptiaca* Ansary and Tewfik
8, x 95, Khasib Formation, BPC well Rumaila no. 18.
9, x 95, Khasib Formation, BPC well Zubair no. 8.

10–13 *Heterohelix ultimatumida* (White)
10, x 95, Qurna Formation, BPC well Rumaila no. 18.
11, x 125, Qurna Formation, BPC well Rumaila no. 18.
12–13, x 120, Qurna Formation, BPC well Zubair no. 8.

14–15 *Heterohelix* sp.
14, x 105, Sadi Formation, BPC well Zubair no. 8.
15, x 95, Sadi Formation, BPC well Zubair no. 8.

16 *Gublerina cuvillieri* Kikoïne
x 85, Qurna Formation, BPC well Rumaila no. 18.

17 *Gublerina glaessneri* Brönnimann and Brown
x 105, Sadi Formation, BPC well Zubair no. 8.

18 *Gublerina* sp. cf. *G. reniformis* (Marie)
x 145, Tanuma Formation, BPC well Zubair no. 8.

19 *Gublerina* sp.
x 90, Tanuma Formation, BPC well Zubair no. 8.

20 *Pseudoguembelina excolata* (Cushman)
x 130, Tayarat Formation, BPC well Rumaila no. 18.

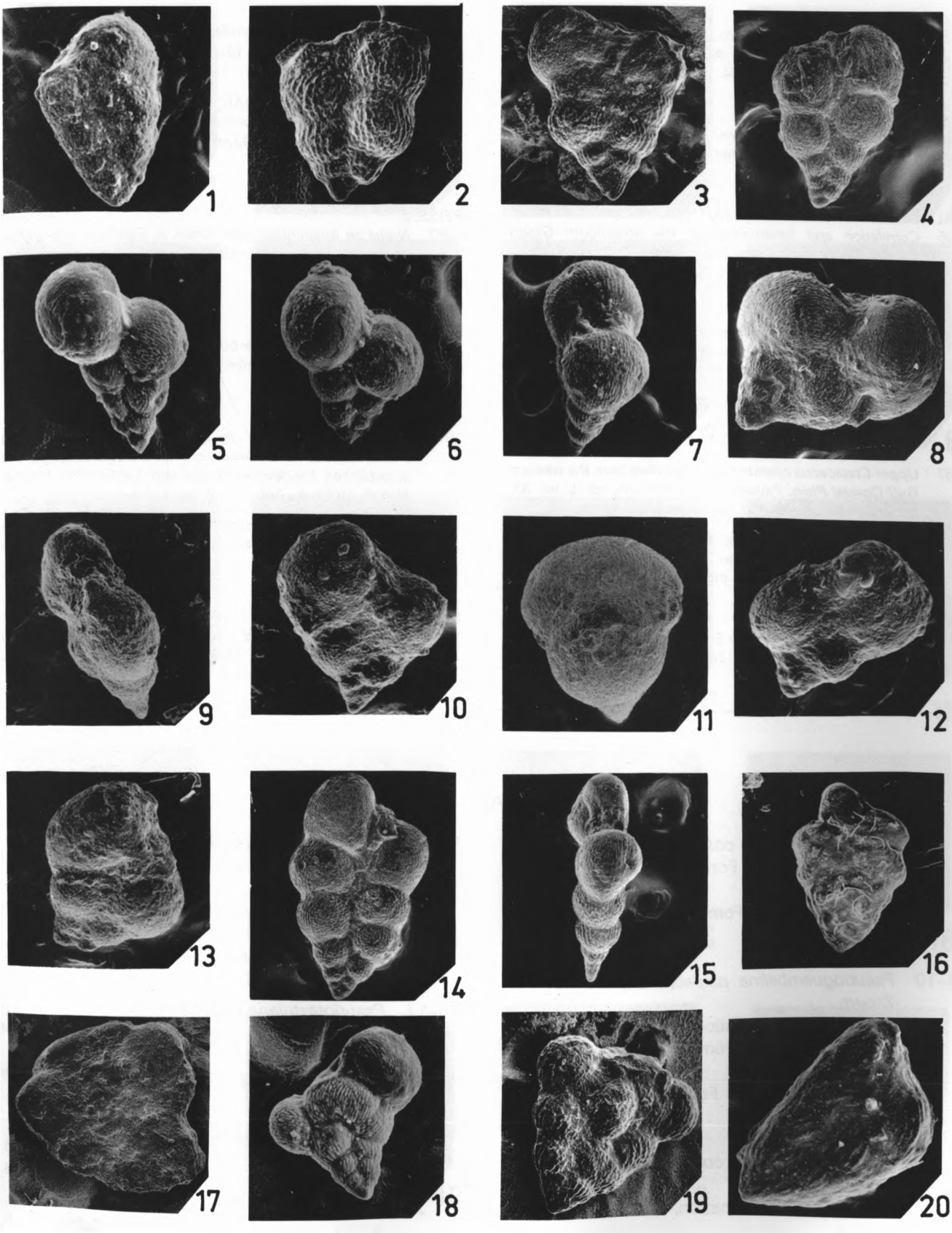
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PLATE 3

1–5 *Pseudoguembelina costulata* (Cushman)
1–3, x 105, Qurna Formation, BPC well Zubair no. 8.
4–5, x 110, Sadi Formation, BPC well Zubair no. 8.

6–10 *Pseudoguembelina palpebra* Brönnimann and Brown
6, x 90, Qurna Formation, BPC well Zubair no. 8.
7–8, x 100, Qurna Formation, BPC well Zubair no. 8.
9–10, x 100, Qurna Formation, BPC well Rumaila no. 18.

11 *Pseudoguembelina cornuta* Seiglie Synonym of *P. palpebra*
x 100, Qurna Formation, BPC well Rumaila no. 18.

12–15 *Pseudoguembelina hammadii* Darmoian, n. sp.
12, x 115, holotype, Sadi Formation, BPC well Zubair no. 8.
13, x 120, paratype, Sadi Formation, BPC well Zubair no. 8.
14–15, x 90, paratypes, Sadi Formation, BPC well Zubair no. 8.

16–17 *Pseudotextularia elegans* (Rzehak)
16, x 90, Qurna Formation, BPC well Zubair no. 8.
17, x 125, Qurna Formation, BPC well Zubair no. 8.

18–19 *Pseudotextularia plummerae* (Loetterle)
18, x 80, Sadi Formation, BPC well Zubair no. 8.
19, x 85, Sadi Formation, BPC well Zubair no. 8.

20 *Sigalia carpatica* Salaj and Samuel
x 120, Sadi Formation, BPC well Zubair no. 8.

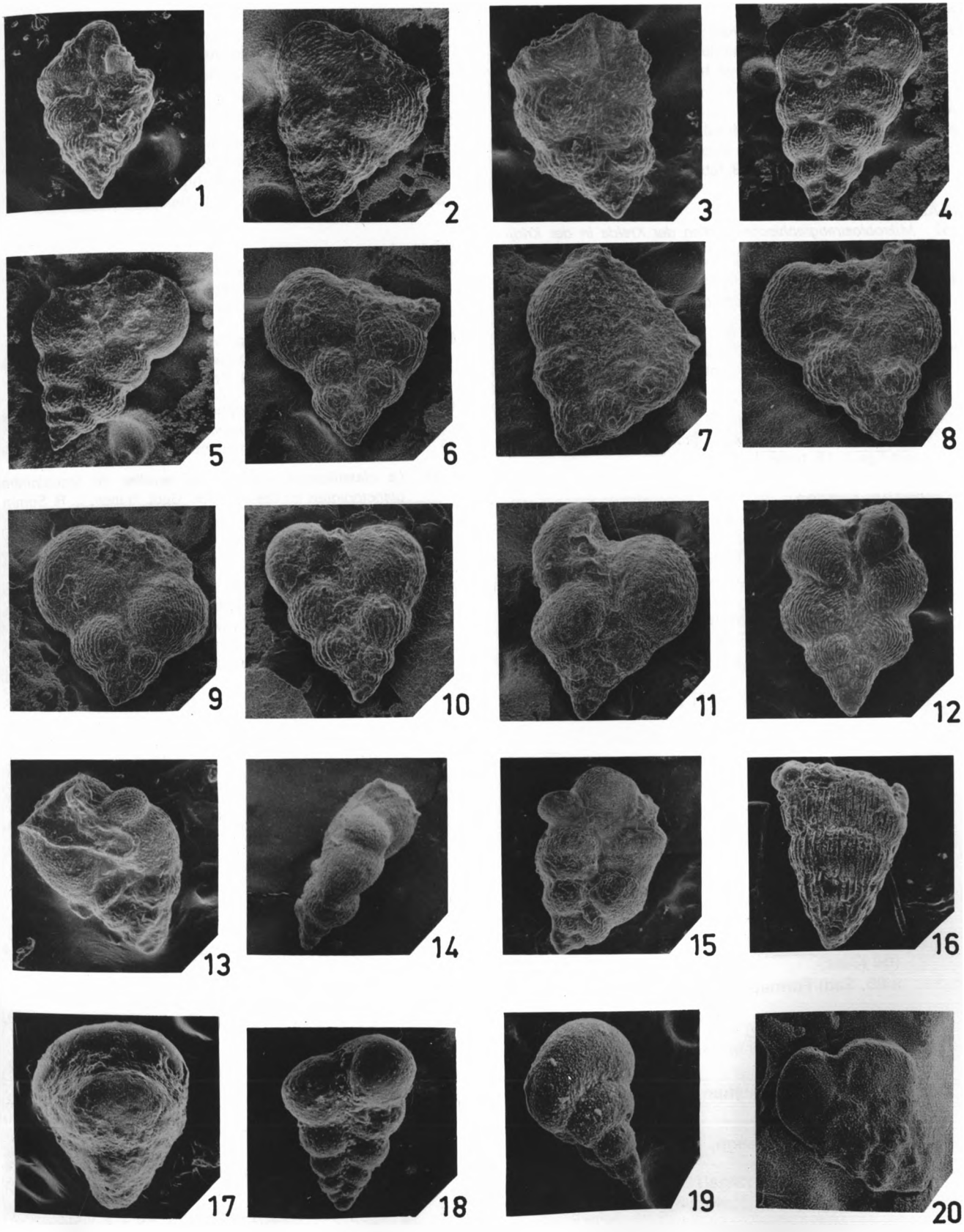
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PLATE 4

1–4 *Sigalia carpatica* Salaj and Samuel
1–3, x 110, Sadi Formation, BPC well Zubair no. 8.
4, x 130, Sadi Formation, BPC well Zubair no. 8.

5 Transitional stage between *Sigalia carpatica* Salaj and Samuel and *Sigalia decoratissima* (de Klasz)
x 85, Sadi Formation, BPC well Zubair no. 8.

6–8 *Sigalia decoratissima* (de Klasz)
6–7, x 85, Sadi Formation, BPC well Zubair no. 8.
8, x 108, Sadi Formation, BPC well Zubair no. 8.

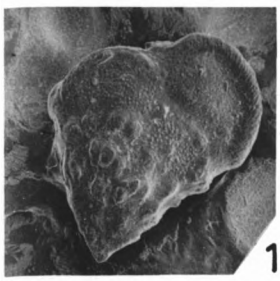
9 *Sigalia* sp.
x 108, Sadi Formation, BPC well Zubair no. 8.

10–12 *Sigalia deflaensis* (Sigal)
10, x 130, Khasib Formation, BPC well Zubair no. 8.
11, x 142, Tanuma Formation, BPC well Rumaila no. 18.
12, x 115, Tanuma Formation, BPC well Rumaila no. 18.

13 *Ventilabrella* sp. cf. *V. eggeri* Cushman
x 135, Tanuma Formation, BPC well Rumaila no. 18.

14–16 *Ventilabrella glabrata* Cushman
14–15, x 55, Sadi Formation, BPC well Zubair no. 8.
16, x 60, Sadi Formation, BPC well Zubair no. 8.

17–20 *Ventilabrella ornatissima* Cushman and Church
17–18, x 125, Sadi Formation, BPC well Zubair no. 8.
19, x 85, Sadi Formation, BPC well Rumaila no. 18.
20, x 75, Sadi Formation, BPC well Rumaila no. 18.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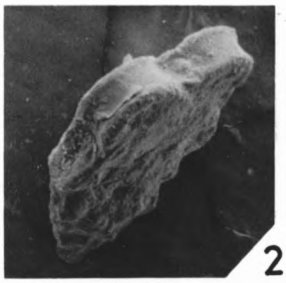
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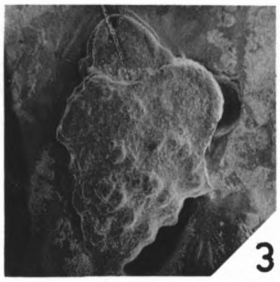
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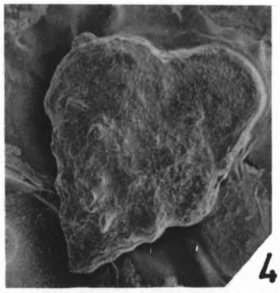
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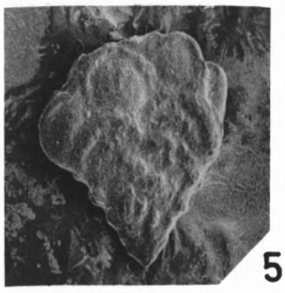
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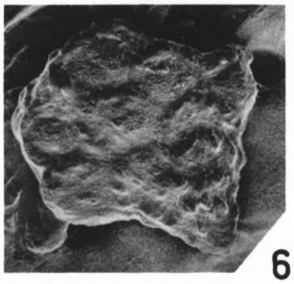
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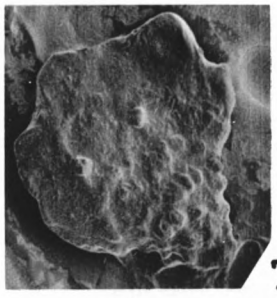
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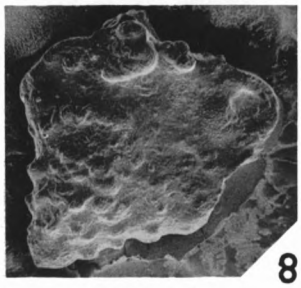
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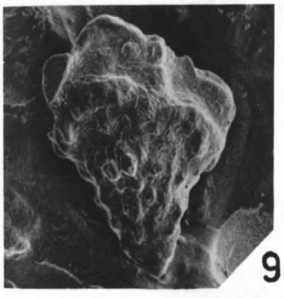
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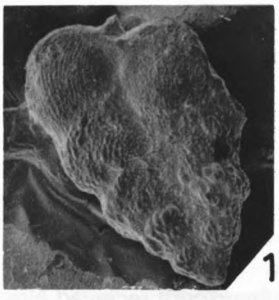
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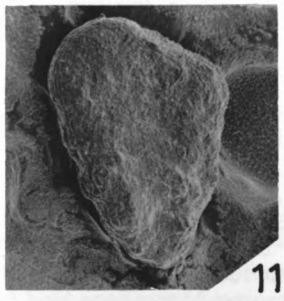
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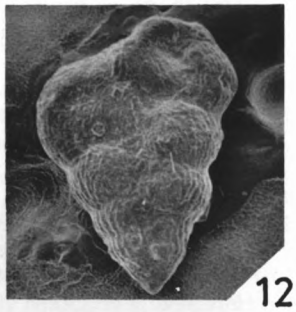
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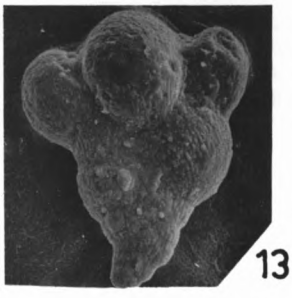
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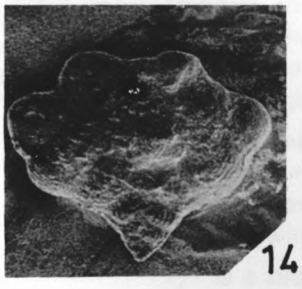
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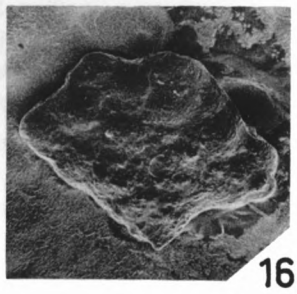
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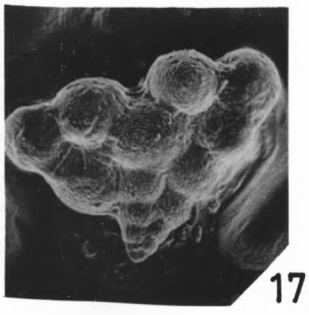
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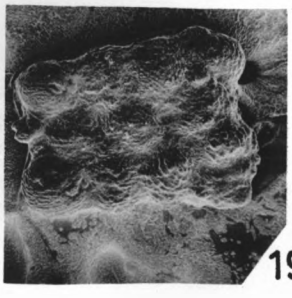
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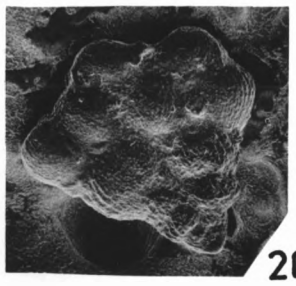
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