

## AGE, BIOZONATION AND STRATIGRAPHY OF KAZHDUMI FORMATION OF SW IRAN

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*Key-words:* SW Iran, Kazhdumi Formation, Albian, Foraminifera.

*Riassunto.* Il presente lavoro riguarda le associazioni a Foraminiferi della Formazione Kazhdumi dell'Iran sudoccidentale. Vengono proposte due biozone e tre sottozone sulla base delle 38 specie e sottospecie riconosciute, di cui alcune nuove. Dal punto di vista litostratigrafico, la Formazione Kazhdumi, databile all'Albiano, ha potuto essere suddivisa in tre membri.

*Abstract.* 38 species and subspecies of Foraminifera, five of which are considered to be new, are recorded from Kazhdumi Formation of SW Iran. The recognized microfossil assemblages have proved being useful for biostratigraphic zonation, age determination and correlation of the examined rocks. Two zones and three subzones are proposed. Foraminiferal faunas indicate an Albian age for the Kazhdumi Fm. Lithologic and petrographical studies showed that the formation can be divided into three members.

### Introduction.

Very little stratigraphic work has been published on smaller Foraminifera of Albian age from SW Iran. The published literature is limited both in number and scope, and mostly derives from the work of the National Iranian Oil Company staff.

The present investigation includes lithological studies on thin sections and the analysis of isolated specimens from samples collected in the Banish area, SW Iran. No detailed micropaleontological work has been done in the latter area. The earliest mention is by Henson (1948) who in his work on larger imperforate Foraminifera from SW Asia mentioned some *Orbitolina* from Kuh-e-Banish. Mojab (1974) studied Albian megafossils of Kuh-e-Banish. To date, the most comprehensive studies of Cretaceous Foraminifera is that by Kalandari (1969) who defined the stratigraphic ranges and provided information on 79 species found in the Lower Cretaceous of Koppet Dagh (NE Iran). The Koppet Dagh assemblages show a close similarity with coeval faunas from Tunisia described by Memmi and Mamouri (1974) and Salaj (1980). Purpose of

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this study was to control the vertical distribution of the Foraminifera in the Albian of southwestern Iran and their potential use in biostratigraphy.

A total of 120 samples were studied during the course of the present research. These include samples examined for age determination to aid mapping and thin sections. Thin sections were examined in order to improve the record of foraminiferal faunas but no quantitative analysis has been carried out upon them. The technique used was, for the most part, the standard method employed in any micropaleontological laboratory.

The area under study is comprised between the geographical coordinates  $52^{\circ}15'$  and  $52^{\circ}30'$  E and  $30^{\circ}10'$  and  $30^{\circ}17'$  N and covers approximately  $25 \times 25$  km (Fig. 1).

### Lithostratigraphy.

Early Cretaceous marine sediments were deposited in Iran during a major marine transgression over most of the country. Within a multibranching rift deep water sediments, diabasic pillows and continental slope deposits accumulated. Setudehnia (1978) divided the Cretaceous system of the Zagros in three parts: Lower Cretaceous (Neocomian—Aptian), Middle Cretaceous (Albian—

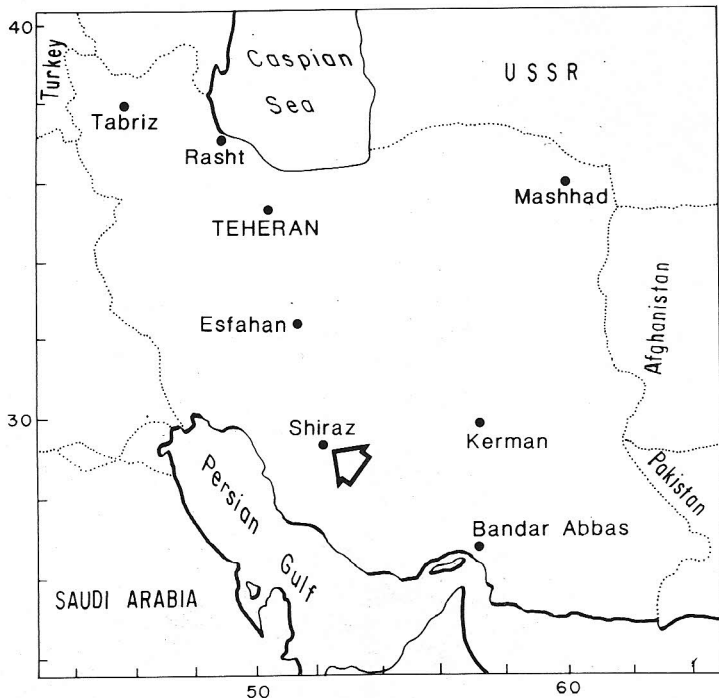


Fig. 1 — Location map. The arrow indicates the exact locality under study.

Turonian) and Upper Cretaceous (Coniacian–Maastrichtian). The Albian in the Zagros basin, is represented by two types of facies:

- 1) one facies is exposed at Fars and in the SE Khuzestan where the Albian marine transgressive sediments consist of widespread marls and limestones (Kazhdumi Formation). The Albian marls rest unconformably on neritic limestones of the Dariyan Formation (Aptian);
- 2) the second facies outcrops in Lurestan, where the Middle Cretaceous is represented by dark gray to black radiolaria-bearing marls and marly limestones of deep water origin (Garau Formation) (Fig. 2).

The Kazhdumi Formation was named by James & Wynd (1965). The type-section was measured at Tang-e-Gurguda, on the southern flank of Kuh-e-Mish (South Iran). In the section measured K.R. Davis (pers. comm.), the Kazhdumi Formation is composed of marls, 137.1 meters thick, overlying a succession of dark marly limestones and marls. The present study, however, indicates that this portion cannot be observed at the type-locality. The Kazhdumi Formation in the studied area is 190 meters thick and conformably overlies the limestone of the Dariyan Formation. Lithologically it is composed of marlstone, marl and marly limestone with some limestones. The overall colour of the formation is light gray to yellowish gray, slightly reddish gray in some places. Morphologically, the Kazhdumi Formation is characterized by very gentle slopes between the scarps of the underlying Dariyan Formation and the overlying Sarvak Formation (Cenomanian). In some places, it is covered by

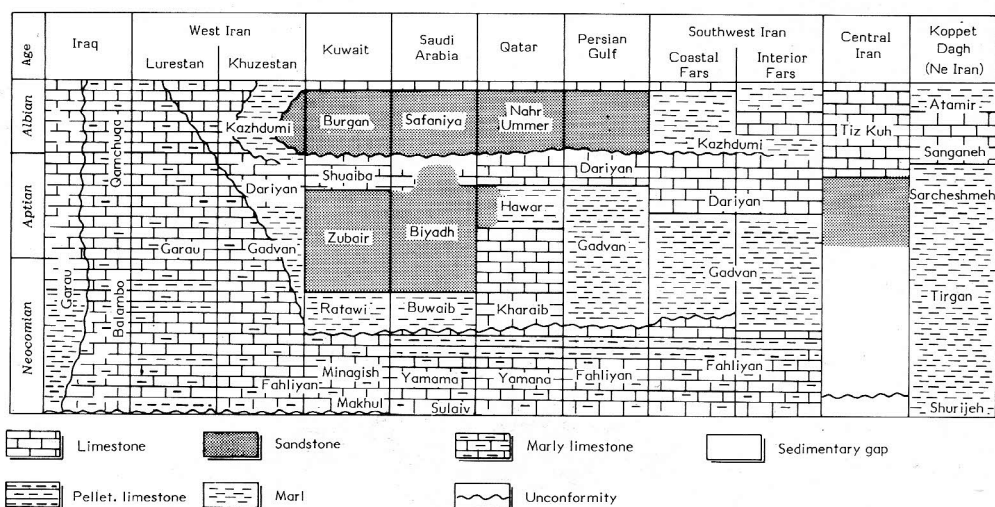


Fig. 2 – Correlation scheme of the Early Cretaceous formations from Iran and surrounding areas.

slumped blocks and scree materials from the overlying Sarvak Formation.

Setudehnia (1971) dated the Kazhdumi Formation as Albian–Cenomanian in age. The present studies leads to an Albian age.

Three lithostratigraphic members have been recognized by Shakib (1983) in the Kazhdumi Formation. They are characterized in ascending sequence as follow (Fig. 3):

Member one: the lowest is 74.5 meters thick. The contact with the underlying Dariyan Formation is marked by the presence of iron oxide nodules. This member includes thin, evenly bedded marly limestones grading upwards into the gray, yellowish weathering marl with a few marly limestones. They are intra-clastic, *Hedbergella*–bearing clayey biomicrite and clayey intramicrite. Moyab (1974) described several megafossils from this member, including ammonites (*Knemiceras cyriacum* Buch), bivalvia (*Nucula archiaci* Vrendenburg, *Trigonia coihuicoensis* Weaver, and *Exogyra* cf. *flabellata* Goldfuss).

Member two: this member is 22.5 meters thick and consists of marine, well and unevenly bedded limestones with a dark and yellowish gray weathering colour. Thickness and bedding feature change upwards. The most important feature of this member is that it contains very large *Orbitolina*. Moyab (1974) recorded *Orbitolina lenticularis* in this member. Petrographically they are *Orbitolina* intramicrite with a lot of stylolite veins and small hematite grains in the lower part. The upper part is represented by *Orbitolina* intramicrite.

Member three: this member is 90 meters thick, and consists of light gray massive and well bedded marly limestones. The upper part is mainly composed of light gray marl with a few limestone beds. Petrographic studies indicate that the marly limestones of lower part are clayey biomicrite. Megafossil content includes echinoids and gastropods.

### Biostratigraphy.

Some part of the Zagros Mountains were explored by AGIP geologists and the stratigraphic results were published by Sampò (1969). His paleontological studies of both larger and smaller Foraminifera were only based on thin section. Sampò (op. cit.) recognized three zones in the Kazhdumi Formation as follows:

1. *Orbitolina discoidea* and *O. conoidea* zone (Albian).

2. *O. concava* zone (Albian).

3. *Oligostegina*–*Hedbergella washitensis* zone, with *Hemicyclamina sigali* subzone (Albian transition to Cenomanian).

Kalantari (1969) described the biostratigraphy of the Sarvestan area (S

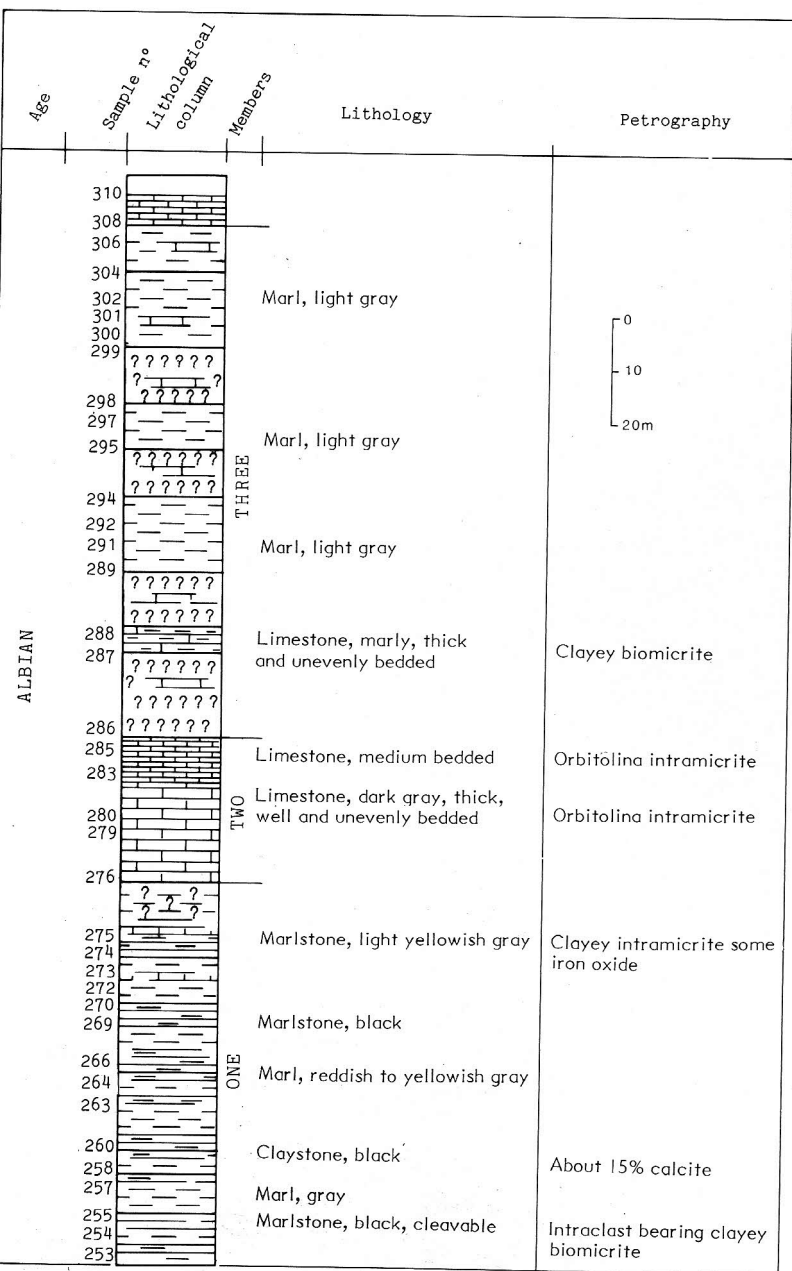


Fig. 3 – Stratigraphic section of the Kazhdumi Formation, SW Iran.

Iran) and in the Albian he recognized two zones. His work was mainly based on thin section studies (Fig. 4).

In dating and correlating the Albian sequence studied, the foraminiferal assemblages of the whole unit have been taken into account. Some species have a larger or shorter stratigraphic range in comparison to those found by other workers in other areas. These discrepancies were discussed in detail by Shakib (1983).

TITHONIAN		BERRIASIAN			VALANGINIAN					Al-Rifaiy 1979 Kuwait	
Rare Radiolaria/ Sponge Spicules		Calpion. alpina/ common Radiolaria		Calpion. elliptica	Calpionellites darder/ Anchispirocy. lustrantica		Pseudocycl. lituus/ Everticycl. spp				
TITH.- BERR.		VALANGINIAN		HAUTERIVIAN		BARREMIAN		APTIAN		Colestaneh 1975 S. Iran	
Tintinnid Zone		Pseudocycl. lituus/ Pseudochrysalidina arabica/Algae			Orbitolina/Choffatella/ Salpingoporella dinarica						
BERR.		VALAN.-HAUT.		BARREMIAN		APTIAN		ALBIAN		CEN.	Sampo 1969 S.W. Iran
Munieria/ Salpingoporella		Pseudocycl. lituus		Dictyoconus arabicus Choffatella decipiens		Choffatella decipiens		Orbitolina discoidea-conoidea	O. concava subsp.	Oligostegina/ Hed. washitensis	
NEOCOMIAN			APTIAN			ALBIAN			CEN.		Kalandari 1976 S.W. Iran
Pseudocycl. lituus & Pseudochrysalidina arabica			Choffatella decipiens & Pseudocycl. rugosa			Orbitolina discoidea-conoidea & O. lenticularis			Hed. washitensis & Hemicycl. sigali		
BERR.-VALAN	HAUT.	BARR.	APTIAN					ALBIAN			Present work
Pseudochrysalidina (D.) arabica	Pseudocycl. lituus	Choffatella decipiens	Schackoina gandolfii	Gls. cf. texanensis	Hedbergella sp.	Favosella washitensis					
		Lenticul. nodosa	Gavelinella barremiana	Quasispir. alexanderi	Saracenaria frankel	Gls. barri	Marsonella subtrochus	Frondicu. filocenta	Probeltammina alexanderi	Spiropt. annectens	Hemicycl. sigali

Fig. 4 — Biostratigraphy of the Lower Cretaceous according to different Authors.

Of the 10 benthonic and planktonic families represented in the Albian assemblages studied, the *Hedbergellidae* and *Ataxophragmiidae* are dominant throughout, while *Polymorphinidae*, *Robertinidae* and *Globigerinelloididae* occur in low percentages. The classification of Foraminifera used here is in accordance with the scheme outlined by Loeblich & Tappan, adapting the 1964 (emended 1974) system for benthonic genera and the recent (1982) classification for planktonic genera.

The author emphasized that a zonation such that here proposed, which incorporates a number of index-species, is preferable to one that considers a single species only, since the areal distribution of Foraminifera tends to be patchy as a result of paleontological factors. The zonal units proposed herein are «interval zones» (International Subcommittee on Stratigraphic Classification, no. 36, July, 15, 1971). Subdivision of these zones into subzones has been attempted and two zones and three subzones were recognized (Fig. 5). Bound-

aries between these zones in many cases coincide with minor, but clear lithological and/or biological changes. Biostratigraphic zones and subzones are defined as follows:

### 1. Hedbergella sp. zone.

Author. New zone.

Definition. The base of this zone is defined by the first appearance of *Hedbergella* sp. Its lower limit is also marked by the co-occurrence of *Hedbergella planispira* and *Eoguttulina anglica*.

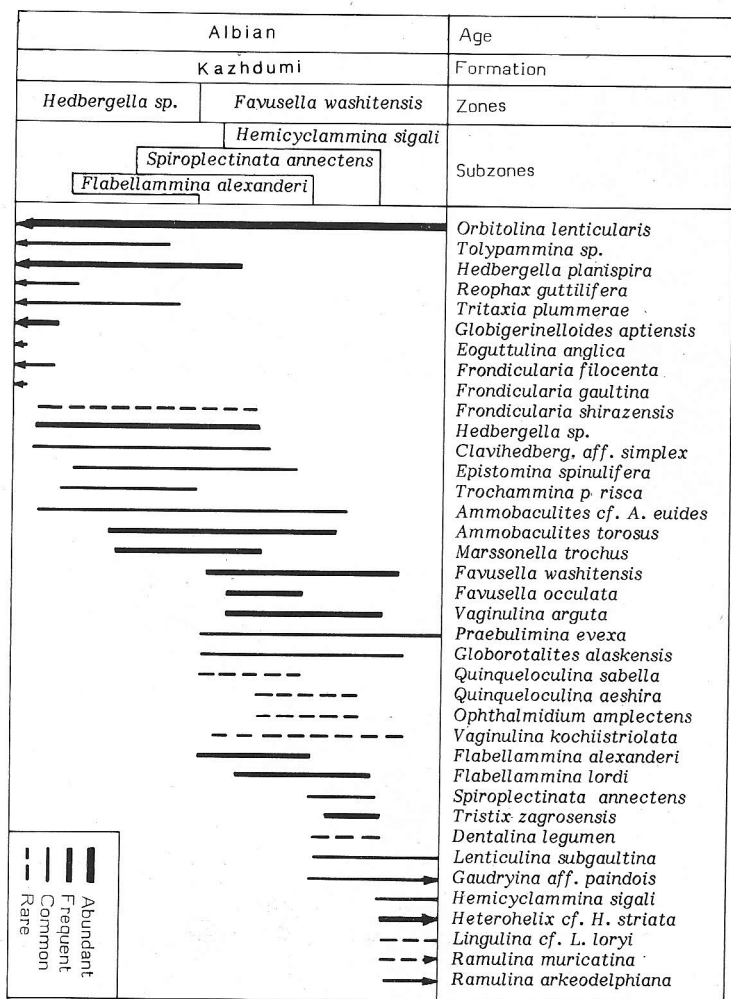


Fig. 5 — Distribution chart of selected species of Albian Foraminifera from the Kazhdumi Formation, SW Iran.

Age. Early Albian.

Remarks. *Hedbergella* sp. is very close to *Hedbergella sigali*. The other important features of this zone are:

- a) the abundance of *Hedbergella* sp., *H. planispira*, *Clavihedbergella* aff. *simplex*, and *Marssonella trochus*;
- b) the sudden appearance of abundant *Oligostegina*;
- c) the first occurrence of *Epistomina spinulifera*, *Trochammina prisca* sp. nov., *Ammobaculites* cf. *euides*, and *A. torosus*.

Adams et al. (1967) recorded *Oligostegina* assemblages in the Bangestan Group (Albian–Campanian) from Lurestan province, NW Iran. *A. torosus* has been recorded from the Albian of Australia (Crespin, 1963), and the Middle Albian of Texas (Frizzell, 1954).

## 2. *Favusella washitensis* zone.

Author. Michael (1972).

Definition. The base of this zone is placed at the appearance of members of the genus *Favusella*, particularly the species *F. washitensis*.

Age. Late Albian.

Remarks. Michael (1972) described *F. washitensis* assemblage zone from the Albian of the Washita Group of N Texas. Some of the Michael's zonal species are similar to those here recognized. This zone correlates with the *Hemicyclammina sigali* zone (Kalantari, 1976), and also with a part of *Oligostegina/H. washitensis* zone (Sampò, 1969). This zone can be divided into three subzones, as follows:

### 2.1. *Flabellamina alexanderi* subzone.

Author. New subzone.

Definition. The lower limit of this subzone is marked by the first appearance of a number of species: *Flabellamina lordi* sp. nov., *Praebulimina evexa*, *Vaginulina arguta*, and *Globorotalites alaskensis*.

Remarks. Other species such as *Quinqueloculina aeshira* and *Q. sabella* occur together throughout this subzone.

### 2.2. *Spiroplectinata annectens* subzone.

Author. New subzone.

Definition. The lower limit of this subzone is marked by the first occurrence of *Spiroplectinata annectens* and *Tristix zagrosensis* sp. nov.

Remarks. Other events are the first occurrence of *Dentalina legumen*, *Lenticulina subgaultina*, and *Gaudryina* aff. *painoides*. The last two species have been recorded by Cushman (1946) from the Cenomanian of Texas. The extinction of a number of species such as *Flabellamina lordi* sp. nov. and *Vaginulina arguta* occurs at the top of this subzone.



### 2.3. *Hemicyclammina sigali* subzone.

Author. Sampò (1969).

Definition. The lower limit of this subzone is placed immediately above the stratigraphic disappearance of *H. planispira*, *D. legumen*, and *Lenticulina subgaultina*.

Age. This subzone is considered here as the top of the Albian stage.

Remarks. *Hedbergella planispira* is one of the most commonly cited middle Cretaceous planktonic foraminiferal species. It has been recorded from the Late Albian—Early Turonian strata of Texas, Mexico, S Dakota, Wyoming and Kansas. This species is also reported in Albian—Cenomanian strata of USSR, England, and Germany, in the Late Aptian—Early Campanian of Trinidad, and in the Santonian and Campanian of W Australia. The disappearance of this species in the Late Albian of SW Iran should be a local event.

Sampò (1969) recorded *Hemicyclammina sigali* subzone in the interval from the Upper Albian to Cenomanian from Kun-e-Dinar, SW Iran, on the basis of the first stratigraphic appearance of a number of species, such as *Hemicyclammina sigali*, *Heterohelix* cf. *H. striata*, and *Ramulina* or *Keodelphina*.

### Conclusions.

The stratigraphic sequence investigated deals with the Kazhdumi Formation belonging to the Bangestan Group from the Zagros area. Lithologic and petrographical studies showed that the sequence consists almost completely of carbonate rocks. The Kazhdumi Formation is somewhat argillaceous, consisting of marl and marly limestone. The present writer divided the Kazhdumi Formation into three members. Thirty eight species and subspecies (of which 5 are considered to be new) belonging to 31 genera and 10 families are recorded. Foraminiferal assemblages suggest an Albian age for the Kazhdumi Formation. The microfossils show a close relationship both in morphological features and in order of appearance with those of similar age occurring in the Tethys and other regions. Diagnostic microfossils have been used for establishing a tentative assemblage zonal scheme for the Kazhdumi Formation. Two zones and three subzones were recognized.

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## REFERENCES

- Adams T.D., Khalili M. & Krosrovi Said A. (1967) - Stratigraphic significance of some Oligosteginid assemblages from Lurestan province, Northwest Iran. *Micropaleont.*, v. 13, pp. 55-67, 1 pl., New York.
- Crespin I. (1963) - Lower Cretaceous arenaceous foraminifera of Australia. *Bull. Bur. Min. Res. Geol. Geophys.*, n. 66, pp. 1-110, 18 pl., 2 tab., Canberra.
- Cushman J.A. (1946) - Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and adjacent areas. *U.S. Geol. Surv. Prof. Paper*, n. 206, 241 pp., 66 pl., Washington D.C.
- Frizzell D.L. (1954) - Handbook of Cretaceous foraminifera of Texas. *Bur. Econ. Geol. Rep. Inv.*, no. 22, 232 pp., 21 pl., 4 tab., Univ. Texas, Austin.
- Henson F.R.S. (1948) - Larger imperforate foraminifera of south-western Asia. Families *Lituolidae*, *Orbitolinidae* and *Meandropsinidae*. *Brit. Mus. Nat. Hist.*, 127 pp., 16 pl., 16 fig., London.
- James G.A. & Wynd J.G. (1965) - Stratigraphic nomenclature of Iranian Oil Consortium Agreement Area. *Bull. Am. Ass. Petrol. Geol.*, v. 49, n. 12, pp. 2182-2245, 98 fig., 1 tab., Tehran.
- Kalantari A. (1969) - Foraminifera from the Middle Jurassic-Cretaceous Succession of Kopet Dagh Region (NE Iran). Unpublished PhD. Thesis, Univ. London, London.
- Kalantari A. (1976) - Microbiostratigraphy of Sarvestan area (SW Iran). NIOC publ. no. 5.
- Loeblich R.A. & Tappan H. (1964) - Treatise on Invertebrate Paleontology. Part C, Protista 2, v. 1, 2. *Univ. Kansas Press Geol. Soc. Am.*, 900 pp., 653 fig., Lawrence.
- Loeblich R.A. & Tappan H. (1974) - Recent advances in classification of foraminifera. In Hedley R.H. & Adams C.G. (Eds.) - *Foraminifera*, v. 1, pp. 1-53, 1 fig., Academic Press, London.
- Loeblich R.A. & Tappan H. (1982) - Classification of the foraminifera. In *Foraminifera*, notes for a short course organized by Buzas M.A. et al. Univ. of Tennessee, Geol. Dept., pp. 22-36.
- Memmi L. & Mamouri A.L. (1974) - Crétacé inférieur du Jebel oust. *Livr. Guide 4th Coll. Micropaleont.*, Serv. Géol. Tunisie, pp. 2-39, Tunis.
- Michael F.V. (1972) - Planktonic Foraminifera from the Comanchean Series (Cretaceous) of Texas. *Journ. Foram. Res.*, v. 2, pp. 200-220, 7 pl., 7 fig., Lawrence.
- Mojab F. (1974) - Some Lower Cretaceous (Albian) invertebrates from Banish, Southern Iran. *Bull. Ind. Geol. Ass.*, v. 7, n. 1, pp. 13-34.
- Salaj J. (1980) - Microbiostratigraphie du Crétacé et du Paléogène de la Tunisie Septentrionale et Orientale. *Inst. Géol. Dionys Star*, 238 pp., 64 pl., 63 fig., 11 tab., Bratislava.
- Sampò M. (1969) - Microfacies and microfossils of Zagros area South western Iran (from pre-Permian to Miocene). *Intern. Sedim. Petrogr. Ser.*, v. 12, 102 pp., 105 pl., E.J. Brill, Leiden.
- Setudehnia A. (1971) - Iran du sud-ouest. *Lexique stratigraphique International* 3, pp. 285-376, Paris.
- Setudehnia A. (1978) - Mesozoic sequence in south western Iran and adjacent area. *J. Petrol. Geol.*, v. 1, pp. 3-24, Beaconsfield.
- Shakib S.S. (1983) - Lower Cretaceous foraminifera of the Banish South West Iran. Unpublished PH.D. Thesis, Univ. London, 338 pp., 17 pl., London.

## PLATE 19

Fig. 1, 2 — *Tolypammima* sp. Side views; x 9.

Fig. 3 — *Reophax guttifera* Brady. Side view; x 60.

Fig. 4, 5 — *Ammobaculites torosus* Loeblich & Tappan. Side and apertural views; 4, x 110; 5, x 300.

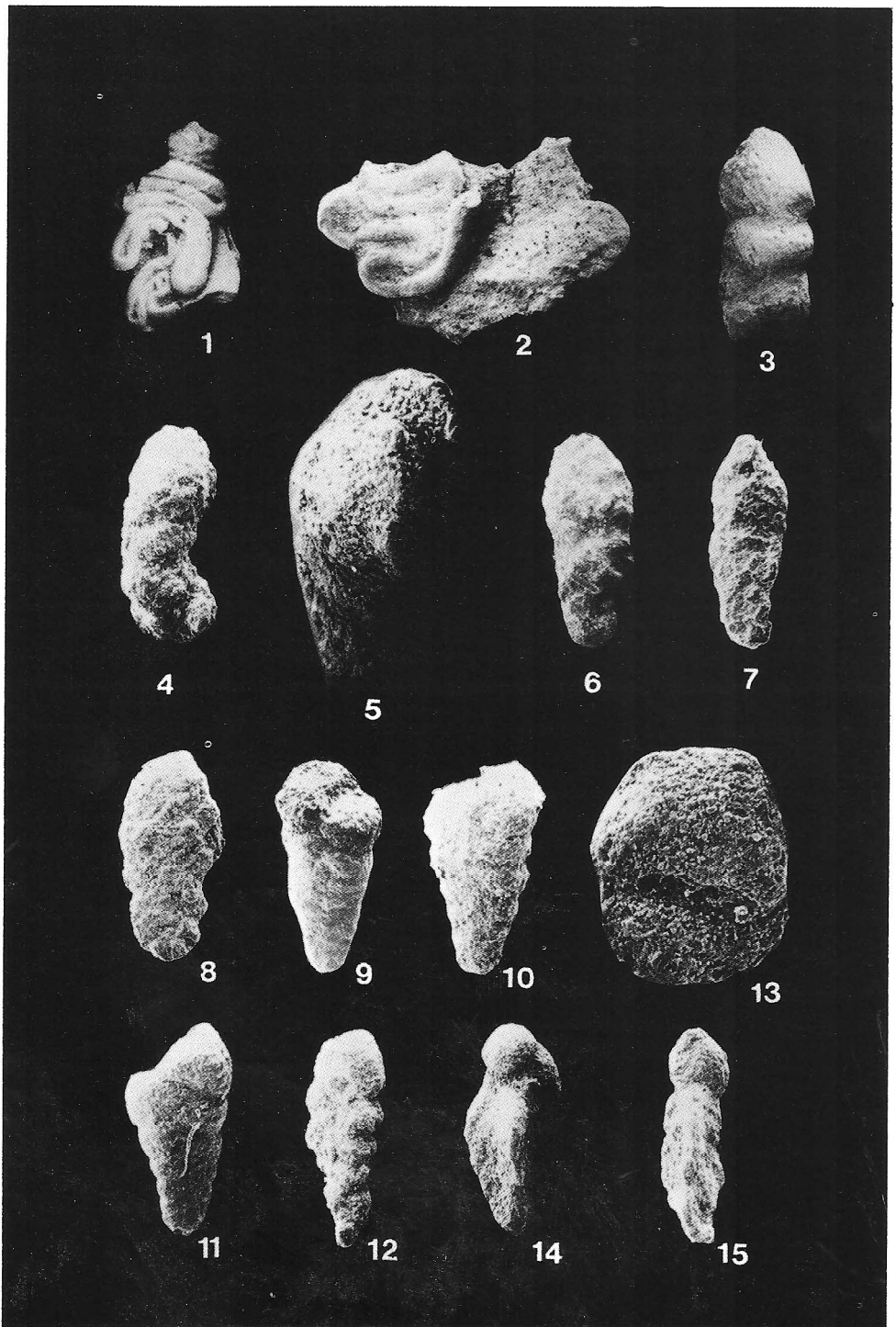
Fig. 6, 7 — *Flabellammima lordi* sp. nov. Side views; 6, x 100; 7, x 75.

Fig. 8 — *Flabellammima alexanderi* Cushman. Side view; x 90.

Fig. 9 - 12 — *Quasispiroplectammima alexanderi* (Cushman). Side and top view; 9, x 20; 10, x 180; 11, x 280; 12, x 150.

Fig. 13 — *Gaudryina* aff. *painoides* Wickenden. Side view; x 150.

Fig. 14, 15 — *Tritaxia plummerae* Cushman. Side views; 14, x 90; 15, x 100.



## PLATE 20

- Fig. 1 - 3 — *Spiroplectinata annectens* (Parker & Jones); x 100.
- Fig. 4 — *Marssonella trochus* (d'Orbigny). Top view; x 132.
- Fig. 5 — *Marssonella trochus* (d'Orbigny). Side view; x 140.
- Fig. 6, 7 — *Orbitolina lenticularis* (Blumenbach). Dorsal views; 6, x 19; 7, x 100.
- Fig. 8 — *Orbitolina lenticularis* (Blumenbach). Edge view; x 52.
- Fig. 9 — *Orbitolina lenticularis* (Blumenbach). Detailed dorsal view; x 70.
- Fig. 10, 11 — *Quinqueloculina sabella* (Loeblich & Tappan). Side views; 10, x 140; 11, x 110.
- Fig. 12, 13 — *Quinqueloculina aeshira* (Loeblich & Tappan). Side views; 12, x 150; 13, x 132.
- Fig. 14 — *Ophthalmidium amplexens* (Loeblich & Tappan). Side view; x 170.



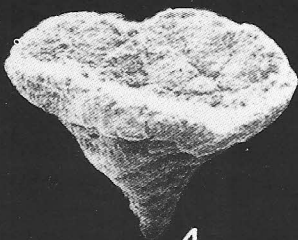
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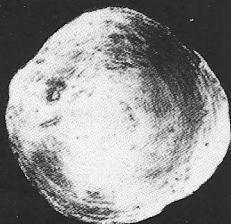
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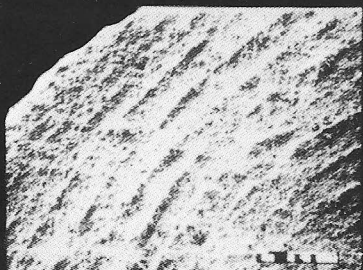
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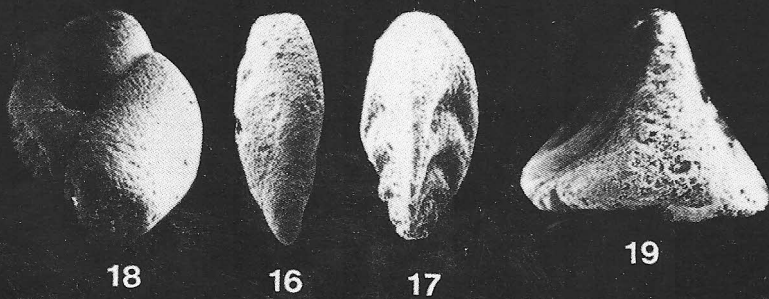
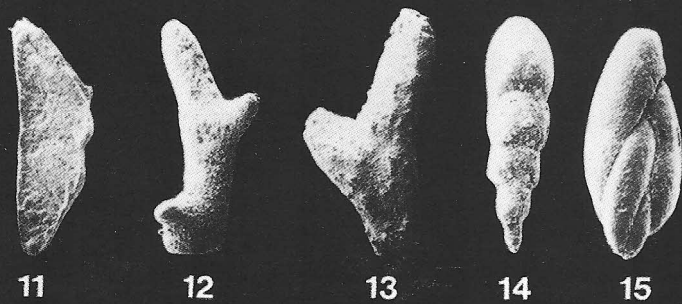
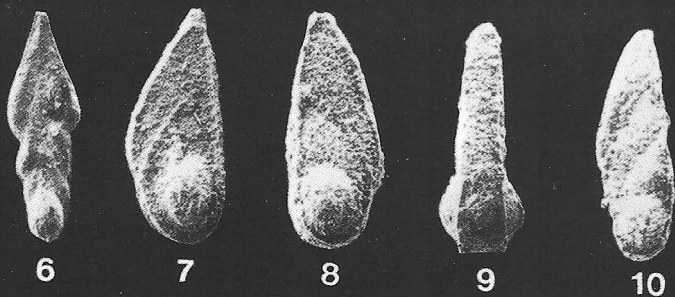
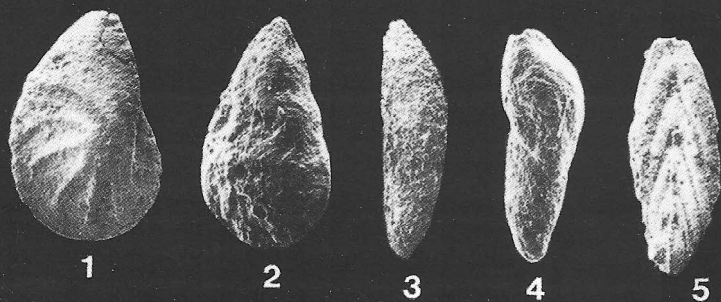
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## PLATE 21

- Fig. 1, 2 – *Lenticulina subgaultina* Bartenstein. Side view; x 85.
- Fig. 3, 4 – *Dentalina legumen* (Reuss). Side views; 3, x 130; 4, x 90.
- Fig. 5 – *Frondicularia gaultina* Reuss. Side view; x 100.
- Fig. 6 – *Frondicularia shirazensis* sp. nov. Side view; x 88.
- Fig. 7 - 9 – *Vaginulina arguta* Reuss. Side and face views; 7, x 100; 8, x 125; 9, x 150.
- Fig. 10 – *Vaginulina arguta* Reuss. Side view; x 100.
- Fig. 11 – *Vaginulina kochiüstriolata* Reuss. Side view; x 55.
- Fig. 12 – *Ramulina arkadelphiana* Cushman. Side view; x 110.
- Fig. 13 – *Ramulina muricatina* Loeblich & Tappan. Side view; x 275.
- Fig. 14 – *Lingulina* cf. *L. loryi* (Berthelin). Side view; x 100.
- Fig. 15 - 17 – *Eoguttulina anglica* Cushman & Ozawa. 15, 17, x 150; 16, x 290.
- Fig. 18, 19 – *Tristix zagrosensis* sp. nov. Side and apertural views; 18, x 110; 19, x 185.





## PLATE 22

- Fig. 1, 2 – *Praebulimina evexa* (Loeblich & Tappan). Side and top views; 1, x 130; 2, x 100.
- Fig. 3 – *Heterohelix* cf. *H. striata* (Ehrenberg). Side view; x 190.
- Fig. 4, 5 – *Heterohelix* cf. *H. striata* (Ehrenberg). Top views; 4, x 500; 5, x 300.
- Fig. 6, 7 – *Globigerinelloides aptiensis* Longoria. Dorsal and edge views; x 140.
- Fig. 8 – *Hedbergella* sp. Dorsal view; x 110.
- Fig. 9 - 11 – *Hedbergella planispira* (Tappan). Dorsal, ventral and apertural views; 9, 10, x 200; 11, x 350.



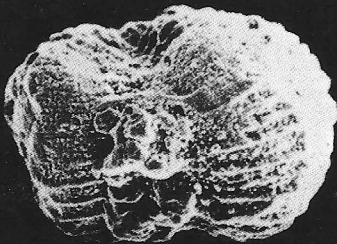
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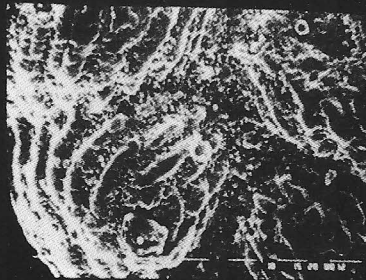
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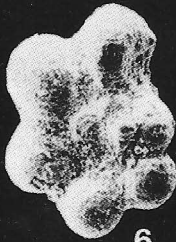
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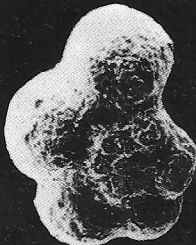
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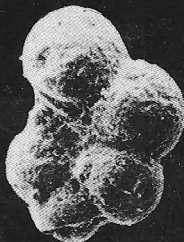
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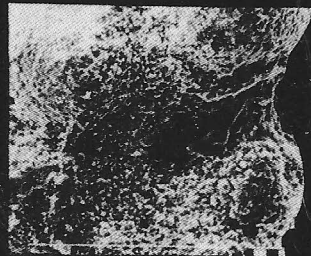
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PLATE 23

Fig. 1, 2 — *Clavihedbergella* aff. *simplex* (Morrow). Ventral and dorsal views; x 200.

Fig. 3, 4 — *Favusella washitensis* (Carsey). Dorsal and ventral views; x 120.

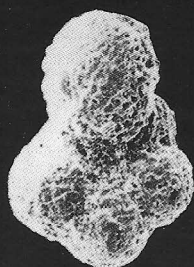
Fig. 5 - 7 — *Favusella occulata* sp. nov. Dorsal, ventral, and edge views; 5, 6, x 90; 7, x 120.

Fig. 8 — *Favusella occulata* sp. nov. Dorsal view; x 130.

Fig. 9 - 11 — *Epistomina spinulifera* (Reuss). Ventral, dorsal and edge views; 9, x 60; 10, x 70; 11, x 130.

Fig. 12, 13 — *Globorotalites alaskensis* Tappan. Dorsal and ventral views; 12, x 230; 13, x 200.

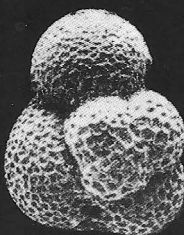
Fig. 14 - 16 — *Hemicyclammina sigali* Maync. 14, 15, x 100; 16, x 145.



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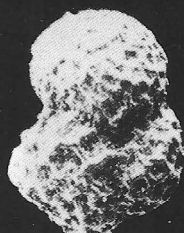
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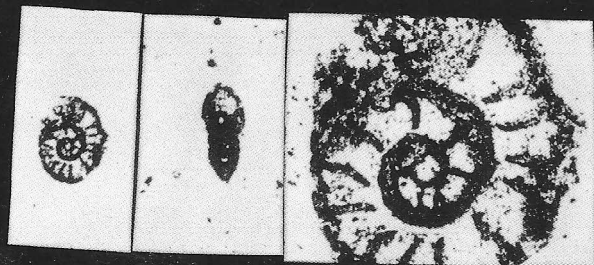
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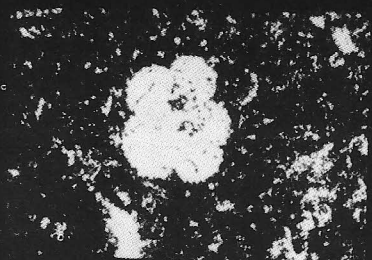
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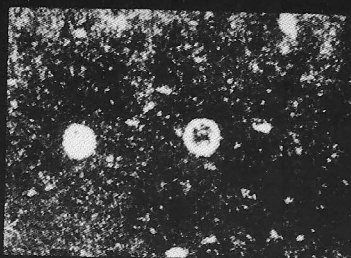
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## PLATE 24

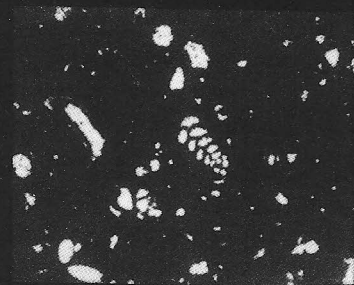
- Fig. 1 — Fossiliferous micrite including *Hedbergella* sp.; x 270.
- Fig. 2 — *Oligostegina* assemblage; x 64.
- Fig. 3 — Fossiliferous micrite including *Quasispiroplectamina alexanderi*; x 33.
- Fig. 4 - 7 — Fossiliferous micrite including *Orbitolina lenticularis* (Blumenbach); 4, x 140; 5, x 180; 6, x 64; 7, x 90.
- Fig. 8 — *Marssonella trochus* (d'Orbigny); x 100.



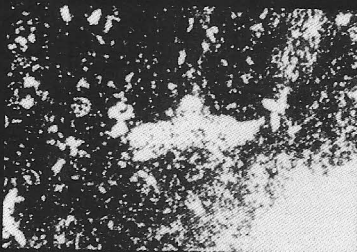
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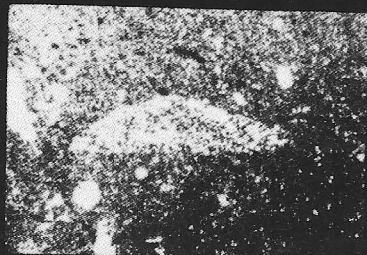
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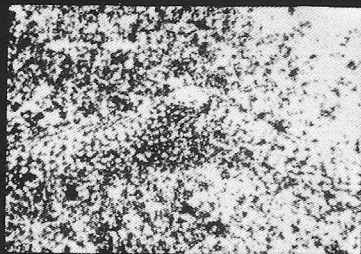
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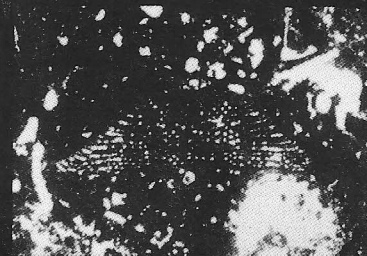
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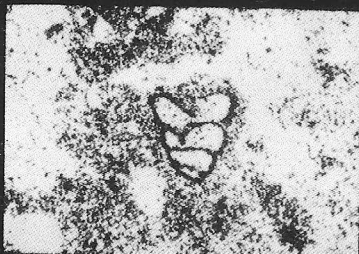
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