36. PTEROPODS AND OSTRACODS

36.1. PRELIMINARY PTEROPOD RESULTS FROM THE MEDITERRANEAN SEA

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INTRODUCTION

During Leg 13 of the DSDP through the Mediterranean, 200 cores were recovered from twenty-eight holes at fifteen sites.

Of the forty-nine core samples examined from Sites 125, 126 and 127A, ten were found to contain pteropods; the age of the pteropod-bearing sediment is Pleistocene.

A preliminary comparison of the DSDP Pleistocene pteropods with those contained in piston cores from the same area indicates that similar planktonic faunas populated the Mediterranean in early and late Pleistocene time. Furthermore, sapropels common in late Last Glacial and Postglacial deposits were also laid down during the earlier phases of the Pleistocene. These sapropelitic silty lutites contain excellently-preserved pteropod oozes.

Samples are designated in the usual DSDP format consisting of leg number, site number, core number, section number, and level from the top of the section in centimeters.

SEDIMENTS

During the Quaternary, deposition of sediments in the Mediterranean basins was controlled by regional tectonic activity and climatic changes. This is indicated by the occurrence of numerous ash layers, turbidite, and slump deposits interbedded with pelagic sediments. None of the sixty piston or DSDP cores examined to date represent continuous uninterrupted sedimentation. However, several selected piston cores, interrupted by minor turbidity current deposits, or cores with stratigraphical hiatuses resulting from removal of sediments by various submarine processes, have been utilized to reconstruct the past climatic and hydrologic history of the Mediterranean in late Quaternary time (Herman, *et al.*, 1969; Herman, 1971a, b, and in press; Grazzini-Vergnaud and Herman-Rosenberg, 1969).

Pteropods occur principally in three main sediment types:

1) **Terrigenous clasts**: Large volumes of terrigenous silty lutites are carried to the sea by rivers and are transported across the relatively narrow shelves via numerous submarine canyons. These sedimentary funnels distribute sediments to the deep unprotected plains. Calcareous skeletal remains (pteropods, foraminifers, and heteropods) are present and well-preserved in the coarse fraction (>62 and $>74\mu$) of these sediments. They are scarce, however, mainly because of the high rates of clastic sedimentation.

2) **Calcareous oozes**: In Holocene sediments, pteropods and foraminifers constitute 90-95 per cent of the planktonic fauna in the coarse fraction, the remainder being made up of heteropods. Due to the relatively higher solubility of aragonite, the original composition of the faunal assemblages is modified by post-depositional solution, and consequently pteropods and heteropods are generally scarce in calcareous oozes older than 12 to 13,000 years.

3) **Sapropelitic deposits**: Repeatedly during late Cenozoic time, the water circulatory system was altered as a result of increased fresh-water discharge and/or restriction of water exchange between the Atlantic and the Mediterranean. This resulted in the stagnation of deeper water layers and consequent deposition of black sapropelitic silty lutites. The dark color of the sediment is due to the high content of finely disseminated organic matter and to iron sulphide minerals. In the sapropels, pteropods, heteropods, and planktonic foraminifers are more abundant and better preserved than in sediments laid down during aerobic conditions; benthonic foraminifers are absent or scarce.

Rates of Sedimentation

Among the important factors determining rates of sediment accumulation are: (a) topographic setting, (b) winnowing of sediments by bottom currents, (c) rates of clastic and biogenic supply, and (d) pre- and post-depositional solution. Seismic reflections (Wong and Zarudzki, 1969) and radiocarbon age determinations (Herman, *et al.*, 1969; Grazzini-Vergnaud and Herman-Rosenberg, 1969; Herman, 1971a, b, and in press) indicate that sedimentation rates are extremely variable, ranging between >200 cm/10^3y off major river cones, and >5 cm/10^3y on the Mediterranean Ridge and other topographic highs

MICROPALEONTOLOGY

Species of Pteropoda

A detailed synonymy and taxonomic discussion has not been attempted here; it will be dealt with in a forthcoming publication. The nomenclature used by Tesch (1946, 1948) is followed in more cases. Pteropods present in Mediterranean sediments are listed in alphabetical order:[1]

Cavolinia inflexa (Lesueur)
Cavolinia longirostris (Lesueur)
Cavolinia tridenta (Forskal)
Cavolinia uncinata (Rang)
Clio cuspidata (Bosc)
Clio polita Pelseneer
Clio pyramidata Linné
Clio pyramidata f. *pyramidata* Linné
Creseis acicula (Rang)
Creseis chierchiae (Boas)
Creseis conica Eschscholtz

[1] Also see plates.

Creseis virgula Rang f. *constricta* Chen
Diacria quadridentata (Lesueur)
Diacria trispinosa (Lesueur)
Hyalocylix striata (Rang)
Limacina bulimoides (d'Orbigny)
Limacina inflata (d'Orbigny)
Limacina retroversa (Fleming) f. *balea* Möller
Limacina retroversa f. *retroversa* (Fleming)
Limacina trochiformis (d'Orbigny)
Peraclis bispinosa Pelseneer
Peraclis sp.
Styliola subula (Quoy and Gaimard)

Faunal Analysis

Distributional patterns of living pteropods indicate that many species have a limited tolerance to changes in temperature and salinity. Food, light, and oxygen are also known to determine their distribution and abundance. Accordingly, variations in planktonic faunal composition in sediments are interpreted as reflecting actual production rates as well as climatic and hydrologic conditions at the time of, and shortly after, their burial. In addition to the above mentioned factors, other variables determine the composition of faunal remains in sediments. Important among these are redistribution by currents and burrowers, changes in accumulation rates of detrital sediments, and the solution of carbonate tests. Dissolution of foraminiferal shells is selective (Ericson *et al*., 1961; Berger, 1967). It varies with genera and species; the more fragile forms are eliminated first thus changing species composition. The criteria which determine the selective solution of foraminifers most probably also apply to pteropods (Herman, 1971a). For instance, pteropods and fragile, minute, planktonic foraminifers abound in Holocene and late Last Glacial sediments from relatively shallow water, but with few exceptions, are absent, or present at low frequencies, in pre-Holocene deeper-water cores.

A synopsis of the faunal assemblages contained in various Mediterranean basins is given in previous publications (Grazzini-Vergnaud and Herman-Rosenberg, 1969; Herman, 1971a, b, and in press).

Distribution of Pteropods

Pleistocene sediments yielding pteropods recovered during Leg 13 are discussed below. Samples were wet-sieved through a stainless steel 62μ sieve. After drying at about 80°C, the pteropods were recorded and counted according to the following scale: Rare (R)–1 to 5 tests; Frequent (F)–6 to 11 tests; Common (C)–12 to 25 tests; Abundant (A)–26 to 100 tests; and Very Abundant (VA)–> 100 tests.

Site 125

Position: Latitude 34° 37.49′N.
Longitude 20° 25.76′E.
Water Depth: 2,782 meters.

The following samples contained pteropods:
125-1-1, 144-145cm:

Samples Examined in Hole 125

Core	Section	Interval (cm)	Core	Section	Interval (cm)
1	1	144-145	2	4	64-65
1	2	62-63	2	4	141-142
1	2	92-93	2	5	98-99
1	3	56-57	2	5	138-139
1	3	76-77	3	1	50-51
1	3	128-129	3	1	113-114
1	4	15-16	3	2	21-22
1	4	88-89	3	2	129-130
1	5	14-15	3	3	10-11
1	5	108-109	3	3	131-132
2	1	104-105	3	4	27-28
2	1	145-146	3	4	138-139
2	2	64-65	3	5	118-119
2	2	119-120	3	5	35-36
2	3	57-58	3	6	49-50
2	3	111-112	3	6	127-128

L. retroversa (R). One specimen of this cold-tolerant species accompanies a cool-temperate assemblage of planktonic foraminifers dominated by *Globorotalia inflata* (d'Orbigny), *Globigerina bulloides* d'Orbigny, *Globorotalia scitula* (Brady), *Globigerinoides ruber* (f. B.) [2], *Globigerina quinqueloba* Natland, *Orbulina universa* (d'Orbigny), and *Globigerina pachyderma* (Ehrenberg).

125-1-3, 76-77cm:

This sample contains an admixture of warm-, temperate-, and cold-tolerant planktonic forms. The pteropodal fauna is dominated by *L. inflata* (VA). Present at high frequencies are *L. trochiformis* (A) and *C. pyramidata* (A), followed by *Limacina* spp. juvenile tests (C), *D. trispinosa* (F), *L. retroversa* (R), *C. cuspidata* (R), *C. tridentata* (R), *Calvolinia* sp. (R), *Creseis* sp. (R), *C. polita* (R), and *S. subula* (R). Planktonic foraminifers observed include the *G. ruber* complex, *G. inflata, Globorotalia truncatulinoides* (d'Orbigny), *Globoquadrina dutertrei* (d'Orbigny), *G. pachyderma* (dextral), *G. bulloides, O. universa,* Globigerinoides sacculifer (Brady), *Globigerinita glutinata* (Egger), *G. scitula, Globigerinella aequilateralis* (Brady), *Globigerinoides tenellus* Parker and *Globigerinita uvula* (Ehrenberg).

The faunal composition of this sample suggests post-depositional mixing of several assemblages with different ecological requirements.

125-1-4, 88-89cm:

The dominant species in this sample is *L. retroversa* (VA). Both formae *L. retroversa* f. *retroversa* and *L. retroversa* f. *balea* are present; the latter is thought to be adaptive to lower temperatures than the former. *C. pyramidata* (F) constitutes 2-3 per cent of the pteropod assemblage. Several specimens of *Creseis* sp. (R) were also observed. The planktonic foraminiferal fauna is dominated by *G. bulloides* and *G. inflata* followed by *G. pachyderma* (dextral), *Globigerina calida* Parker, *G. ruber* (f. B.), *G.*

[2]This form differs from the typical *G. ruber* in possessing a more compact and thicker test, smaller apertures and flattened chambers. It is believed to be a colder-water form than *G. ruber* s.s.

quinqueloba, G. uvula, Globorotalia anfracta Parker, and *G. scitula.*

The fauna is composed of cold-water and eurythermal elements which inhabited the sea during a glacial period.

125-1-4, 14-15 cm:

L. inflata (VA) dominates the pteropod assemblage. Also represented at high frequencies are *S. subula* (VA), *C. pyramidata* (A), and *L. retroversa* (A). Less abundant are *L. trochiformis* (C), *Limacina* spp. (C), juvenile tests, *Creseis* sp (F), *Peraclis* sp. (F), juvenile tests, *Cavolinia* sp. R (tip).

The accompanying planktonic foraminifers include the *G. ruber* complex, *G. quinqueloba, G. inflata, O. universa, G. bulloides, G. pachyderma* (dextral), *G. aequilateralis, G. scitula, G. truncatulinoides, G. glutinata, G. anfracta, G. uvula, Globigerina digitata* Brady, *Hastigerina pelagica* (d'Orbigny), and *Globigerinoides conglobatus* (Brady).

The admixture of planktonic species with different temperature tolerance suggests post-depositional mixing of sediments.

Site 126

Position: Latitude 35° 09.72′N.
Longitude 21° 25.63′E.
Water Depth: 3,730 m.

Samples Examined in Hole 126

Core	Section	Interval (cm)
1	1	86-87
1	2	47-48
1	2	136-137
1	3	111-112
1	3	134-135
1	4	27-28
1	4	124-125
1	5	85-86
1	5	126-127
1	6	19-20
1	6	123-124

Core	Section	Interval (cm)
1	1	79-80
1	1	147-148
1	2	50-60
1	2	139-140
1	3	68-69
1	3	140-141

Pteropods were not observed in any of these samples. The coarse fraction contains planktonic and benthonic foraminifers.

Site 127A

Position: Latitude 35° 43.90′N.
Longitude 22° 29.81′E.
Water Depth: 4,654 m.

Samples Examined in Hole 127A

Core	Section	Interval (cm)
1	1	79-80
1	1	147-148
1	2	59-60
1	2	139-140
1	3	68-69
1	3	140-141

The following samples contained pteropods:

127A-1-1, 79-80cm:

The assemblage is composed of a diversified warm-temperate planktonic fauna. *S. subula* is the dominant species (VA), it is followed by *Creseis* spp. VA (only tips preserved), *L. inflata* (VA), *C. acicula (C), C. pyramidata* (C), *Limacina* spp. (C), juvenile tests, *C. conica* (F), Cavolinia spp. (F) (tips only), *D. trispinosa* (R), *H. striata* (R), *C. cuspidata* (R), and *Peraclis* sp. (R).

The associated planktonic foraminiferal fauna is dominated by the *G. ruber* complex, *G. sacculifer*, and dextral *G. pachyderma*.

The occurrence of low latitude epiplanktonic pteropods (*Creseis* spp.) with species known to have deeper water habitat such as *S. subula, L. inflata, D. trispinosa* and *Peraclis* sp. suggests a period with climates and hydrographic conditions similar to those of today.

127A-1-1, 147-148cm:

This small sample contains one specimen of *Creseis* sp. and one foraminifer, *G. ruber* (the pink variety).

127A-1-2, 59-60cm:

The faunal composition in this sample resembles 127A-1-1, 79-80cm. *S. subula* (VA), is the dominant pteropod; it is followed by *L. inflata* (VA), *Creseis* spp. VA (only the tips preserved), *L. trochiformis* (A), *C. acicula* (C-A), *C. pyramidata* (C-A), *C. polita* (R), *C. chierchiae* (R), *H. striata* (R) *Cavolinia* sp. R (tip), and *Peraclis* sp. (R).

The associated planktonic foraminiferal fauna is dominated by the *G. ruber* complex and *G. succulifer.*

127A-1-2, 139-140cm:

Only rare specimens of the following species were found in the fraction $> 62\mu$: *L. inflata* (R), *L. trochiformis* (R), *C. acicula* (R), and *S. subula* (R). The planktonic foraminiferal fauna is also meager; the following forms are present: *G. sacculifer*, the *G. ruber* complex and *G. pachyderma* (dextral).

127A-1-3, 68-69cm:

This sample contains one pteropod, *S. subula.* Several juvenile globigerinas and one specimen of *G. quinqueloba* were also observed.

127A-1-3, 140-141cm:

Similar to the preceding samples, very little material was left after wet sieving. The following species were observed: *L. inflata* (R), *Limacina* sp. (R) (juvenile), *C. pyramidata*

(R), and *S. subula* (R). A few planktonic foraminifers also occur: *G. quinqueloba, G. sacculifer, G. scitula,* the *G. ruber* complex, and *O. universa.*

The planktonic faunas in the last three samples are dominated by warm-temperate species. The scarcity of faunal remains may be due to rapid rates of clastic deposition. It is not certain, however, whether the examined samples represent pelagic sedimentation or whether they were deposited by turbidity currents.

DISCUSSION

It has been shown that pteropods have restricted tolerance to changes in temperature, salinity, oxygen, and water depth, and therefore are useful indicators of past environments. (Herman-Rosenberg 1965, Herman 1968; 1971a).

To date, thecosomatous pteropods have not been employed extensively in biostratigraphy; this is in part due to our incomplete knowledge as to the range of the various species. Furthermore, owing to the aragonitic nature of their tests, pteropods are more susceptible to solution than other marine microfossils, hence their relatively limited occurrence in pre-Pleistocene sediments.

In order to resolve many fundamental problems in regional paleoclimates, stratigraphy and tectonics, the utilization of several independent techniques (absolute age determinations, oxygen isotope paleothermometry, and biostratigraphic correlations) as well as that of several groups of co-occurring organisms may be essential.

A thorough investigation of Mediterranean pteropod sequences is currently underway. It is anticipated that eventually a basic biostratigraphic zonation of Cenozoic sediments, based upon the distribution of species and subspecies of pteropods, will be achieved. This will be done by correlating pteropodal sequences with established foraminiferal series.

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PLATE 1

Figures 1-3	*Creseis acicula,* × 30; from Core SDS 166-331 cm.
Figures 4, 5	*Creseis acicula* × 40; from Core SDS 166-18.5 cm.
Figure 6	*Creseis acicula*, SEM, × 300; from Core CH 61-40-15 cm.
Figure 7	*Creseis acicula*, SEM, same specimen as in Figure 6, × 400.
Figures 8-10	*Creseis conica,* × 30; from Core SDS 166-331 cm.
Figure 11	*Creseis virgula constricta,* × 30; from Core SDS 166-331 cm.
Figure 12	*Creseis virgula,* × 30; from Core SDS 166-331 cm.
Figure 13	*Hyalocylix striata,* × 12; from Core SDS 166-385 cm.

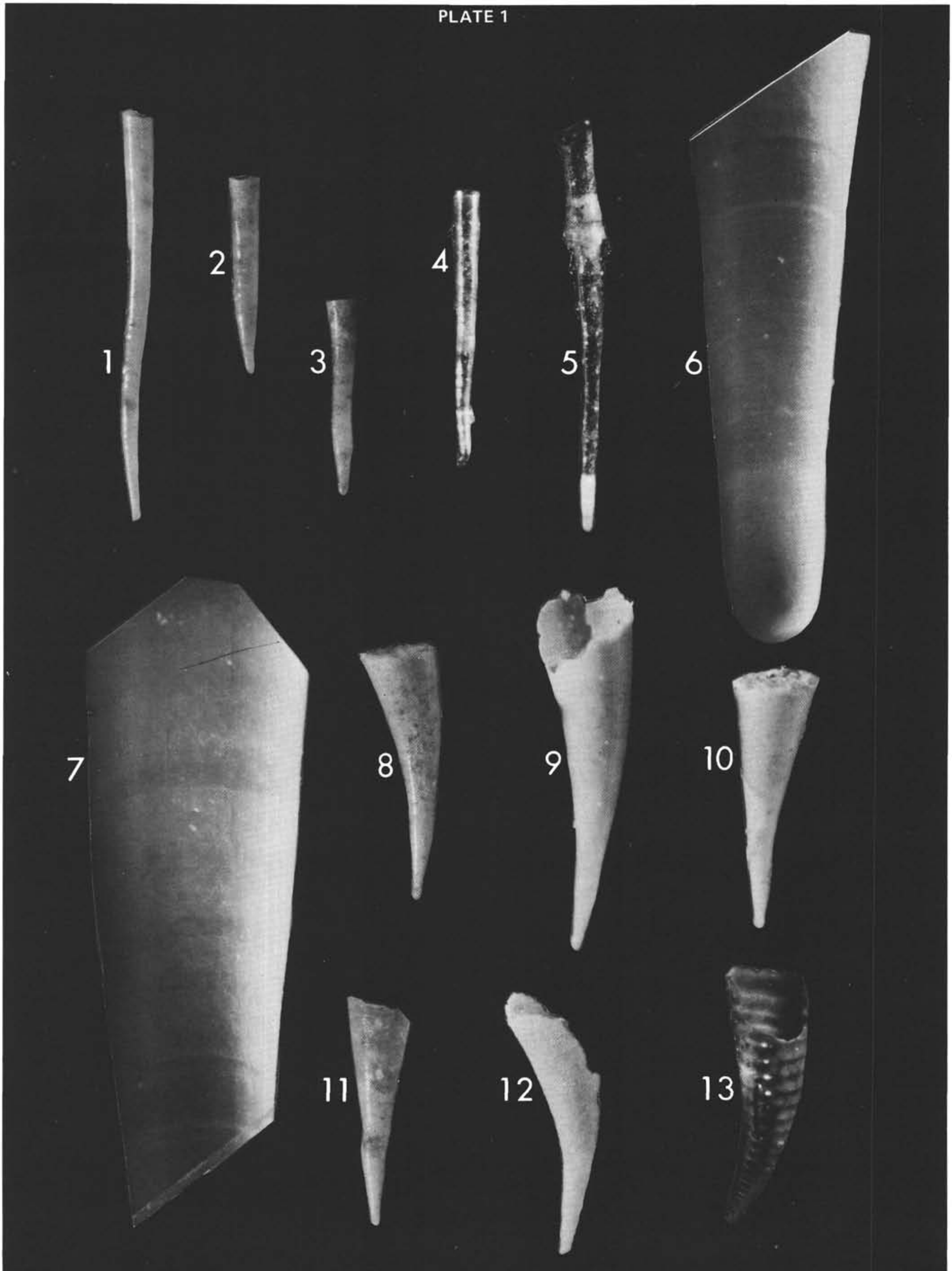
PLATE 1
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PLATE 2

Figures 1-5	*Limacina trochiformis,* apertural view, X 30; from Core SDS 166-308.5 cm.
Figure 6	*Limacina trochiformis,* SEM apertural view, X 100; from Core CH 61-40-15 cm.
Figures 7, 8	*Limacina trochiformis,* spiral view, X 30; from Core SDS 166-331 cm.
Figure 9	*Limacina inflata,* SEM apertural view, X 125; from Core CH 61-40-15 cm.
Figure 10	*Limacina inflata,* apertural view, X 20; from Core V 14-115-5 cm.
Figure 11	*Limacina inflata*, equatorial side view, X 20; from Core V 14-115-5 cm.
Figure 12	*Limacina bulimoides,* apertural view, X 30; from Core V-14-115-500 cm.
Figures 13, 14	*Limacina bulimoides,* X 30; from Core V-14-115-500 cm.
Figure 15	*Limacina bulimoides,* SEM, spiral view, X 100; from Core CH 61-40-15 cm.

PLATE 2