Pakistan Journal of Hydrocarbon Research
Vol.3, No.2(July 1991), P.61-79, 5 Figs., 1 Table, 9 Plts.

Foraminiferal Biostratigraphy and Paleoenvironment Interpretation of the Paleocene to Eocene Patala and Nammal Formations from Khairabad-East, Western Salt Range, Pakistan

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ABSTRACT

A shaly and marly sequence of Patala and Nammal formations (Paleogene) in the Khairabad East section (Western Salt Range) bears rich planktonic foraminiferal assemblages. The analysis of 24 samples collected at varying intervals revealed four biozones from Late Paleocene to Early Eocene age. The Patala Formation ranges from the Late Paleocene P6 zone to Early Eocene P8b zone whereas the Nammal Formation extends from P8b zone close or up to the end of the Early Eocene P9 zone. Qualitative and quantitative analysis of planktonic and benthic foraminifers suggest a deposition in open sea fully marine environments and reflect a shifting tendency from upper slope to outer shelf environments for the Patala Formation whereas the Nammal Formation is indicative of middle to outer shelf environments. The zonal scheme for planktonic Foraminifera is applied after Blow (1979).

INTRODUCTION

Paleogene rocks are well developed throughout the Upper Indus Basin. During a field trip in 1989, Paleogene rocks (Lockhart, Patala and Nammal formations) were sampled at the Khairabad East section, Western Salt Range, which is a classic collecting site and an important biostratigraphic reference section because of the abundant and well preserved foraminifers, especially planktonics. The objectives of the investigation are to establish a precise biostratigraphy of the Paleogene lithologic units based on planktonic foraminiferal zonation, to mark the Paleocene/Eocene boundary in the area and to describe the paleoenvironments. Moreover, a correlation with earlier established larger foraminiferal zones is envisaged.

LOCATION AND GEOLOGY

The Salt Range composite orocline (Sarwar and DeJong, 1979) forms the southern limit of the Kohat-Potwar depression. The orocline is an upthrown block of a low angle thrust fault (Seeber and Jacob, 1977) having five prominent bends including an acute bend around the Kalabagh fault known as Mianwali re-entrant. The Khairabad East section, located east of Kalabagh fault approximately at Lat. 71° 38′ 15″ and long. 32° 52′ 30″ is situated about 20 km. north of Mianwali and approximately 3 km. east of Khairabad (Figure 1). Throughout the orocline, the formations are exposed in considerable thicknesses and extend below the Kohat-Potwar depression where the Patala Formation is considered as a potential source rock (Raza, 1973).

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STRATIGRAPHY

A generalized stratigraphic sequence of the area is given in Figure 2. Sedimentation began from Precambrian and lasted until Pleistocene with several interruptions in deposition but the rocks exposed in the Khairabad East section range from Paleocene to Pleistocene. A brief description of the sampling units is given.

Lockhart Limestone (Paleocene)

The unit is light to medium grey, medium bedded, hard, nodular, fossiliferous limestone with some grey marl intercalations. The unit is approximately 130m thick in the nearby area of Khairabad East section (PPL, 1969) and conformably underlies the Patala Formation.

Patala Formation (Paleocene)

The Patala Formation consists of shale and marl with subordinate limestone and minor sandstone. The shale is medium/dark grey to blackish, in places carbonaceous and approximately 30m thick in the sampling area.

Nammal Formation (Eocene)

The formation consists of alternating layers of shale, marl and limestone. The shale is greenish to olive green, the marl is light/medium grey to brown while the limestone is

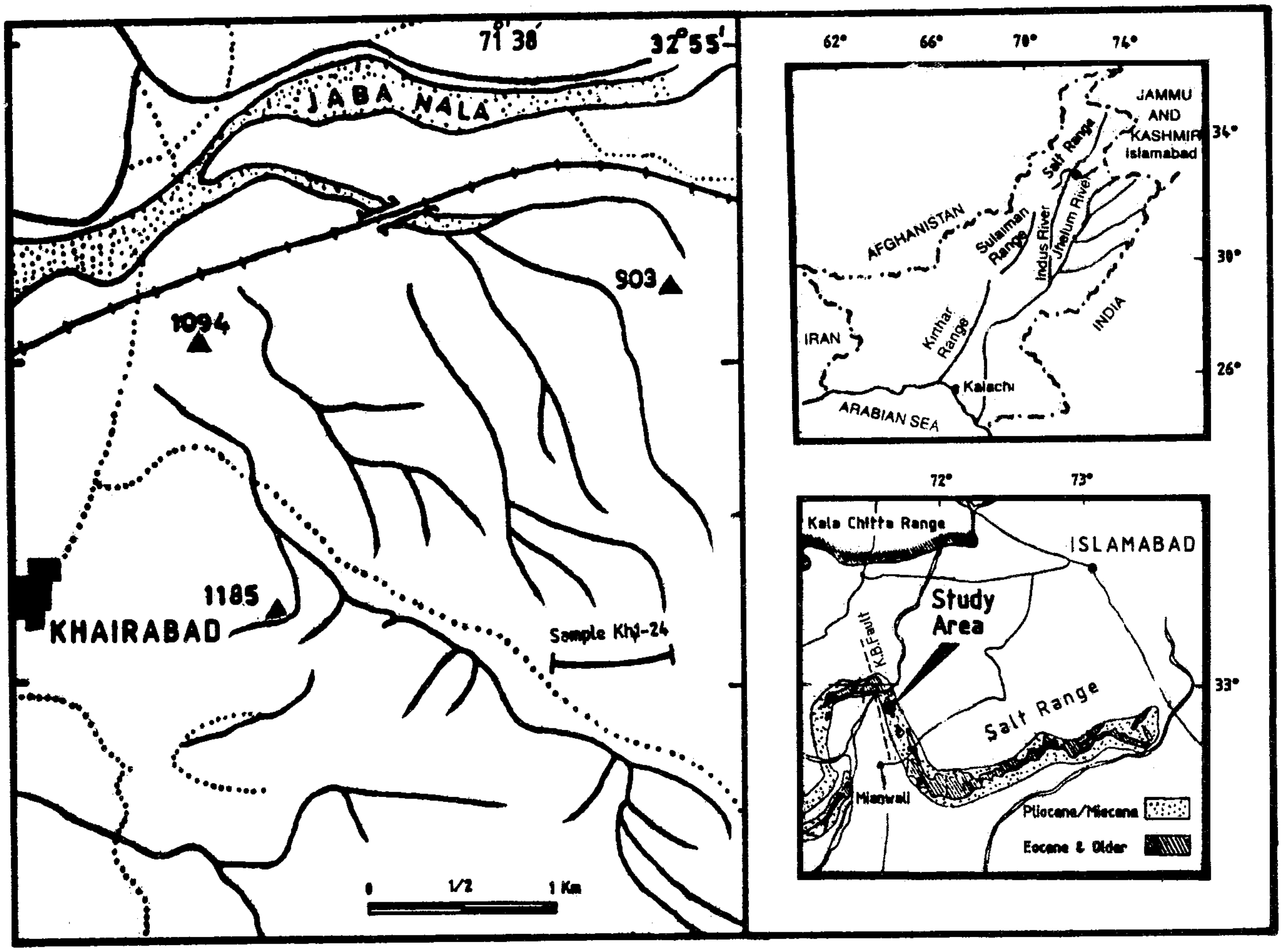


Figure 1— Location map of the study area with sampling location. (topo sheet no. 38P/9).

light grey to bluish grey. The unit is 60 m thick in the Khairabad area (Shah, 1977). Above the Nammal Formation a few metre thick layer of gypsum is present which is being quarried.

SAMPLING, PREPARATION AND ILLUSTRATIONS

During March 1989, an HDIP-BGR party collected 26 samples (Kh1-24) from Lockhart Limestone, Patala and Nammal formations of Paleogene age at varying intervals. A lithologic column with approximate sampling locations and respective lithologies is given in Figure 3. Almost all the samples consist of shale and marl. About 250 grams of each sample were soaked in hydrogen peroxide (H_2O_2) and water for 10-12 hours. A few drops of ammonium hydroxide (NH_4OH) were added to neutralize the acidic reaction. The samples were washed on a 90μm sieve. Washed residues were dried at 60-80 °C and treated in an ultrasonic bath for 15 minutes to clean the fossils. Then the material was finally washed and dried. Nine planktonic foraminiferal plates are attached. Four plates (1-4) were prepared with Scanning Electron Microscope (SEM) photographs at Bundesanstalt für Geowsissenchaften und Rohstaffe (BGR), Hannover, Germany, while the other five plates (5-9) were prepared by simple photographic camera at HDIP.

PREVIOUS WORK

Numerous publications are available on the Paleogene foraminiferal biostratigraphy i.e. Davies and Pinfold (1937), Haque (1956), Smout & Haque (1956), Raza (1967), Cheema (1968), Khan (1969) and Latif (1970). All of them described the smaller and larger benthic foraminifers with some occasionally present planktonic foraminifers. Weiss (1988) made the first attempt to establish the biostratigraphy based on planktonic zonation.

BIOSTRATIGRAPHY

The biostratigraphic results are based on the study of 24 samples including one from Lockhart Limestone, eleven from the Patala Formation and fourteen from the Nammal Formation. The samples are quantitatively rich in

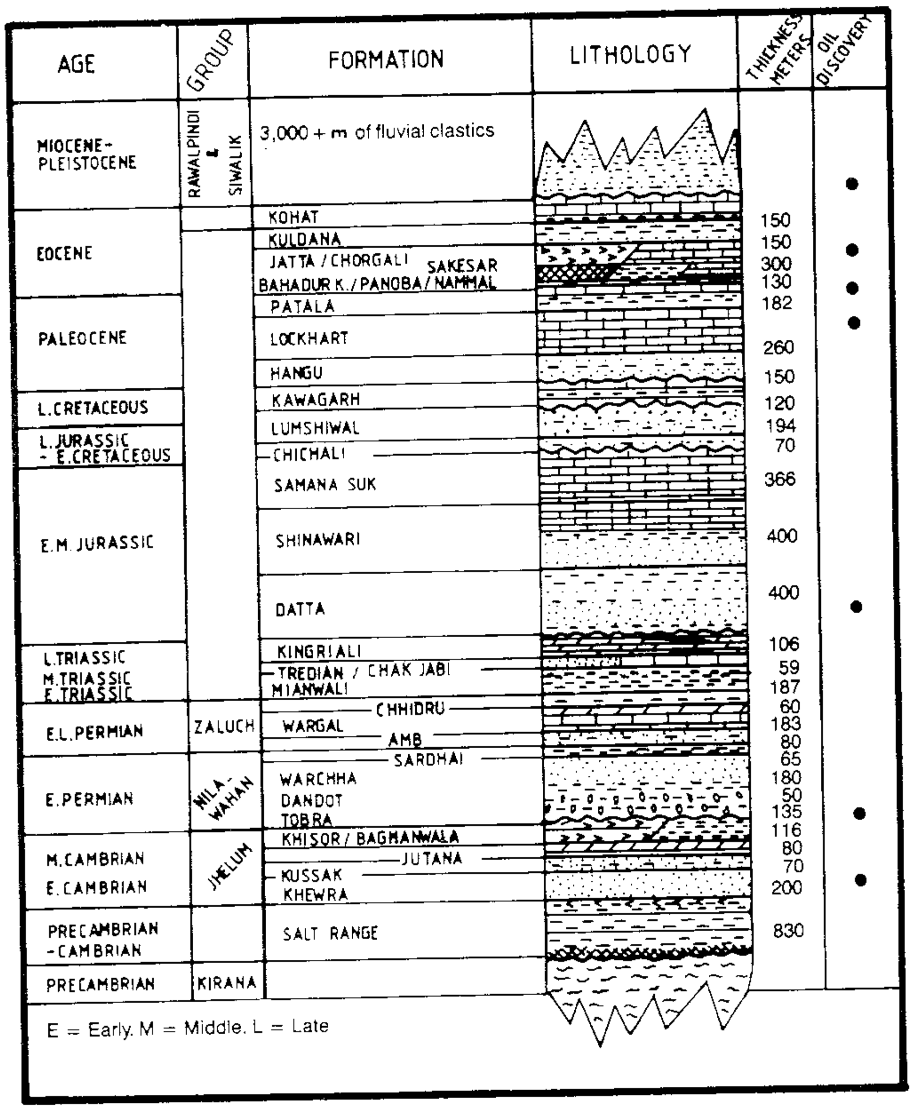


Figure 2— Generalized lithostratigraphic column of the Salt Range and Kohat-Potwar depression (after Khan et al, 1986).

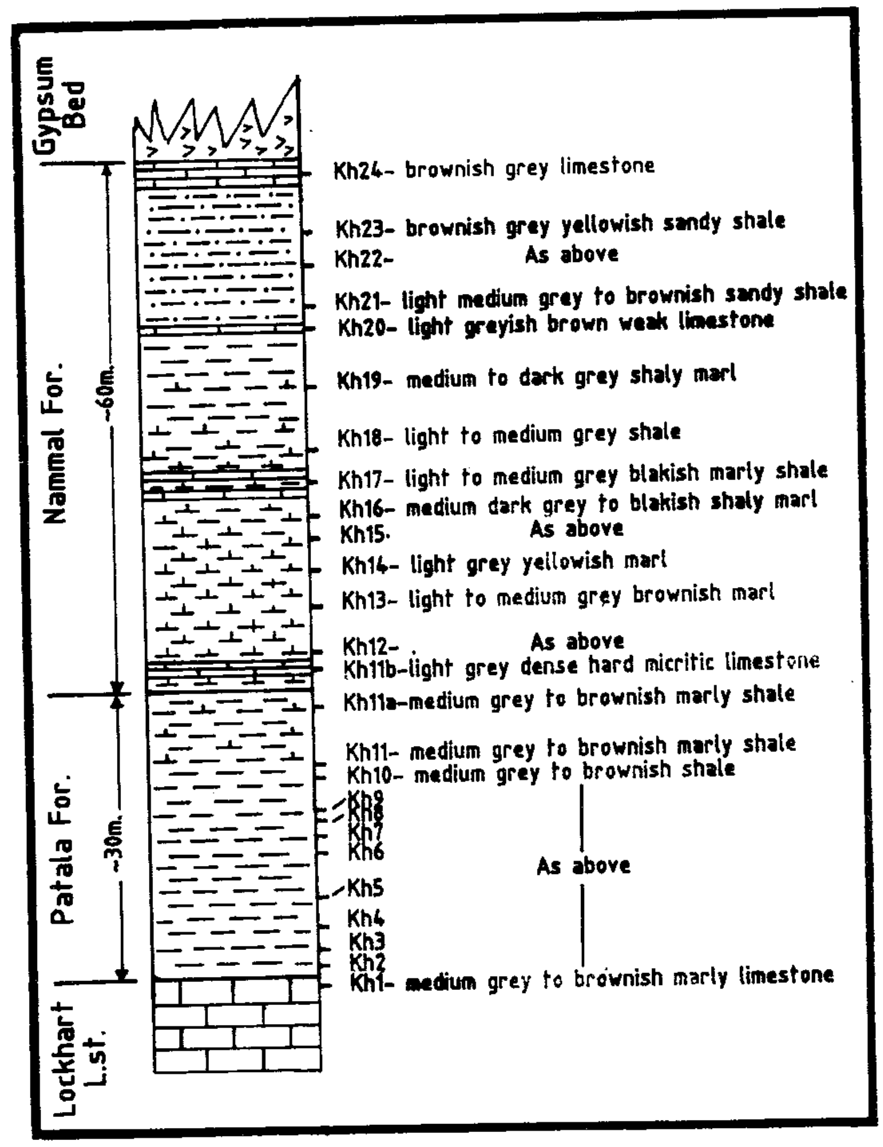


Figure 3—Lithologic column with sampling locations and lithologies.

planktonic foraminifers. A foraminiferal distribution chart comprising about 50 planktonic and 85 benthic (larger and smaller) foraminiferal species with their relative abundance is given in Figure 4. Planktonic foraminifers are identified after Blow (1979) and Bolli et al, (1985), smaller benthic foraminifers after Haque (1956), whereas the larger benthic foraminifers are identified after Nuttall (1926), Davies and Pinfold (1937) and Smout (1954). Following the zonation scheme of Blow (1979), four successive biozones have been identified which are mentioned below (Figure 4), their comparison with Berggren and van Couvering (1974) and Bolli et al (1985) is shown in Table 1.

4) *Acarinina aspensis/Globigerina lozanoi prolata* Zone-**P9** (sample Kh16-21)

3.ii) *Morozovella aragonensis/M. formosa* Subzone-**P8b** (sample Kh11-14)

3.i) *Morozovella formosa-M.lensiformis* Subzone-**P8a** (sample Kh9-10)

2) *Acarinina wilcoxensis berggreni* Zone-**P7** (sample Kh6-8)

1) *Morozovella subbotinae subbotinae/M.velascoensis acuta* Zone-**P6** (sample Kh1-5).

The lowest zone (P6) belongs to the Late Paleocene that may extend up to the middle of the next zone (P7) according to Blow (1979), whereas following Bolli (1985), the base of the (*Morozovella edgari*)*M. acuta* zone that coincides well with the base of the P7-zone of Blow (1979), marks the horizon from where Early Eocene begins. The upper two and a half zones cover the whole Early Eocene age. Along with the long range planktonic foraminifers, very rare occurrences of the Middle Eocene marker species, *Subbotina aff.crociapertura* and *S.aff. frontosa frontosa* in samples Kh22-23 have been encountered. The latter one is the marker species of the base of the *Subbotina frontosa frontosa* Zone-P10 of Blow (1979). Due to the rare occurrence and doubtful identification the zone can not be established clearly, however, their occurrence is puzzling. Certain foraminiferal species, e.g. *Turborotalia pseudoimitata* Blow (1979) and several *Acarinina* species are for the first time recorded from Pakistan Tertiary sediments. The result based on the Blow (1979) zonation can be summarized as follows: The Patala Formation ranges in age from Late Paleocene to Early Eocene whereas the Nammal Formation extends close or upto the end of the Early Eocene at the Khairabad East section.

PALEOENVIRONMENTS

Paleoenvironmental interpretations are generally based on the qualitative and quantitative analysis of planktonic

Table 1. Correlation of Paleogene zonation given by different authors (after Weiss, 1988).

Epoch: Early Tertiary (pars)

Epoch	Age m.y.		Plankt. foraminiferal zones (BERGGREN + VAN COUVERING 1974)		Datum planes	
Early Tertiary (pars)	33	Eocene, Late	P17	G. gortanii - Gr. centralis	L	Hantkenina
		Eocene, Late	P16	Cr. inflata	L	mexicana
		Eocene, Late	P15	Ga. mexicana	L	lehneri - rohri
		Eocene, Middle	P14	Tr. rohri - G. ita houei		
		Eocene, Middle	P13	O. beckmanni		
		Eocene, Middle	P12	G. lehneri		
		Eocene, Middle	P11	Ga. kugleri	F	lehneri - topilensis
		Eocene, Middle	P10	H. aragonensis	F	Hantkenina
		Eocene, Early	P 9	A. densa		
		Eocene, Early	P 8	Gr. aragonensis		
		Eocene, Early	P 7	Gr. formosa	F	aragonensis
		Eocene, Early	P 6 b	Gr. subbotinae - Psh. wilcoxensis	F	Pseudohastigerina
	51		P 6 a	Gr. velascoensis - Gr. subbotin.		
		Paleocene, Late	P5	Gr. velascoensis	L	
		Paleocene, Late	P 4	Gr. pseudomenardii	F	pseudomenardii
		Paleocene, Middle	P 3	Gr. p. pusilla - Gr. angulata	F	angulata
		Paleocene, Middle	P 2	Gr. uncinata - Gr. spiralis	L	daubjergensis
		Paleocene, Early	P 1 d	Gr. compressa - Gr. inconstans / Gr. trinidadensis		
		Paleocene, Early	P 1 c	Gr. pseudobulloides		
		Paleocene, Early	P 1 b	G. triloculinoides		
	65	Paleocene, Early	P 1 a	G. eobulloides		

Plankt. foraminiferal zones (BLOW 1979)		Datum markers	
P17	G. g. gortanii - Gr. (T) centralis	F	gortanii
P16	Cr. inflata	L F	inflata
P15	P. semiinvoluta	F	semiinvoluta
P14	Gr. (M) s. spinulosa	L	beckmanni
P13	Ga. beckmanni	F	
P12	Gr. (M) lehneri	L	boweri
P11	Ga. kugleri - S. frontosa bow.	F	kugleri
P10	S. f. frontosa - Gr. (T) pseudomay.	F	frontosa
P 9	Gr. (A.) aspensis - G. lozanoi prolata	F	aspensis
P 8 b	Gr. (M.) aragonensis - Gr. (M) formosa	F	aragonensis
P 8 a	Gr. (M.) formosa - Gr. (M.) lensiformis	F	formosa
P 7	Gr. (A.) wilcoxensis berggreni	F	wilcoxensis berggr.
P 6	Gr. (M) S. subbotinae - Gr. (M) velasc. acuta	F	subbotinae
P 5	Mg. s. soldadoensis - Gr. (M) velascoens.	F	soldadoensis
P 4	Gr. (Gr.) pseudomenardii	F	pseudomenardii
P 3	Gr. (M.) a. angulata	F	angulata
P 2	Gr. (A.) p. praecursoria	F	praecursoria
P 1 b	Gr. (T) c. compressa / Eog. eobulloides simplicissima	F	compressa
P 1 a	Gr. (T) pseudobulloides - Gr. (T) archaeocompressa	F	pseudobulloides
PIX	Gr. (T) longiapertura	L	Rugoglobigerina

Plankt. foraminif. zones (TOUMARKINE + LUTERBACHER 1985)	Datum markers	
T. cerroazulensis s.l.	L	cerroazulensis s.l.
Gt. semiinvoluta	L	semiinvoluta
Tr. rohri	L	rohri
O. beckmanni	L F	beckmanni
M. lehneri		
Gt. s. subconglobata	L	aragonensis
	F	mexicana s.s.
H. nuttalli	F	Hantkenina
A. pentacamerata	F	cerroazul. frontosa
M. aragonensis	F	pentacamerata
M. f. formosa	F	aragonensis
M. subbotinae	L	(edgari) acuta
(M. edgari) M. acuta	L	velascoensis
M. velascoensis		
Pl. pseudomenardii	L F	pseudomenardii
Pl. pusilla	F	pusilla
M. angulata	F	angulata
M. uncinata	F	uncinata
M. trinidadensis	F	trinidadensis
M. pseudobulloides	F	pseudobulloides
"G" eugubina	F	eugubina

F = First occurrence

L = Last occurrence

and benthic foraminifers. The quantitative approach is based on the carefully assigned frequency classes elaborated in the foraminiferal distribution chart with their respective ranges (Figure 4). The numeric value of each species in a sample depends upon the confidence in estimation/counting. The plankton/benthos ratio, a useful means to estimate the distance from the shore line, is very high in the samples studied (Figure 5) and thus shows an open sea marine paleoenvironment (Grimsdale and van Morkhoven, 1955). Mixed benthic foraminiferal assemblages with low abundance do not allow to characterize the samples in terms of pronounced faunal trends to predict the possible paleoenvironments. Moreover, the deep sea (bathyal and abyssal) fauna changes gradually with water depth mainly in terms of relative abundance rather than in generic or species composition of the assemblage (Saint-Marc, 1986). Therefore quantitative methods are applied for precise prediction of depositional environments that display a shifting tendency from slope environment to middle shelf environment.

Low percentages of agglutinated benthic foraminifers (Figure 5) are explained by the high availability of calcium carbonate (Gradstein and Berggren, 1981) whereas the dominance of calcareous benthics indicates deposition in an area which was well oxygenated and characterized by normal salinity and/or high temperature, (Saint-Marc, 1986).

Except for a few, as the samples are extremely rich in foraminifers, therefore, a small portion (0.02 gm) of dried residue from each sample is counted approximately and the results are converted to show the relative abundance in terms of number of foraminifers per gram of dry sediment. High percentages of planktonic Foraminifera and large numbers of foraminifers per gram of dry sediment indicate good preservation conditions for the fauna and absence of dissolution. These data also confirm the deposition far above the CCD ($CaCO_3$ compensation depth) (Figure 5).

The Fisher index (Alpha index), easily determined from a graph with number of species and number of individuals (Murray, 1973), is a useful tool for characterizing the foraminiferal population in different marine environments. High alpha values (above 7) are indicative of normal marine environments whereas deep bathyal and abyssal environments give values of 10 or greater (Douglas, 1979).

The keeled planktonic genus *Morozovella* gradually decreases in abundance and its complete absence above sample Kh12 plays a meaningful role in paleoenvironmental interpretation because trends from low trochospiral-unkeeled towards high trochospiral-keeled forms reflect successive attempts of colonising at deeper water depth and vice-versa (Hart, 1980) and it is also believed that keeled genera indicate depths greater than 100m (Leckie, 1987) (Figures 4, 5).

Samples Kh2-5 and Kh10-12

High planktonic foraminiferal percentages (98%), low agglutinated benthic foram percentages (30%) and high calcareous benthic percentages (50-70%), high alpha values (above 7) and the presence of the trochospiral-keeled genus *Morozovella* indicate marine outer shelf environments (Figure 5).

Samples Kh6-9

High percentages of planktonic foraminifers (98% of the total foram. count), relatively high percentages of agglutinated benthics (45-70% of the total benthic foram. count), very high alpha values (10) accompanied with high amounts of trochospiral-keeled planktonic foraminifers and the presence of a benthic species closely related to *Gaudryina pyramidata* in sample Kh6 indicative of an upper depth limit largely below 200 meters (Morkhoven et al, 1986) reflect upper slope environments (Figure 5).

Samples Kh13-23

Almost equal abundance of planktonic and benthic foraminifers reflect middle shelf environments. This is supported by the absence of the keeled planktonic genus *Morozovella*. In the sample Kh14, low planktonic percentage and the presence of larger benthic foraminifers indicate shallow water influence which is interpreted as downslope movement and mixing of shallow water deposits with relatively deeper water sediments (Figure 4). The overlying gypsum deposits are rather in favour of the assumption that shallowing of the sea took place in the upper most part of the section.

On the basis of this approach it is reasonable to consider the Patala Formation (samples Kh2-11a) as indicative of open marine outer shelf to upper slope paleoenvironments whereas the Nammal Formation (samples Kh12-23) shows middle to outer shelf paleoenvironments.

DISCUSSION AND CONCLUSION

The foraminiferal biostratigraphy and paleoecology based on the study of 24 samples of Patala and Nammal formations collected in sequence from Khairabad East section, Western Salt Range, produced the following results:

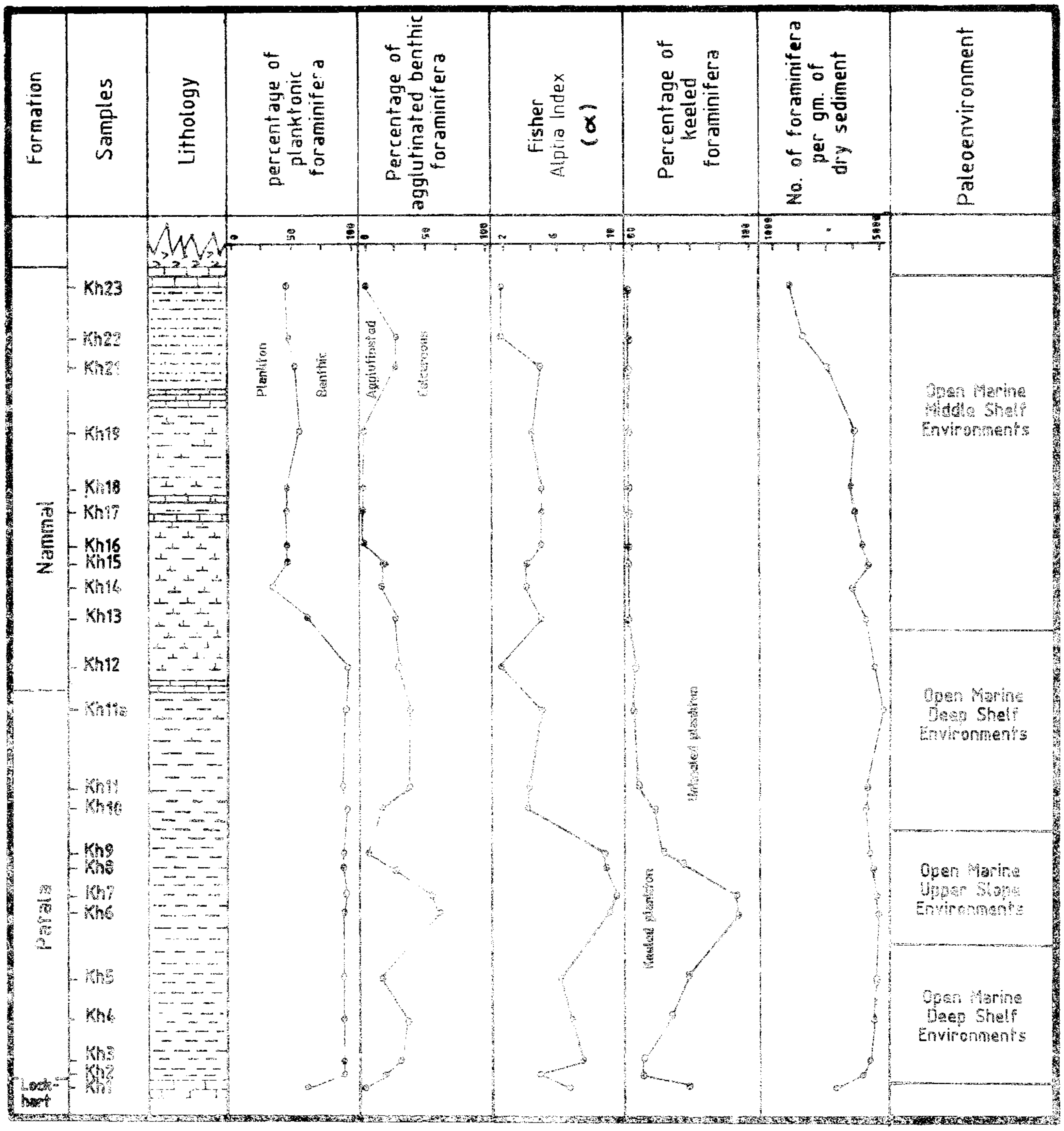


Figure 5— Statistical analysis of foraminiferal assemblages and paleoenvironment interpretation.

Four biozones are identified from *Morozovella subbotinae subbotinae/M. velascoensis acuta* Zone-P6 to *Acarinina aspensis/Globigerina lozanoi prolata* Zone-P9 which indicate a continuous sedimentation from the Late Paleocene to the end of the Early Eocene. The *Planorotalites pseudomenardii* Zone-P4 (Weiss, 1988) was not observed due to an accepted longer range (at least to P6 zone) of *Planorotalites pseudomenardii* according to Blow (1979). Additionally, we did not find any hiatus between the Paleocene and Eocene.

According to the proposed zonations, the Patala Formation which is considered to be restricted to the Late Paleocene age in the Salt Range, continued to deposit up to the middle of the Early Eocene as was reported earlier by Weiss (1988), whereas the Nammal Formation of Early Eocene extends close or up to the end of Early Eocene age and the Paleocene/Eocene boundary lies somewhere in the lower part of the Patala Formation in this area of the Salt Range (Figure 4). The occurrence of the Middle Eocene marker species in top Nammal (samples Kh22-23) is questionable because according to published literature Middle Eocene was not deposited in the Salt Range. Relatively younger ages of Patala and Nammal formations in this area and the two other formations of Early Eocene age (Sakesar and Chorgali) which are not developed here but are present above the Nammal Formation in other areas

DESCRIPTION OF PLATES

PLATE I

1-3 *Morozovella velascoensis occlusa* (Loeblich & Tappan), sample Kh1.
4-5 *Morozovella aequa* (Cushman & Renz), sample Kh1
6-7 *Morozovella acuta* (Toulmin), sample Kh1

PLATE II

1-3 *Morozovella edgari* (Premoli Silva & Bolli), sample Kh4
4-6 *Morozovella subbotinae* (Morozova), sample Kh4
7-8 *Morozovella formosa* (Bolli), sample Kh4

PLATE III

1-2 *Acarinina pseudotopilensis* (Subbotina),sample Kh4
3-4 *Acarinina wilcoxensis wilcoxensis* (Cushman & Ponton), sample Kh4
5-6 *Acarinina wilcoxensis strabocella* (Loeblich & Tappan), sample Kh4

PLATE IV

1-3 *Acarinina nicoli nicoli* (Martin), sample Kh4
4-6 *Turborotalia pseudoimitate* (Blow), sample Kh4
7-8 *Planorotalites chapmani* (Parr), sample Kh4
9 *Pseudohastigerina wilcoxensis* (Cushman & Ponton), sample Kh4

PLATE V

1-3 *Morozovella occlusa occlusa* (Loeblich & Tappan). x84, sample Kh3
4-6 *Morozovella velascoensis velascoensis* (Cushman). x60, sample Kh3
7-9 *Morozovella aequa dolabrata* (Jenkins). x95, sample Kh8
10-12 *Morozovella aragonensis* (Nuttall). x80, sample Kh3

PLATE VI

1-3 *Morozovella marginodentata* (Subbotina). x115, sample Kh6
4-6 *Morozovella velascoensis acuta* (Toulmin). x77, sample Kh3
7-8 *Morozovella quetra* (Bolli). x68, sample Kh10
9-10 *Morozovella formosa* (Bolli). x60, sample Kh10
11-13 *Morozovella subbotinae subbotinae* (Morozova). x25, sample Kh9

PLATE VII

1-3 *Acarinina wilcoxensis berggreni* (El Naggar). x48, sample Kh7
4 *Acarinina pentacamerata* (Subbotina). x45, sample Kh11a
5-6 *Acarinina nicoli nicoli* (Martin). x36, sample Kh4
7-9 *Pseudohastigerina wilcoxensis wilcoxensis* (Cushman & Ponton). x58, sample Kh14
10-12 *Acarinina lodoensis* (Mallory). x91, sample Kh11
13 *Planorotalites chapmani* (Parr). x20, sample Kh3
14-15 *Acarinina camerata* (Khalilov). x68, sample Kh13
16-17 *Acarinina pseudotopilensis* (Subbotina). x55, sample Kh8
18-19 *Acarinina collactea* (Finlay). x28, sample Kh15

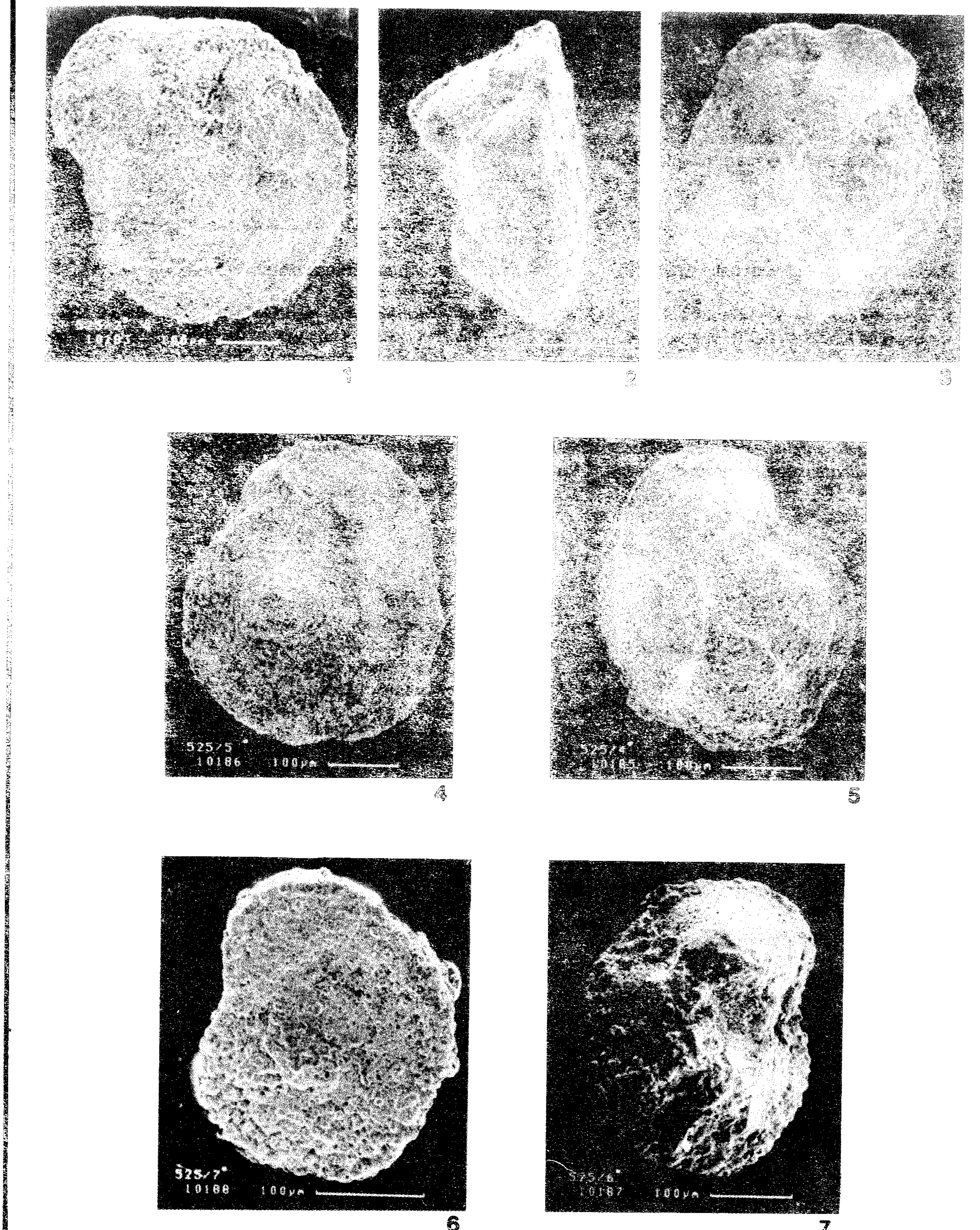
PLATE VIII

1-3 *Acarinina broedermanni broedermanni* (Cushman & Bermudez). x113, sample Kh15
4-6 *Acarinina collactea* (Finlay). x130, sample Kh15
7-9 *Turborotalia griffinae* (Blow). x104, sample Kh15
10-11 *Acarinina aspensis* (Colom). x50, sample Kh15
12-13 *Acarinina wilcoxensis strabocella* (Loeblich & Tappan). x48, sample Kh9

PLATE IX

1-3 *Subbotina lozanoi lozanoi* (Colom). x104, sample Kh15
4-6 *Muricoglobigerina esnehensis* (Nakkady). x103, sample Kh14
7 *Subbotina aff. frontosa frontosa* (Subbotina). x39, sample Kh23
8 *Subbotina inaequispira* (Subbotina). x40, sample Kh12
9 *Subbotina linaperta* (Finlay). x32, sample Kh11a
10 *Subbotina aff. crociapertura* (Blow). x40, sample Kh23
11-12 *Subbotina lozanoi prolata* (Bolli). x46, sample Kh15
13 *Subbotina hornibrooki hornibrooki* (Brönnimann). x20, sample Kh12
14 *Planorotalites pseudoscitula* (Glaessner). x18, sample Kh
15-16 *Muricoglobigerina soldadoensis soldadoensis* (Brönnimann). x20, sample Kh14

PLATE I



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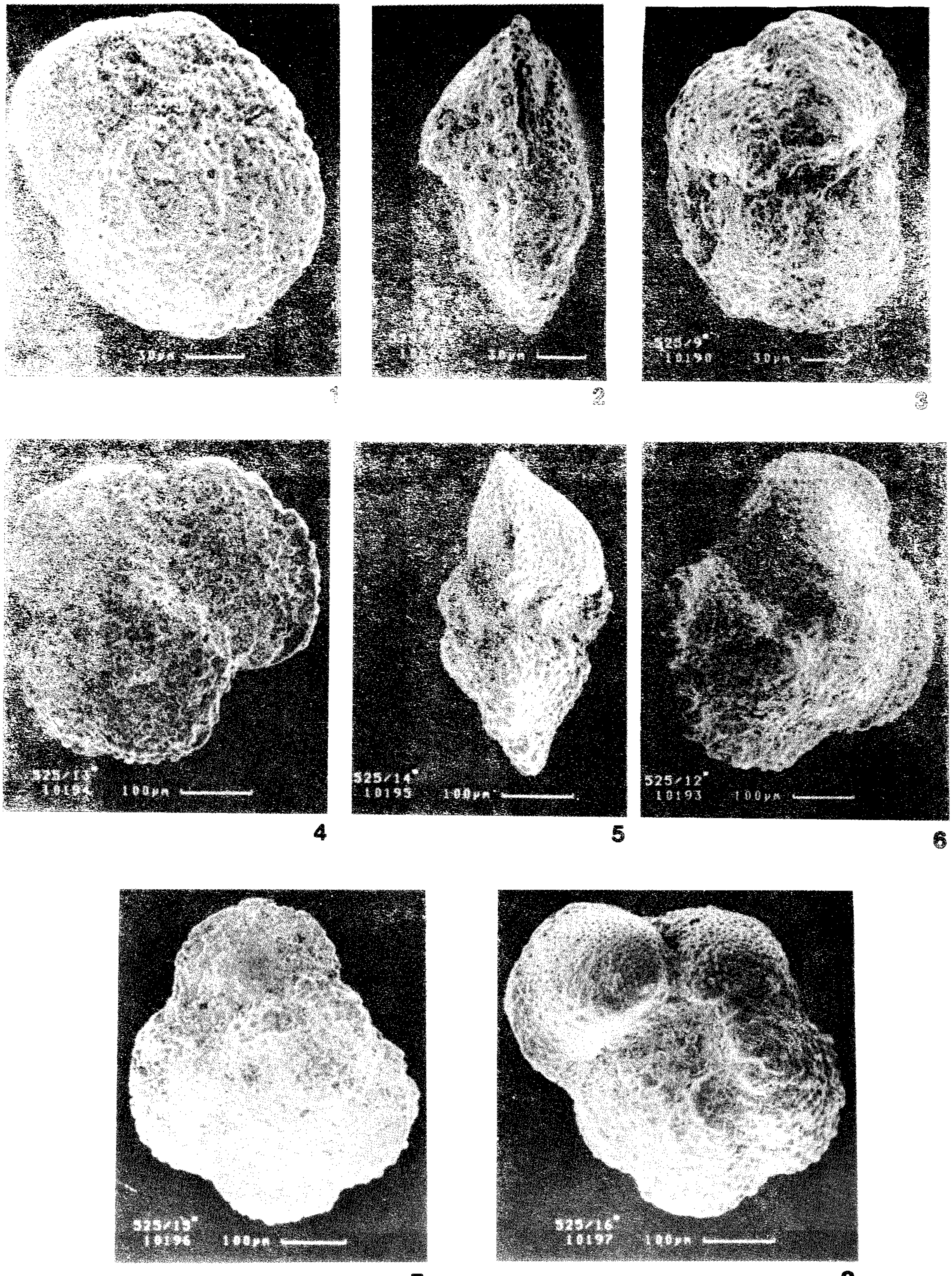
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PLATE III

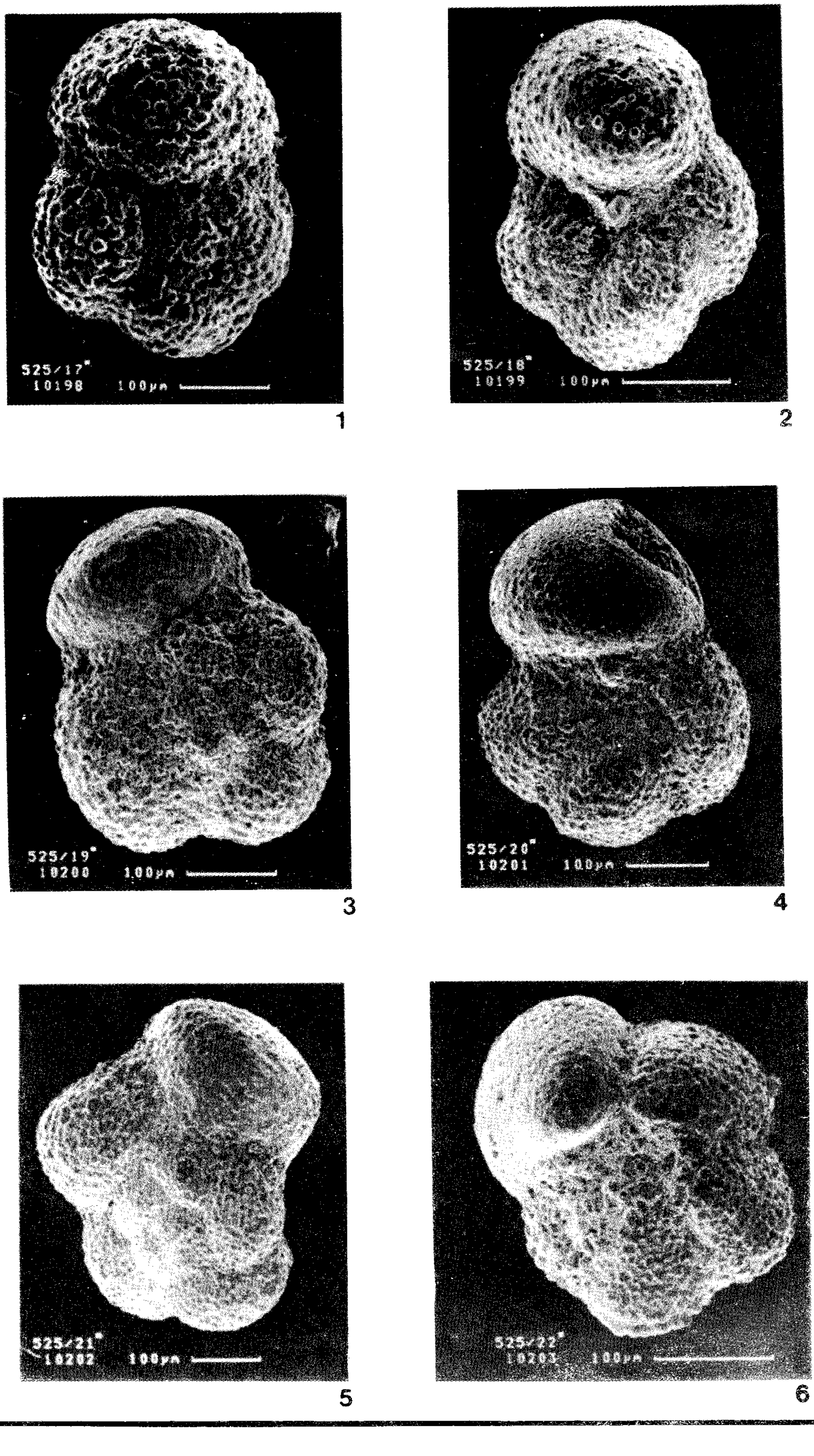
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PLATE IV

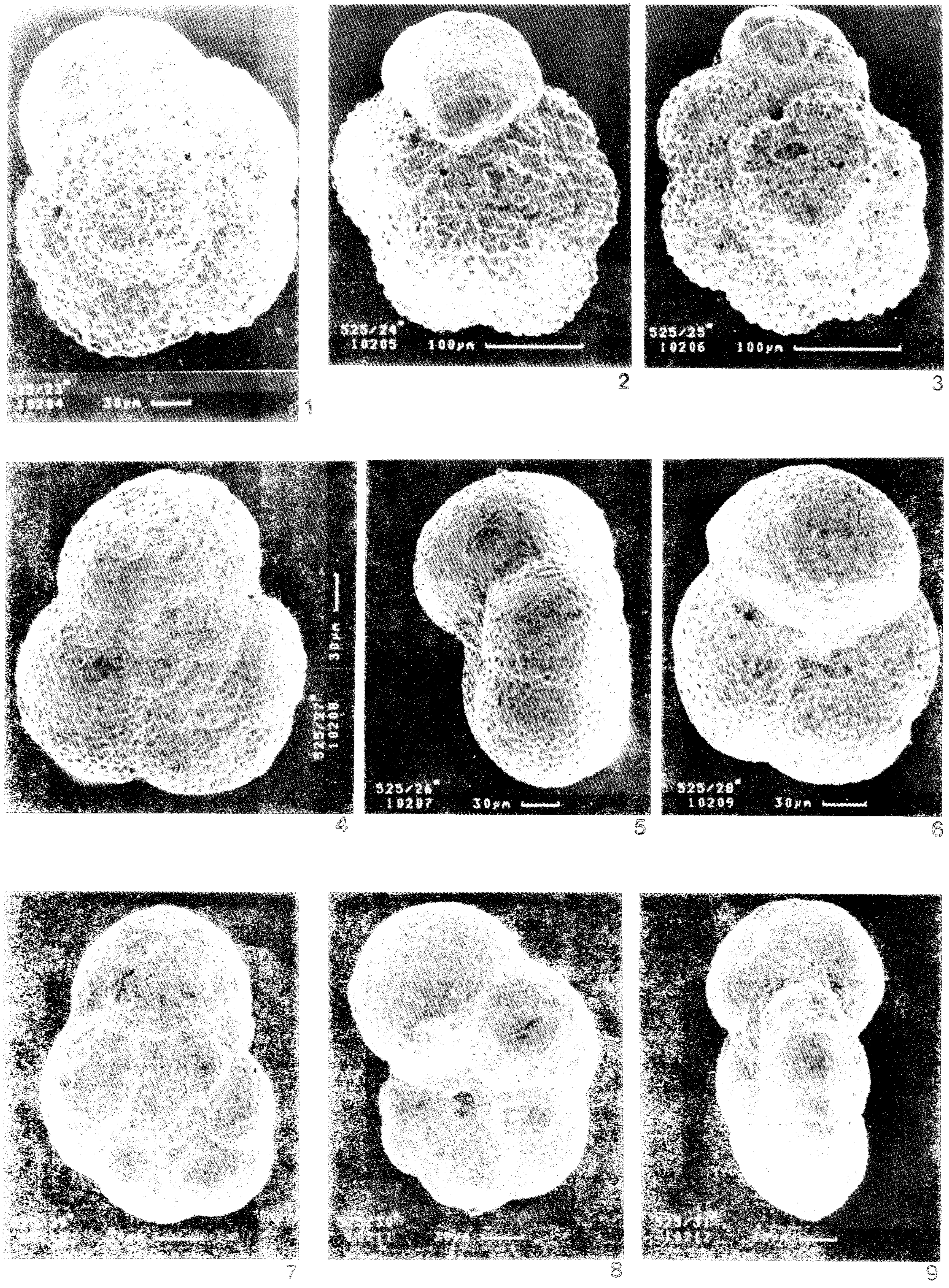
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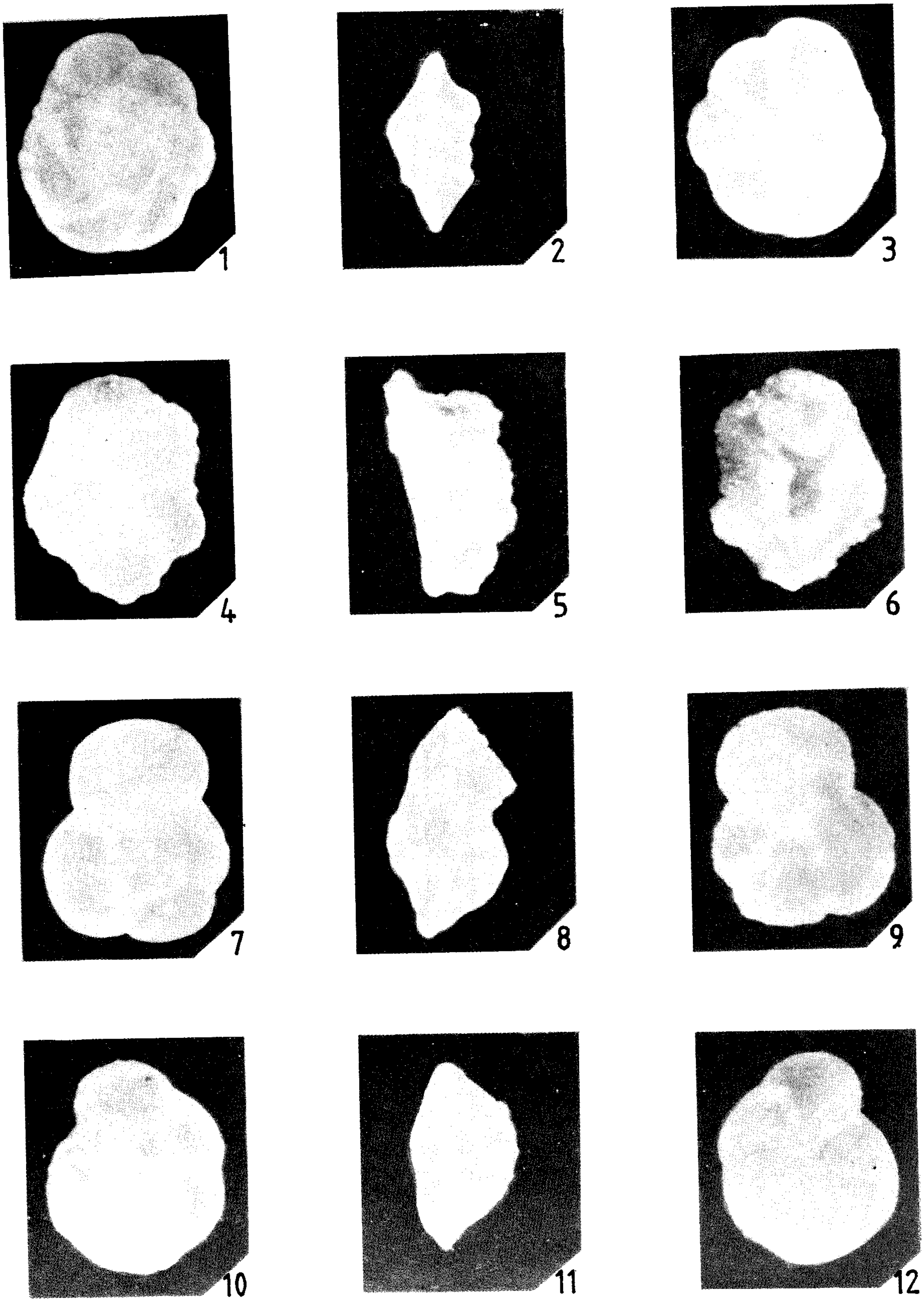
PLATE V



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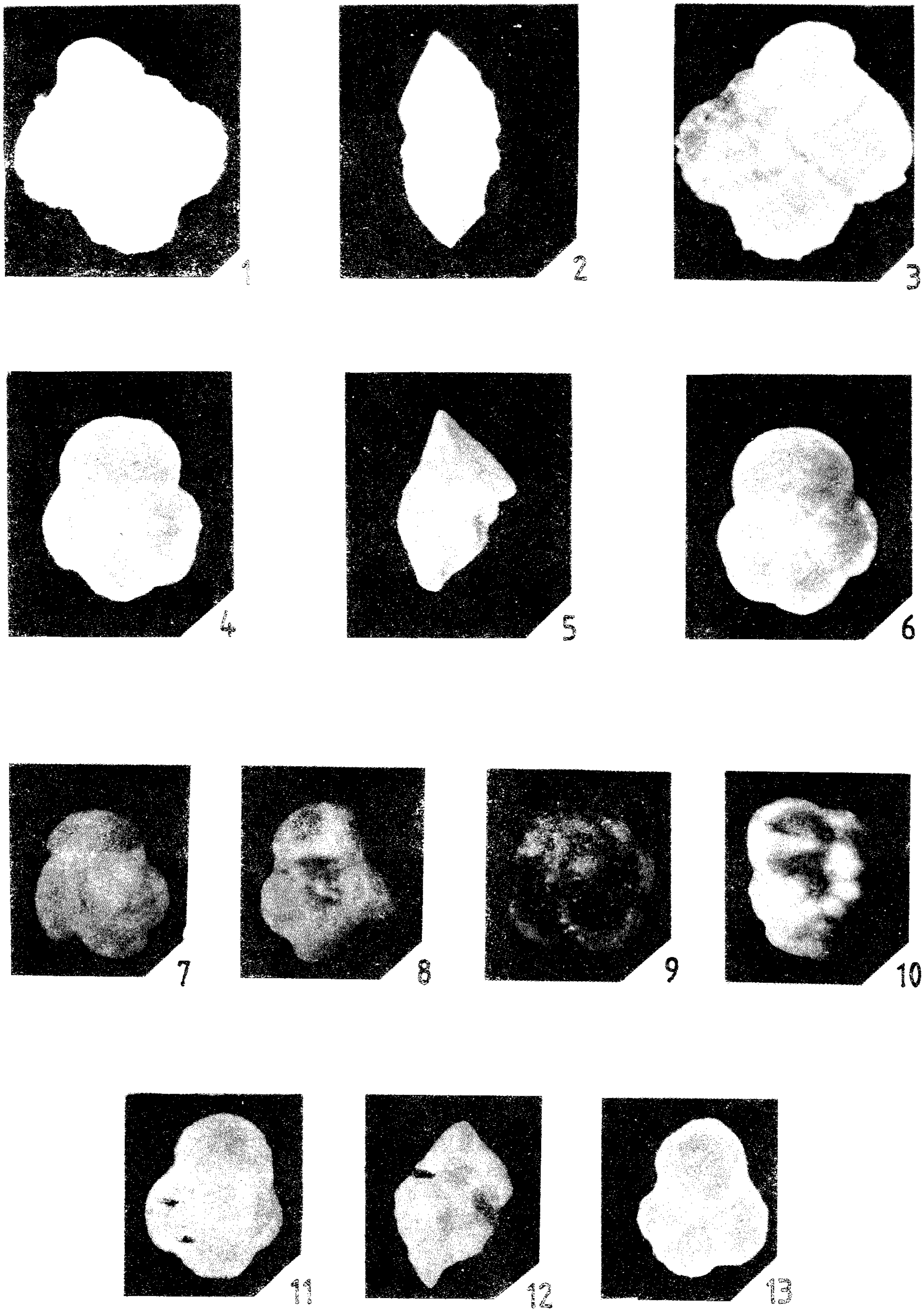

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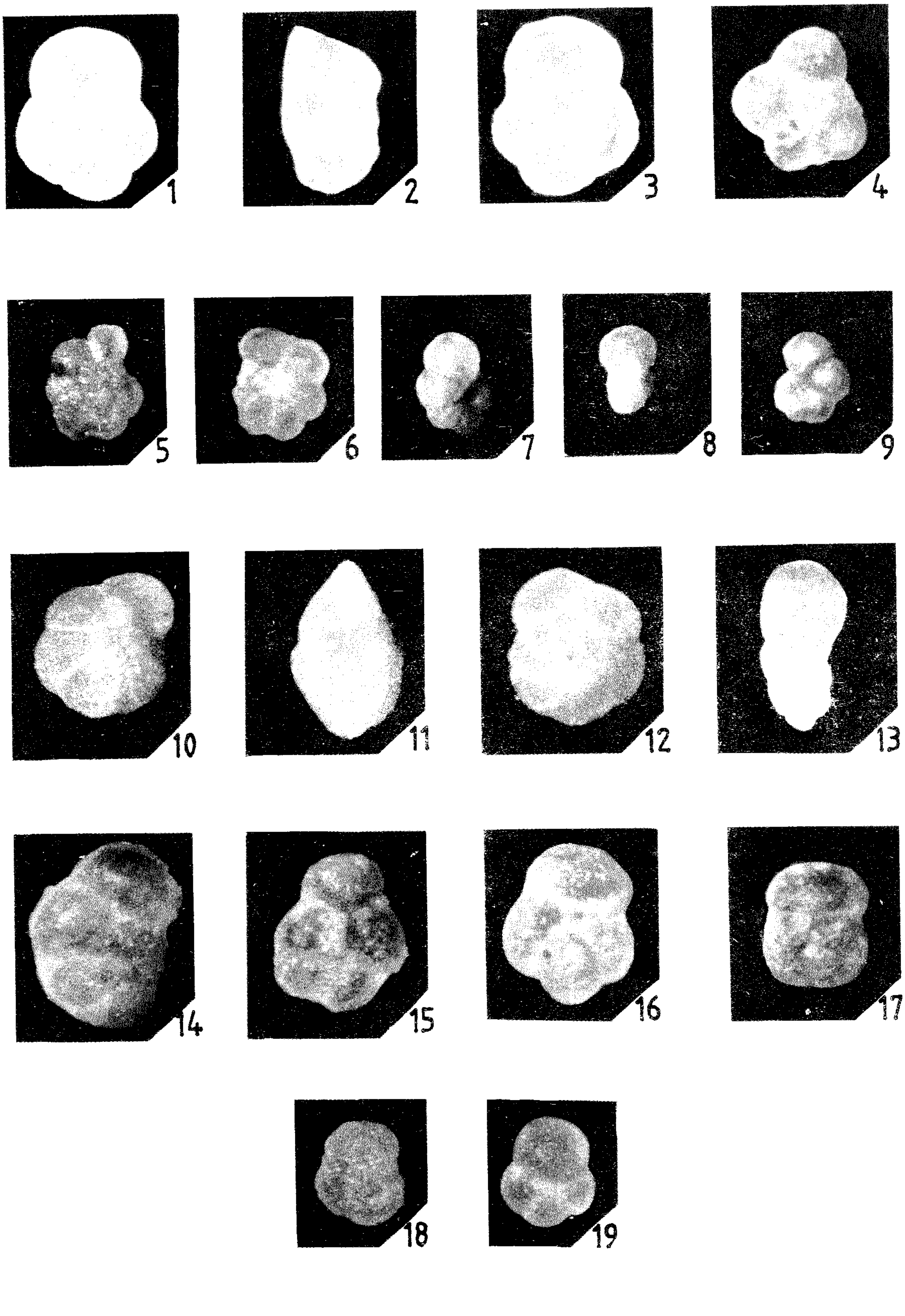

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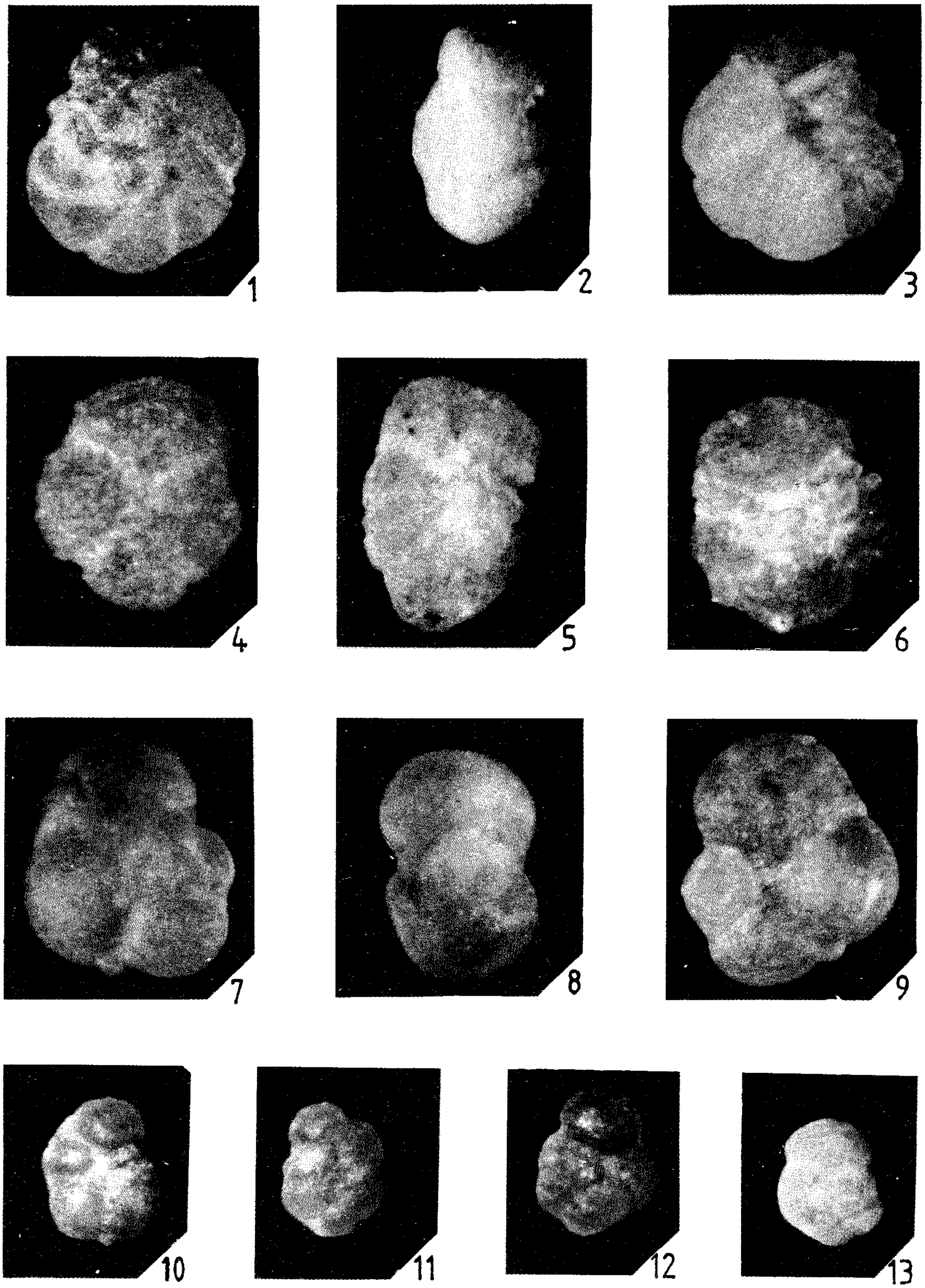
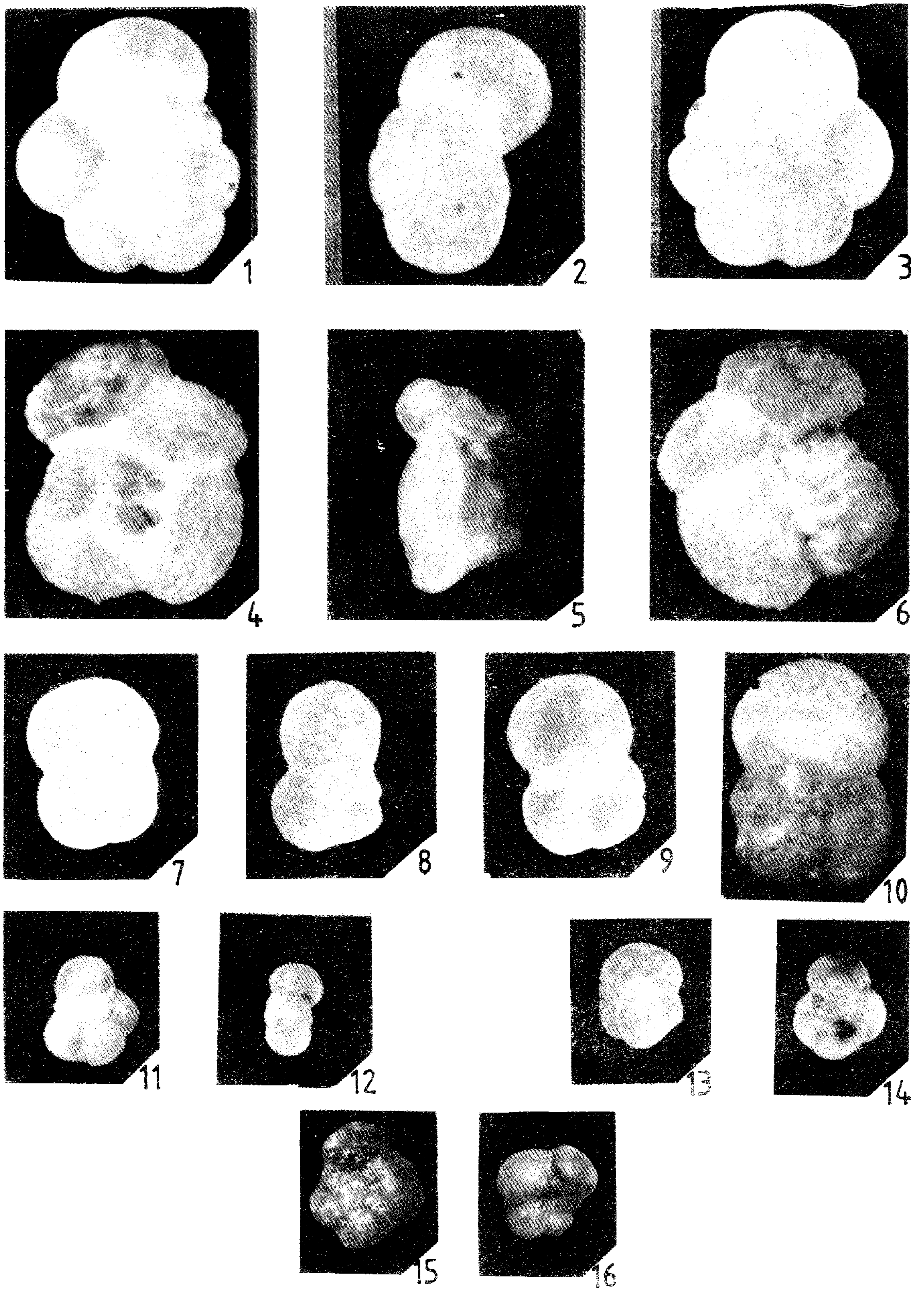


PLATE IX



of the Salt Range are not consistent results. This favours the possibility of major facies changes. Therefore, it seems necessary to carry out plankton biostratigraphic and paleoenvironment analysis studies together with those on the sedimentology of Patala, Nammal, Sakesar and Chorgali formations in other areas of the Salt Range to solve this discrepancy.

Very high plankton/benthos ratios indicate open sea fully marine environments. Qualitative and quantitative analysis of foraminifers show a tendency of environmental shift from outer shelf to upper slope environments for the Patala Formation whereas the Nammal Formation is indicative of middle to outer shelf environments. Fluctuations of sea level as recently published by Haq et al, (1988), explain well the change of paleoenvironments. Their early Eocene highstand of supercycle TA2 compares well with the upper bathyal slope paleoenvironment of Kh6-9 samples from the early Eocene part of the Patala Formation.

ACKNOWLEDGEMENT

The assistance of Mr. Naseer Ahmed Shafique during analysis is highly appreciated. Special thanks to Dr. Asrar M. Khan for critically reading the manuscript and giving useful suggestions.

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APPENDIX
FORAMINIFERAL SPECIES LIST

A) **Planktonic Foraminifera**

*Acarinina aspensis** (Colom), 1954
A.broedermanni broedermanni (Cushman & Bermudez),*1949
*A.camerata** Khalilov,1956
*A.collactea** (Finlay),1939
*A.convexa convexa** Subbotina, 1953
*A.cuneicamerata** Blow, 1979
*A.decepta** (Martin), 1943
*A.interposita** Subbotina, 1953
*A.lodoensis** (Mallory), 1959
*A.nicoli nicoli** (Martin), 1943
*A.nicoli salisburgensis** (Gohrbandt), 1967
*A.pentacamerata** Subbotina, 1936
*A.pseudotopilensis** Subbotina, 1953
A.wilcoxensis wilcoxensis (Cushman & Ponton), 1932
*A.wilcoxensis berggreni** (El Naggar), 1966
*A.wilcoxensis strabocella** (Loeblich & Tappen), 1957
M.acuta (Toulmin), 1941
Morozovella aequa aequa (Cushman & Renz), 1942
M.aequa lacerti (Cushman & Renz), 1946
M.aequa dolabrata (Jenkins), 1965
*M.edgari** Premoli Siva & Bolli, 1973
M.aragonensis (Nuttall), 1930
M.formosa (Bolli), 1957
M.marginodentata (Subbotina), 1953
M.occlusa occlusa (Loeblich & Tappan), 1957
M.quetra (Bolli), 1957
M.subbotinae subbotinae (Morozova), 1939
M.subbotinae gracilis (Bolli), 1957
M.velascoensis velascoensis (Cushman), 1925
Muricoglobigerina esnehensis (Nakkady), 1950
Mg.soldadoensis soldadoensis (Brönnimann), 1952
Mg.soldadoensis angulosa (Bolli), 1957
Planorotalites chapmani (Parr),1938
Pl.pseudomenardii (Bolli), 1957
Pl.pseudoscitula (Glaessner), 1937
Pseudohastigerina wilcoxensis wilcoxensis (Cushman & Ponton), 1932
Subbotina compacta (Subbotina), 1953
*S.crociapertura** (Blow, 1979
S.eocaenica (Terquem), 1882
*S.frontosa frontosa** (Subbotina), 1953
*S.hornibrooki hornibrooki** (Brönnimann), 1952
S.inaequispira (Subbotina), 1953
S.linaperta (Finlay), 1939
S.lozanoi lozanoi (Colom), 1954
S.lozanoi prolata (Bolli), 1957
S.triangularis triangularis (Bolli), 1957
S.triloculinoides triloculinoides (Plummer), 1926
*Turborotalia griffinae** Blow, 1979
*T.pseudoimitata** Blow, 1979
Globanomalina simplex, Haque, 1956

*Species reported for the first time in Pakistan.

B) **Larger Benthic Foraminifera**

Assilina dandotica, Davies, 1937
A.granulosa (d' Archiac), 1847
A.subspinosa Davies, 1937
Discocyclina dispansa (Sowerby), 1840
D.ranikotensis Davies, 1927
D.undulata Nuttall, 1926
Lockhartia altispira Smout, 1954
L.conditi (Nuttall), 1926
L.haimei (Davies), 1927
Nummulites atacicus Leymerie, 1846
N.globulus Leymerie, 1846
N.irregularis Deshayes, 1838
N.lahirii (Davies), 1937
N.subirregularies De la Harpe, 1883
Operculina salsa Davies, 1937
Rotalia trochidiformis (Lamarck), 1804

C) **Smaller Benthic Foraminifera**

Ammodiscus angustus (Friedberg),
Anomolinoides aragonensis (Nuttall),1930
Anomalinoides aff. A. acuta (Plummer),1927
Astacolus vomeriformis Haque, 1956
Bigenerina sp. Haque,1956
Bulimina cf. B. pseudoquadrata Haque, 1956
B. pupoides d'Orbigny, 1846
B. macilenta Cushman & Parker, 1939
Cibicides alleni (Plummer),1927
C.carinatus Haque,1956
C.lobatulus (Walker &Jacob),1798
C.nammalensis Haque,1956
C.punjabensis Haque,1960
Clavulinoides lakiensis Haque, 1956
D.distans (Reuss),1855
Dentalina cf. D.havanensis Cushman & Bermudez,1937
Dentalina cf. plummerae Cushman,1940
D.soluta Reuss,1851
Dorothia alabamensis Cushman,1940
Fissurina orbignyana Seguenza,1862
Fursenkoina dubia (Haque),1956

APPENDIX (Contd.)
FORAMINIFERAL SPECIES LIST

Gaudryina carinata Franke,1914
G.carinata var nammalensis Haque,1956
G.pyramidata var. nitida Haque, 1956
Grigelis pyrula (d'Orbigny),1826
Chiloguembelina cf. midwayensis var. nammalensis (Haque), 1956
Lenticulina chambersi (Garrett),1939
L.degolyeri (Plummer),1927
L.midwayensis (Plummer),1927
Lenticulina aff.L. subalata (Reuss),1854
L.reussi (Haque),1956
Nonionella minuta Haque,1956
Pleurostomella alternans (Schwager),1866
Pseudogloborotalia khairabadensis Haque,1956
Pyramidulina macneili (Hantken),1944
P.acuminata (Cushman),1875
Reussoolina apiculata (Reuss),1851
Sphaeoroidina dubia Haque,1956
Stilostomella cf. S. ewaldi (Reuss),1851
Textularia crookshanki Haque,1956
Triloculina sarahae Haque,1956
Vaginulinopsis mexicanus var nudcostatus (Cushman & Hanna), 1935
V.saundersi (Hanna & Hanna),1924
Vulvulina aff. V.pennatula (Batsch), 1791
Valvulineria hillsi Haque,1956
V.patalaensis Haque,1956
V.ranikotensis Haque,1956
Woodella nammalensis Haque,1956