12. RADIOLARIAN BIOSTRATIGRAPHY FROM LEG 112 ON THE PERU MARGIN[1]

P. De Wever,[2] J.-P. Caulet,[3] and J. Bourgois[4]

ABSTRACT

The radiolarian fauna found at the 10 sites drilled during Ocean Drilling Program (ODP) Leg 112 range in age from Eocene to Holocene. Relatively abundant and well-preserved assemblages are present in Sites 682, 683, 685, and 688. Occurrence tables of 175 species are presented for these sites. For each site, stratigraphic results are summarized in two figures showing the radiolarian biozonation, the inferred hiatuses, and barren intervals. The Pliocene/Pleistocene and Miocene/Pliocene boundaries were not recognized from radiolarian stratigraphy. Pleistocene and middle Miocene radiolarian assemblages are generally abundant and well preserved. New stratigraphic data are given for some rarely described species, such as *Cypassis irregularis*, *Lamprocyrtis daniellae*, *Plectacantha cresmatoplegma*, *Pterocanium grandiporus*, *Pseudocubus warreni*, and *Phormostichoartus* (?) *crustula*.

INTRODUCTION

JOIDES Resolution departed Callao, Peru, in October 1986 to drill 27 holes at 10 sites on the Andean continental margin off Peru. Two processes, coastal upwelling and plate subduction, shaped this margin and its sediments since Eocene time; these processes were of interest to us.

During Leg 112, drilling was concentrated along two seismic corridors perpendicular to the trench axis off Peru. The northern corridor (near 9°S off Trujillo, central Peru) was cored at three ODP sites (683, 684, 685; Fig. 1) to constrain previous seismic interpretations (von Huene et al., 1985). These sites are seaward of two industry drill holes (Delfin and Ballena) and landward of two DSDP Sites (320 and 321) on the Nazca Plate (see Suess, von Huene, et al., 1988). The southern corridor (near 11°S off Lima, central Peru) was cored at five sites (679, 680, 681, 682, 688; Fig.1) and provided stratigraphic control at both the seaward (Sites 682 and 688) and the landward ends (Site 679) of the Lima Basin. Results from drilling on either flank of the Lima Basin amplify the indication of subsidence, which had been previously deduced from dredging results. Two additional sites (686 and 687 near 13°S off Pisco) provided additional data for paleoenvironmental interpretation on a north-south transect. These sites reveal that the Quaternary sediment record thickens enormously southward—from 14 m in the north to more than 300 m in the south—and is tectonically controlled (see Suess, von Huene, et al., 1988).

Objectives of Leg 112 were both tectonic and paleoenvironmental. The tectonic objective was to test hypotheses inferred from geophysical data and conventional sampling along the Peru margin: (1) about the seaward extent of the continental crust, (2) the nature of the margin's junction with the accretionary complex, and (3) to relate the tectonic history of the continental margin to the plate convergence of the oceanic crust. The record of paleoenvironmental changes and the diagenetic process of the forearc basins are linked closely to the tectonic history of the margin.

Initiation of the eastern Pacific boundary current circulation and the associated wind system (a process that established the coastal upwelling regime during Miocene time) occurred during the subduction of the modern Nazca Plate beneath the South American craton, leading to the development of forearc basins (Pisco Basin, Lima Basin, Salaverry Basin, Trujillo Basin, etc.). Sedimentation in these elongated basins on the shelf and upper slope off Peru reflects vertical movement of the Andean margin basement and records the detailed oceanographic history of one of the best-developed coastal upwelling regimes (Suess and Thiede, 1983; Thiede and Suess, 1983).

Both the rapid vertical motion of forearc basins and the influx of biogenic matter from coastal upwelling mixed with terrigenous material generate an extreme range of chemical and sedimentological conditions that affect diagenesis. Leg 112 addresses this interplay between tectonic and oceanographic processes and their role in sedimentation and diagenesis of the forearc basins. The paleoenvironmental history is recorded in the sediment sequences drilled in the forearc basins and on the adjacent continental slope. Discovering the amplitude of vertical tectonic movement of these basins and the timing of these events were prime objectives. In addition, we wished to date the onset of coastal upwelling and to determine the response of the upwelling circulation regime to tectonic and climatic forcing.

Radiolarians were recovered from many levels of the deep sites (Figs. 2 and 3), but they are rare from shallow shelf sites. Radiolarian assemblages range in age from Eocene to Holocene, but the fauna is well preserved only in middle Miocene to Holocene sediments.

METHODS

Core-catcher samples were collected from every core recovered at all sites during Leg 112. Samples were cleaned in boiling water and Calgon and, when necessary, in hot dilute hydrogen peroxide. Residue was sieved (at 63 μm) and the greater than 63-μm particles were mounted on slides with Canada Balsam. For some samples from Sites 685 and 688, the techniques used for Mesozoic rocks (De Wever et al., 1979; De Wever, 1982) were employed to extract radiolarians. All sampled intervals were examined by the authors. Radiolarian findings for Sites 682, 683, 685, and 688 are summarized in range charts showing all previously described species, general abundance and preservation of assemblages, and depth of penetration (Tables 1 through 4). These charts do not report
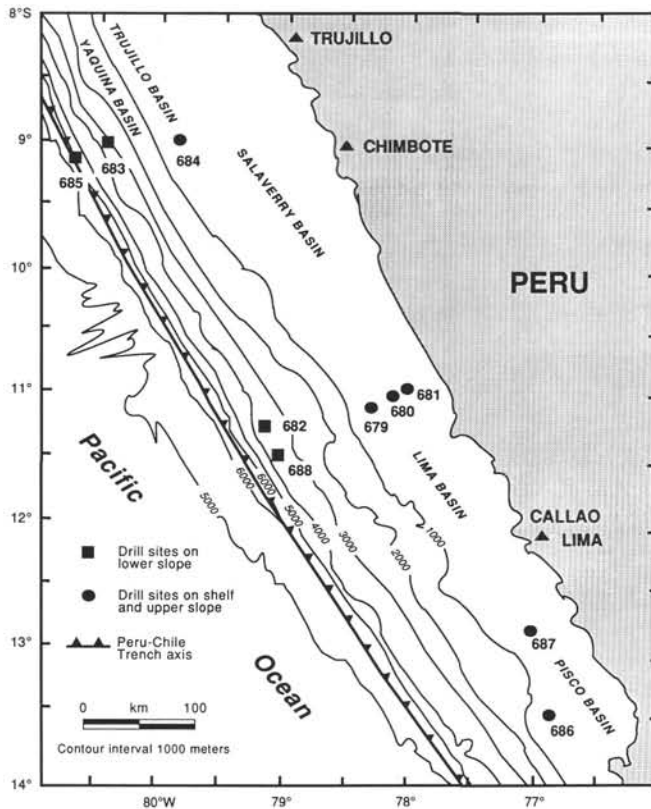
Figure 1. Locations of transects in the northern (C–D, 9°S) and southern (A-B, 11°30'S) areas of investigation, bathymetry, and location of sites drilled during Leg 112. Bathymetry in meters.

quantitative abundances, but rather, evaluate species on their presence or absence only.

RADIOLARIANS AT EACH SITE

The radiolarian zones used here (Figs. 4 and 5) for the last 4.5 m.y. are those of Johnson et al. (in press) and are designated by both NR numbers and specific names. The older zones are those defined by Riedel and Sanfilippo (1978). The reader should be cautioned that both these zonations contain *S. peregrina* Zones that are defined differently. We tried to use the radiolarian range charts published by Nigrini (1985). Unfortunately, most of the stratigraphic markers common in the central Pacific appear to be absent off the Peru margin. The biozonation proposed by Goll (1980) for the eastern tropical Pliocene and Pleistocene sediments was not used because many of his stratigraphic markers are not present in our material. As many hiatuses were noted and paleomagnetic control is poor, reliable ages for radiolarian events could not be determined. In some cases, the radiolarian assemblage is diluted by abundant diatoms.

Site 679

Site 679 (11°03.52'S, 78°15.92'W) is located on the seaward edge of an outer-shelf mud lens that formed under the influence of the Peru coastal upwelling system. The compressed stratigraphic section contains a record of late Neogene and Quaternary coastal upwelling. Of the five holes drilled at Site 679, two of them (Holes 679B and 679E) were studied for radiolarians. Radiolarians were observed only in Samples 112-679B-1H-CC (6.5 mbsf) and -2H-CC (16.0 mbsf). The presence of species such as *Pterocorys minythorax*, *Cycla-*

dophora davisiana, *Lamprocyclas junonis* gr., and *Octopyle stenozona* gr. indicate a Quaternary age.

Site 680

Site 680 (11°03.90'S, 78°04.67'W) is centered on an east-west transect of three sites across the sedimentary sequence of the Peruvian outer shelf and upper slope deposited under strong coastal upwelling conditions. Three holes were drilled at Site 680.

Radiolarians are rare because of diatom dilution in Samples 112-680A-1H-CC (8.3 mbsf) to -5H-CC (46.3 mbsf) and Samples 112-680B-1H-CC (5.5 mbsf) to 2H-CC (15.0 mbsf), but preservation is good. Species such as *Dictyophimus infabricatus*, *Pterocanium grandiporus*, *O. stenozona* gr., *P. minythorax*, *Lamprocyrtis nigriniae*, *Botryostrobus seriatus*, and *Pterocanium korotnevi* are characteristic of a late Pleistocene age. However, no detailed radiolarian zonation can be proposed because many deep living species, such as *Stylatractus universus*, probably never lived in such shallow waters above the continental shelf.

Site 681

Site 681 (10°58.60'S, 77°57.46'W) is the most landward (and consequently the shallowest) of the three sites (679, 680, 681) along the east-west transect crossing the upwelling deposits of the Peruvian shelf and upper slope. This site is also located nearest the origin of coastal upwelling centers associated with the headlands near 11°S. The water depth at this site nearly coincides with the top of the oxygen-minimum zone. Of the three holes drilled at Site 681, radiolarians were studied in core-catcher samples from Holes 681A and 681B.

Radiolarians are rare in Samples 112-681A-1H-CC (6.5 mbsf) to -3H-CC (25.5 mbsf). Species assemblages are typical of the upper Quaternary of the eastern Pacific. Representatives of the colonial form *Acrosphaera murrayana* appear to be abundant in this upwelling population. Reworked specimens of *Phormostichoartus fistula* were observed in Sample 112-681A-2H-CC (16.0 mbsf). In Hole 681B, radiolarians are rare in Samples 112-681B-1H-CC (5.9 mbsf) to -4H-CC (34.4 mbsf), but those present are indicative of a late Quaternary age.

Site 682

Site 682 (11°15.99'S, 79°03.73'W) is located on the landward side of the lower slope of the Peru Trench at a water depth of 3788 m. This part of the slope is considered more as a part of the Peruvian continental margin, before the Neogene Andean orogeny, than an element accreted during the orogeny.

Radiolarians are rare to few and are moderately to well preserved in the samples from Cores 112-682A-1H to -48X. Many barren intervals were observed (see Table 1).

The Pleistocene period is condensed. Sample 112-682A-1H-CC (9.9 mbsf) is related to Zones NR1/NR2 (*Buccinosphaera invaginata* and *Collosphaera tuberosa* Zones). The presence of *S. universus*, *Phormostichoartus pitomorphus*, *Anthocyrtidium nosicaae*, *L. nigriniae*, and *Lamprocyrtis neoheteroporos* places Samples 112-682A-2H-CC (19.3 mbsf) and -3H-CC (28.8 mbsf) in early to middle Pleistocene. The Pliocene/Pleistocene boundary could not be recognized because *Pterocanium prismatium* was not observed. The interval between Samples 112-682A-3H-CC (28.8 mbsf) and-7X-CC (66.8 mbsf) belongs to Zones NR6/NR7 (*P. prismatium* and *Anthocyrtidium jenghisi* Zones), which are early Pleistocene and late Pliocene in age. This is based on the absence of *L. nigriniae* and the occurrence of *C. davisiana*, *Theo-*

Figure 2. Simplified structural transect, based on seismic survey and results across the Peruvian margin at 11°30′S.

corythium vetulum, and *Anthocyrtidium ehrenbergi*. The boundary between the two zones is not certain because of barren intervals and the absence of *P. fistula*.

In Sample 112-682A-8X-CC (76.3 mbsf), the last occurrences of *Stichocorys peregrina* and *Anthocyrtidium pliocenica*, combined with the absence of *L. neoheteroporos* and *C. davisiana*, are characteristic of an early Pliocene age. Rare specimens of *Lamprocyrtis daniellae* and *Pseudocubus vema* confirm an early Pliocene age for the interval between Samples 112-682A-8X-CC (76.3 mbsf) and -11X-CC (104.8 mbsf), which has been placed in the *S. peregrina* Zone of Riedel and Sanfilippo (1978).

Samples 112-682A-12X-CC (114.3 mbsf) through -19X-CC (180.8 mbsf) are barren of radiolarians. Radiolarians are rare and moderately preserved in Samples 112-682A-20X-CC (190.3 mbsf) to -23X-CC (218.8 mbsf). The presence of *Didymocyrtis antepenultima* and *Diartus hughesi* place these sediments in the early late Miocene *D. antepenultima* Zone.

Radiolarians are absent from Samples 112-682A-24X-CC (228.3 mbsf) to -28X-CC (266.3 mbsf). Few and moderately preserved forms recorded in Sample 112-682A-29X-CC (275.8 mbsf) are characteristic of the *Diartus petterssoni* Zone.

The radiolarian fauna is generally rare and poorly preserved downhole. Samples 112-682A-32X-CC (295.1 mbsf)

and -35X-CC (320.7 mbsf) contain rare specimens that are indicative of the *Didymocyrtis alata* Zone. This age assignment is confirmed by an exceptionally abundant and well-preserved assemblage in Sample 112-682A-34X-CC (311.2 mbsf), including *Didymocyrtis mammifera*, *Didymocyrtis tubaria*, *Didymocyrtis violina*, *Dorcadospyris dentata*, *Liriospyris parkerae*, and *Stichocorys wolffii*.

Rare and poorly preserved Eocene radiolarians were observed in the oldest sediments recovered in Hole 682A. Unfortunately, no zonation can be proposed for Samples 112-682A-46X-CC (417.7 mbsf) and -47X-CC (427.2 mbsf).

Site 683

Holes 683A (9°01.69′S, 80°24.40′W) and 683B (9°01.59′S, 80°24.26′W) were drilled in lower-slope sediments of the Peru continental margin (off the Yaquian Basin). The setting is similar to that at Site 682 except that the water depth at Site 683 is about 3080 m, whereas at Site 682 it is about 3800 m.

The upper part of Hole 683A contains an abundant and well-preserved radiolarian fauna of Holocene age. The last occurrence of *S. universus* in Sample 112-683A-6H-CC (49.7 mbsf) places this sample in Zone NR3 (*S. universus* Zone). The absence of *B. invaginata* in Peru margin material does not permit us to discriminate between Zones NR1 (*B. invaginata*

183
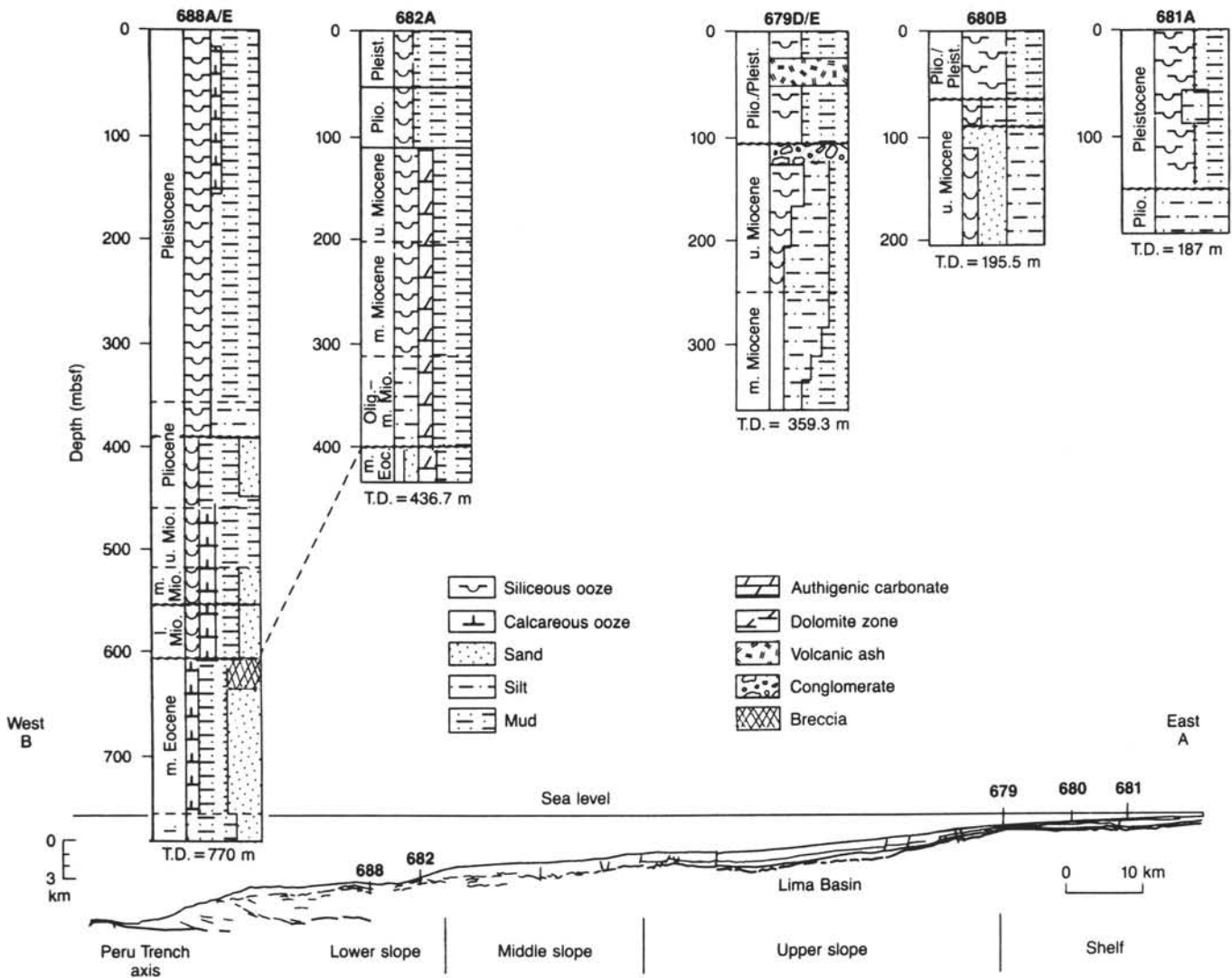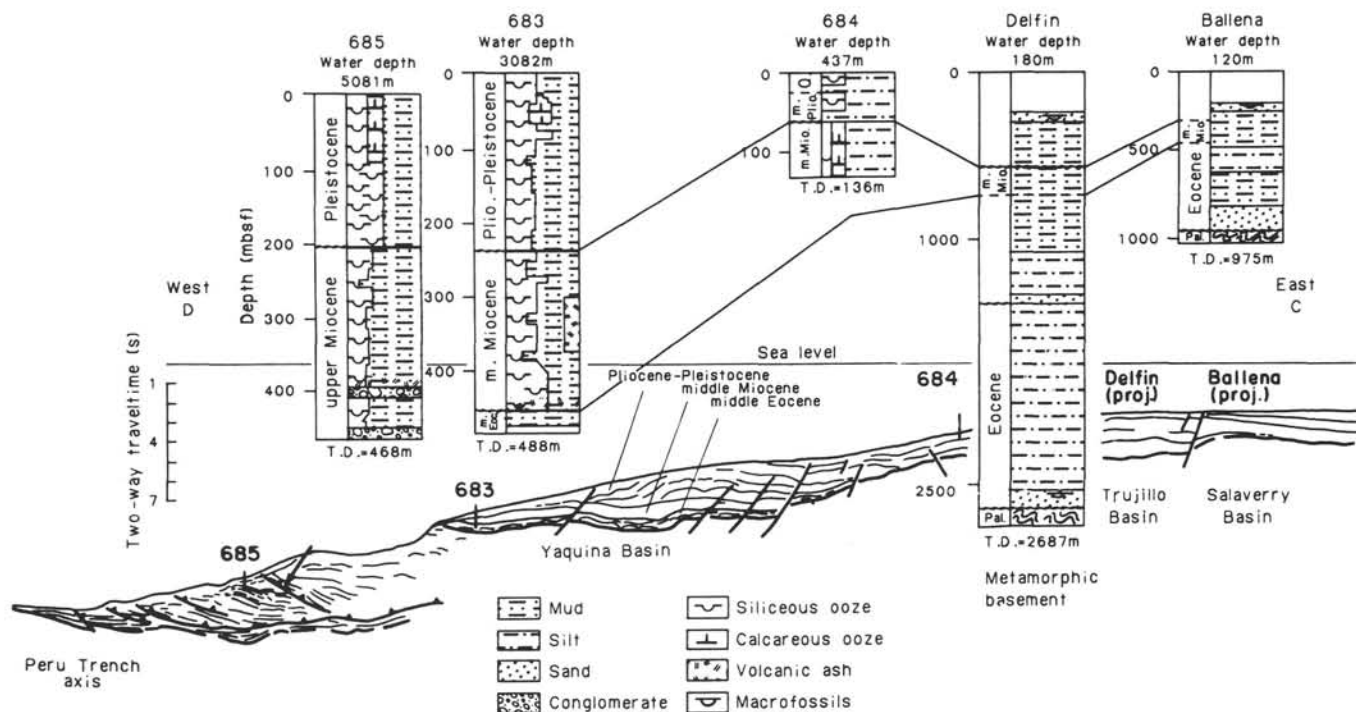
Figure 3. Simplified structural transect, based on seismic survey and results across the Peruvian margin at 9°S. Included are results from industry holes, Ballena and Delfin. T.D. = total penetration depth.

Zone) and NR2 (*C. tuberosa* Zone). Thus, the upper part of Hole 683A, down to Sample 112-683A-5H-CC (40.2 mbsf) is late to middle Pleistocene in age.

The interval between Samples 112-683A-6H-CC (47.7 mbsf) and -22X-CC (201.7 mbsf) spans the middle Pleistocene to late Pliocene Zones NR3 to NR7 (*S. universus* Zone to *A. jenghisi* Zone). Zonal boundaries cannot be precisely determined because of the scarcity of almost all stratigraphic marker species. However, some rough age assignments, based on occurrences of rare species, may be proposed. Sample 112-683A-7H-CC (59.2 mbsf) can be referred to Zones NR3/NR4 (*S. universus/A. ypsilon* Zones), which are younger than 0.8 Ma because of the presence of *Pterocorys hertwigii* (Johnson et al., in press). Co-occurrences of *Anthocyrtidium angulare*, *L. nigriniae*, *L. neoheteroporos*, and *P. pitomorphus*, in Sample 112-683A-11X-CC (97.2 mbsf) are indicative of the early Pleistocene Zone NR5 (*A. angulare* Zone). The stratigraphic range of *L. nigriniae* may be much longer here than in tropical areas (Johnson et al., in press). Both *L. nigriniae* and its ancestor, *L. neoheteroporos*, are present in sediments recovered from Samples 112-683A-10X-CC (87.7 mbsf) (top of *L. neoheteroporos*) to 112-683A-17X-CC (154.2 mbsf) (bottom of *L. nigriniae*). Co-occurrences of *T. vetulum* and *C. davisiana* in Sample 112-683A-19X-CC (173.2 mbsf) place this sample in the late Pliocene in age.

The last consistent occurrence of *S. peregrina* in Sample 112-683A-23X-CC (211.2 mbsf) suggests an early Pliocene age for this sample. The interval between Sample 112-683A-23X-CC (211.2 mbsf) and -25X-CC (230.2 mbsf) is placed in Zones NR8/NR9 (*S. peregrina/P. fistula* Zones) because many representatives of *L. neoheteroporos*, whose first appearance is located in Zone NR7 (*A. jenghisi* Zone) in tropical sediments (Johnson et al., in press) are present, along with many specimens of *P. fistula*, whose last occurrence marks the limit between Zones NR8 and NR9. The presence of *L. daniellae* in Samples 112-683A-24X-CC (220.7 mbsf) and -25X-CC (230.2 mbsf) correlates well with its occurrence in DSDP Site 586B

material (Caulet, 1985). Episodic occurrences of rare tropical forms and apparently local variation of some stratigraphic ranges do not permit us a more detailed zonation of the Pliocene sequence in Hole 683A.

A dramatic change in radiolarian composition occurs in Sample 112-683A-26X-CC (239.7 mbsf). More than 50% of the species present in the upper samples disappear completely. Occurrences of *Botryostrobus miralestensis*, *Diartus petterssoni*, *D. antepenultima*, *Didymocyrtis laticonus*, and *Stichocorys delmontensis* place Samples 112-683A-26X-CC (239.7 mbsf) to -29X-CC (268.2 mbsf) in the *D. antepenultima* Zone (early late Miocene). The first occurrence of *D. antepenultima* is used to mark the lower limit of this zone.

In Samples 112-683A-29X-CC (268.2 mbsf) to -40X-CC (372.7 mbsf) and -42X-CC (390.7 mbsf) to -45X-CC (419.2 mbsf) radiolarians are few to rare, and preservation is moderate. Sediments barren of radiolarians were recorded in Sample 112-683A-41X-CC (381.2 mbsf), and from Sample 112-683A-44X-CC (409.7 mbsf) to the bottom of the hole. All of this interval (112-683A-29X-CC [268.2 mbsf] to bottom of hole) is middle Miocene in age. However, the limit between the two middle Miocene radiolarian biozones is not easily recognized, mainly because *D. petterssoni* is so rare. Last occurrences of *D. mammifera* and *L. parkerae* are tentatively used to mark the top of the *Dorcadospyris alata* Zone between Samples 112-683A-39X-CC (363.2 mbsf) and -40X-CC (372.7 mbsf). The stratigraphic range of *S. wolffii* appears to be diachronous in this hole relative to previously published ranges (Sanfilippo et al., 1985).

Occurrences of radiolarian species in Hole 683A are recorded in Table 2. Hole 683B was located 320 m upslope from Hole 683A and was washed down to allow for two overlapping cores. All core-catcher samples from this hole were studied for radiolarians, which are present in all samples. Their preservation is good in Miocene sediments, and poor to moderate in the Eocene interval. They are common to abundant in Miocene sediments, few to common in the Eocene.
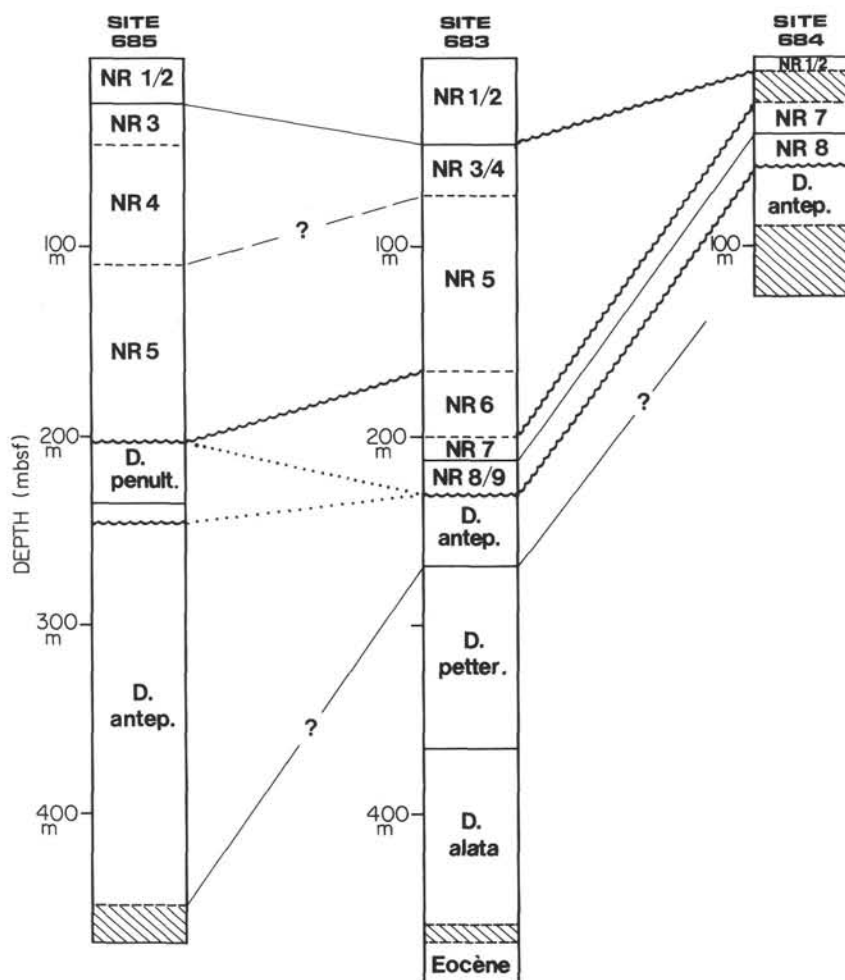
Figure 4. Summary of stratigraphic results based on radiolarians (northern transect, 9°S).

A *D. petterssoni* Zone assemblage was observed in Samples 112-683B-1X-CC (412.0 mbsf) to -6X-CC (459.5 mbsf), indicating a middle Miocene age.

A strongly recrystallized assemblage of Eocene age (*Eusyringium fistuligerum*, *Dictyoprora mongolfieri*, and *Podocyrtis papalis*) was found in Samples 112-683B-7X-CC (469.0 mbsf) to -9X-CC (488.0 mbsf).

In Site 683, two hiatuses can be deduced from the radiolarian stratigraphy. The first is located between Samples 112-683A-25X-CC (230.2 mbsf) and -26X-CC (239.7 mbsf), and spans the upper part of the late Miocene. The Miocene/Pliocene boundary cannot be recognized. The second hiatus is located between Samples 112-683B-6X-CC (459.5 mbsf) and -7X-CC (469.0 mbsf). The early Miocene and all of the Oligocene is missing.

Site 684

Site 684 (8°59.49'S, 79°54.35'W) is located in a small sediment pond on the flank of the Trujillo Basin, in an area on the upper slope otherwise devoid of sediments. It represents the northern point of a transect along the Peruvian coastal upwelling regime.

The sediments at Site 684, compared with previously drilled sites along the transect, record the latitudinal variability of the upwelling (Site 684, part A). Radiolarians are rare to abundant in all three holes drilled at Site 684. Their preserva-

tion is generally excellent, except in organic-rich pyritic mud intervals.

All core-catcher samples from Hole 684A were studied for radiolarians. They are well preserved, but are generally rare to few, because of dilution by diatoms, except in Sample 112-684A-5H-CC (43.3 mbsf) where they are common. An assemblage of the Peru margin Holocene (*Plectacantha cresmatoplegma*, *D. infabricatus*) was found in Sample 112-684A-1H-CC (5.3 mbsf). Rare radiolarians of Quaternary age were observed in Sample 112-684A-2H-CC (14.8 mbsf), but no assignment to a radiolarian biozone can be proposed. A major hiatus (late Pliocene) seems to be located between Samples 112-684A-2H-CC (14.8 mbsf) and -3H-CC (24.3 mbsf). Samples 112-684A-3H-CC (24.3 mbsf) and -4H-CC (33.8 mbsf) are placed in the middle Pliocene Zone NR7 (*A. jenghisi* Zone). These samples contain many specimens of *T. vetulum*, rare *A. jenghisi*, and no *C. davisiana*. It is interesting to note the relative abundance of the rare species *L. daniellae* at these levels. The occurrence of *S. peregrina*, and the absence of *L. neoheteroporos* place Sample 112-684A-5H-CC (43.3 mbsf) in Zone NR8 (*S. peregrina* Zone). Sample 112-684A-6H-CC (52.8 mbsf) is barren of radiolarians. Rare, but well-preserved, bispecific assemblages of *D. antepenultima* and *D. hughesi* give an early late Miocene age (*D. antepenultima* Zone) to the interval between Sample 112-684A-7H-CC (62.3 mbsf) and -10X-CC (88.6 mbsf). Because Sample 112-
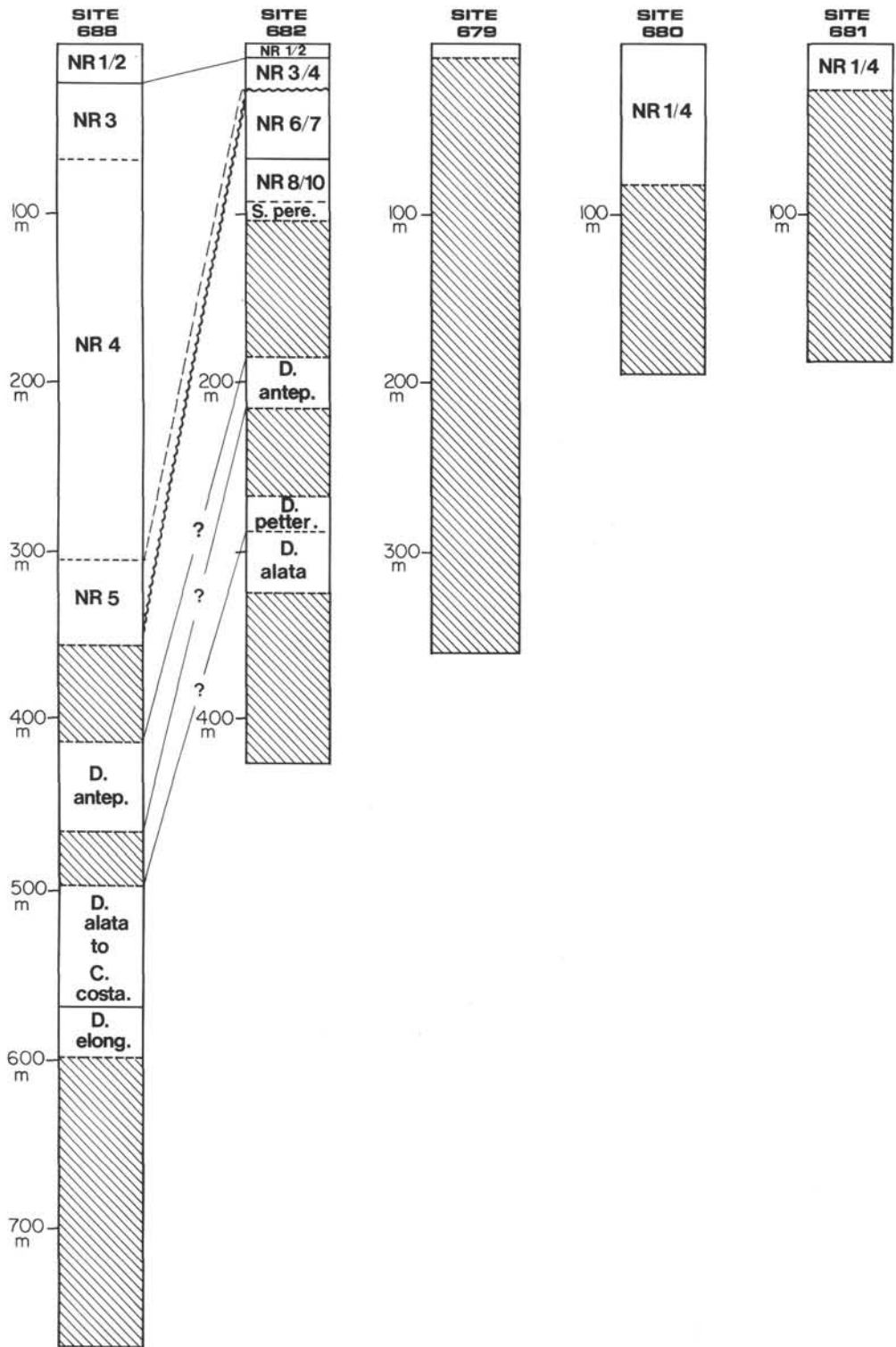
Figure 5. Summary of stratigraphic results based on radiolarians (southern transect, 11°30'S).

684A-6H-CC (52.8 mbsf) is barren, no direct evidence exists for a hiatus spanning the upper part of the late Miocene, but it seems likely that Sample 112-684A-11X-CC (98.1 mbsf) is barren.

Transitional forms between *D. antepenultima* and *D. laticonus* were observed in Sample 112-684A-12X-CC (107.6

mbsf). However, no age assignment can be proposed because radiolarians are too rare in this sample, as well as downhole.

Radiolarians are well preserved, but rare to few, in all core-catcher samples from Hole 684C. Samples 112-684C-1H-CC (7.8 mbsf) and -2H-CC (17.3 mbsf) contain a Quaternary assemblage. Sample 112-684C-3H-CC (26.8 mbsf) can be

related to the middle Pliocene Zone NR7 (*A. jenghisi* Zone). *L. daniellae* is abundant. Samples 112-684C-4H-CC (36.3 mbsf) to -6X-CC (48.5 mbsf) are assigned to Zone NR8 (*S. peregrina* Zone). Sample 112-684C-7X-CC (58.0 mbsf) is barren of radiolarians. The interval between Samples 112-684C-8X-CC (67.5 mbsf) and -10X-CC (86.5 mbsf) belongs to the *D. antepenultima* Zone. Below this interval, and following the same sequence as in Hole 684A, a barren sample and rare late to middle Miocene forms were successively observed.

Site 685

Site 685 (9°06.78'S, 80°35.01'W) is located on the lower slope of the Peru Trench, at a depth of 5070 m, about 1200 m above the trench floor. The stratigraphy and fabric of the cored section are consistent with the accretionary nature apparent in the seismic record. The change from upper Miocene nonaccretionary to accretionary sediments along the Peru Trench occurs after the Nazca Ridge was subducted at the latitude of the site. At the same time, sedimentation increased dramatically following the onset of coastal upwelling. Hole 685A was drilled to a depth of 459.1 mbsf into the lower slope sediment prism.

All core-catcher samples from Hole 685A have been studied for radiolarians. They are well preserved and abundant to common in Samples 112-685A-1H-CC (4.1 mbsf) to -23X-CC (213.1 mbsf). Downhole, they are generally few to rare and moderately to poorly preserved. Samples 112-685A-47X-CC (430.6 mbsf) to -51X-CC (468.1 mbsf) are almost barren. The techniques used for Mesozoic rocks (De Wever et al., 1979; De Wever, 1982) were employed to extract radiolarians from Samples 112-685A-39X-CC to -51X-CC (357.1–468.1 mbsf).

The last appearance of *S. universus* in Sample 112-685A-4H-CC (32.6 mbsf) marks the lower limit of Zones NR1/NR2 (*B. invaginata*/*C. tuberosa* Zones). Last appearances of *A. nosicaae* and *P. pitomorphus* in Sample 112-685A-6X-CC (51.6 mbsf) place the lower limit of Zone NR3 (*S. universus* Zone) above this sample. The interval from this boundary to the first appearance of *L. nigriniae* in Sample 112-685A-21X-CC (194.1 mbsf) has not been divided; it spans the middle and early Pleistocene Zones NR4/NR5 (*A. ypsilon*/*A. angulare* Zones). Many Miocene species, like *D. antepenultima*, *Didymocyrtis penultima*, and *S. peregrina*, were observed in Sample 112-685A-22X-CC (203.6 mbsf). It is not clear if this sample is of Pleistocene or Miocene age, since the sample may be either contaminated or contain reworked fauna. This uncertainty is probably related to a hiatus. Sample 112-685A-23X-CC (213.1 mbsf) can be assigned to the late Miocene *D. penultima* Zone. The occurrences of many reworked specimens, such as *D. petterssoni* and *Cyrtocapsella elongata*, and specimens originating from the sub-Antarctic, such as *Prunopyle hayesi*, as well as two barren samples, are indicative of strong currents and reworking patterns during the late Miocene. The lower limit of this interval has been tentatively placed at the first appearance of *D. penultima* in Sample 112-685A-26X-CC (233.6 mbsf). Radiolarian assemblages found downhole include many species characteristic of the early late Miocene *D. antepenultima* Zone markers: *D. antepenultima*, *D. hughesi* and *S. delmontensis*. The transitions between *D. petterssoni* and *D. hughesi* and between *D. laticonus* and *D. antepenultima* are unclear. In the former case, the transition appears to be prolonged between Samples 112-685A-45X-CC (411.6 mbsf) and -49X-CC (449.6 mbsf), while in the latter case no specimens of *D. laticonus* were observed; hence, no lower limit is proposed herein for the *D. antepenultima* Zone. Samples 112-685A-43X-CC (392.6 mbsf) and -44X-CC (402.1 mbsf) contain reworked species of

Eocene/Oligocene age (*Dorcadospyris ateuchus*, *Eusyringium fistuligerum* and *Lithocyclia aristotelis*). Occurrences of radiolarians in Hole 685A are recorded in Table 3.

Site 686

Site 686 (13°28.81'S, 76°53.49'W) is located in the West Pisco Basin. It represents the southernmost point of the north-south transect designed to study paleoceanography along the outer Peru shelf. The drilling area is adjacent to exposures on land of the famous Miocene Pisco Formation, a classic association of diatomites, cherts, and dolomites, thought to have formed under coastal upwelling conditions (Muizon and Bellon, 1980). Two holes were drilled at Site 686 in a water depth of 447 m to recover sediments deposited under upwelling conditions during the late Neogene and Quaternary age. Drilling at Hole 686A penetrated 205.7 m, and at Hole 686B, 303 m, of Quaternary sediments. The base of the Quaternary was not reached.

All core-catcher samples from Hole 686A were studied for radiolarians. They are generally rare, but well to moderately preserved in all samples.

A Quaternary radiolarian assemblage, including *L. nigriniae*, was found in Samples 112-686A-2H-CC (14.6 mbsf), -5H-CC (43.1 mbsf), -9X-CC (72.7 mbsf), -12X-CC (101.2 mbsf), and -13X-CC (110.7 mbsf). Other samples in this interval are barren.

Site 687

Site 687 (12°51.78'S, 76°59.43'W) is located on the seaward flank of the tectonically stable Lima Platform, which forms the eastern and southern boundaries of the Lima Basin in this area. Two holes were drilled at Site 687 to recover upper-slope sediments deposited under upwelling conditions during the late Neogene and Quaternary. Drilling at Hole 687A penetrated 202.00 m and at Hole 687B, 185.80 m of Quaternary and Pliocene sediments. The base of the Quaternary was reached at 127.92 m in Hole 687A and at 110.22 m in Hole 687B. All core-catcher samples from Hole 687A were studied for radiolarians. They are rare in all samples, but preservation is good to moderate.

The usual Quaternary radiolarian assemblage with *L. nigriniae* was found in Samples 112-686A-1H-CC (5.1 mbsf) and -14X-CC (120.2 mbsf). Samples 112-687A-6H-CC (52.6 mbsf) to -7X-CC (62.1 mbsf), Samples 112-687A-10X-CC (82.1 mbsf) to -15X-CC (129.7 mbsf), and Samples 112-687A-17X-CC (148.7 mbsf) to -19X-CC (167.7 mbsf) did not yield sufficient radiolarians to allow us to determine ages. Samples 112-687A-2H-CC (14.6 mbsf) to -5H-CC (43.1 mbsf), and 112-687A-8X-CC (64.7 mbsf), -20X-CC (177.2 mbsf), and -22X-CC (196.2 mbsf) are barren. Samples 112-687A-11X-CC (62.1 mbsf) to -13X-CC (1110.7 mbsf) and -16X-CC (139.2 mbsf) were unavailable for radiolarian investigations. Sample 112-687A-10X-CC (82.2 mbsf) contains *Didymocyrtis tubarius*, which is indicative of an early Miocene age and is probably reworked.

Site 688

Site 688 (11°32.26'S, 78°56.57'W) is on the lower slope of the Peru Trench about 30 km landward of the trench axis. The site is located about 32 km south-southeast from Site 682, parallel to the regional trend. Five holes were drilled in a water depth of 3820 m at Site 688, but cores were recovered from only three holes (688A, 688C and 688E). Drilling in Hole 688A penetrated 350.3 m of mostly Quaternary hemipelagic sediments. The lowermost sample at 343.4 mbsf may be late Pliocene in age. One core of Quaternary diatomaceous mud was recovered at 359.8 mbsf in Hole 688C. Drilling at Hole 688E penetrated 779 m of Quaternary to Eocene sediments.

Techniques used for shales and Mesozoic rocks were employed to extract radiolarians from Sample 112-688E-16R-CC (498.0 mbsf), and the remaining downhole samples.

Radiolarians were studied in all core-catcher samples from Hole 688A. They are common to abundant, and generally well preserved in all samples. The last appearance of *S. universus* in Sample 112-688A-4H-CC (36.8 mbsf) marks the top of Zone NR3 (*S. universus* Zone). The interval between the top of the hole and this sample is placed in the late Pleistocene Zones NR1/NR2 (*B. invaginata*/*C. tuberosa* Zones). The lower limit of Zone NR3 (*S. universus* Zone) cannot be determined because the first occurrence of *Collosphaera tuberosa* was not recognized. A single occurrence of this species was observed in Sample 112-688A-3H-CC (27.3 mbsf). The last occurrence of *A. nosicaae*, (0.6 to 0.7 Ma in tropical areas; Johnson et al., in press), in Sample 112-688A-8X-CC (74.8 mbsf), is indicative of Zone NR4 (*A. ypsilon* Zone). The lower limit of Zone NR4 cannot be determined because only one occurrence in Sample 112-688A-34X-CC (321.8 mbsf) of *A. angulare* was observed. Co-occurrence of *L. nigriniae* in the same sample is indicative of the early Pleistocene Zone NR5 (*A. angulare* Zone). Rare radiolarian species of early Pliocene age (*S. peregrina*, *A. pliocenica*, and *P. vema*) are reworked in Samples 112-688A-34X-CC (321.8 mbsf) and -35X-CC (331.3 mbsf). The Pliocene/Pleistocene boundary was not recognized. Occurrences of radiolarian species in Hole 688A are recorded in Table 4.

All core-catcher samples from Hole 688E were studied for radiolarians. They are rare, except in Sample 112-688E-1R-CC (355.5 mbsf), which contains few radiolarians. Preservation is generally poor. Sample 112-688E-1R-CC (355.5 mbsf) is probably of early Pleistocenen age as it contains *L. neoheteroporos*. Samples 112-688E-2R-CC (365.0 mbsf) to -7R-CC (412.5 mbsf) are poor in radiolarians. Rare specimens of *D. hughesi*, *C. tetrapera*, *S. delmonten-sis*, *P. fistula*, and *Eucyrtidium cienkowskii* are indicative of an early late Miocene age for Sample 112-688E-8R-CC (422.0 mbsf). Radiolarians are very rare and moderately preserved in Samples 112-688E-10R-CC (441.0 mbsf) to -12R-CC (460.0 mbsf). Occurrence of *D. antepenultima* in these samples is indicative of the *D. antepenultima* Zone (early late Miocene). Samples 112-688E-13R-CC (469.5 mbsf) to -16R-CC (498.0 mbsf) are barren of radiolarians. Well-preserved specimens of *C. tetrapera*, *S. delmontensis*, *E. cienkowskii*, *L. parkerae*, and *Calocycletta robusta* are common in Sample 112-688E-19R-CC (526.5 mbsf). This level is tentatively referred to the *D. alata* Zone (early middle Miocene). In Sample 112-688E-19R-CC (526.5 mbsf), well preserved and abundant radiolarians are indicative of an early *D. alata* Zone to a late *C. costata* Zone interval (late early Miocene to early middle Miocene): *D. mammifera*, *D. tubarius*, and no *D. laticonus*, *Dendrospyris bursa*, *Calocy-cletta virginis*, or *L. parkerae*. One reworked specimen of *Lychnocanoma elongata*, common in the early Miocene, was observed. The same fauna was observed down to Sample 112-688E-23R-CC (564.5 mbsf). In Samples 112-688E-25R-CC (583.5 mbsf) and -26R-CC (593.0 mbsf), well-preserved and common specimens of *Centrobotrys petrush-evskayae*, *C. tetrapera*, *Didymocyrtis prismaticus*, *Histias-trum martinianum*, *L. elongata*, *Tessarospyris podo-dendros*, and *Theocyrtis tuberosa* place this interval in the early Miocene (*L. elongata* to *C. tetrapera* Zones). No direct evidence exists for a hiatus between the late and early Miocene, but sedimentation rates were probably low during the early Miocene in this area. Downhole, radiolarians are generally absent or rare and are strongly recrystallized. No age assignment can be proposed for the interval.

SUMMARY

Stratigraphy

Stratigraphic results are summarized in Figures 2 and 3. Pleistocene radiolarian assemblages are generally well preserved in almost all sites. However, most traditional stratigraphic markers are missing and only one precisely dated event was observed: the last occurrence of *S. universus* (0.4 Ma; Morley and Shackleton, 1976), which marks the boundary between Zones NR2 and NR3 (*C. tuberosa* and *S. universus* Zones). This event was recognized in all sites, except the shallow ones (Sites 679, 680, 681). Other definitive Pleistocene zonal markers, between Zones NR1 and NR2 (FAD of *B. invaginata*), between Zones NR3 and NR4 (FAD of *C. tu-berosa*) and between Zones NR4 and NR5 (LAD of *A. angulare*), were not recognized. Some events were tentatively used to indicate biozones, even though no absolute ages were available for this material. The LAD of *A. nosicaae* and of *P. pitomorphus* lie within Zone NR4. The FAD of *L. nigriniae* may be diachronous and older than in tropical sediments. It has been found, herein, to occur in the lower part of Zone N5, whereas in tropical sediments (Johnson et al., in press), it occurs in the upper part of Zone NR5.

Because of hiatuses and/or barren intervals, the Pliocene/Pleistocene boundary (NR5/NR6) was recognized only in Site 683. In Site 683, a late Pliocene age was surmised for Sample 112-683A-19X-CC (173.2 mbsf) on the basis of the co-occurrence of *L. neoheteroporos*, *C. davisiana*, and *T. vetulum*. However, the NR5/NR6 boundary is not precise because no specimens of *Pterocanium prismatium* were found. The boundary between NR7 and NR8 (LAD of *S. peregrina*; 2.6 to 2.7 Ma in Johnson et al., in press) was recognized in Sites 682, 683, and 684. The *S. peregrina* Zone, which spans the late Miocene and early Pliocene, was recognized only in Sample 112-682A-8X-CC (76.3 mbsf), based on a rare co-occurrence of *Pseudocubus vema* (an early sub-Antarctic and Mediterranean Pliocene species), *S. peregrina*, and *L. daniellae*, whose stratigraphical range is short and typical of the early Pliocene part of the *S. peregrillna* Zone (Caulet, 1985).

The upper part of the late Miocene was not recognized using the radiolarian data in Leg 112 material. Thus, the Miocene/Pliocene boundary could not be defined. Assemblages referred to the *D. penultima* Zone were only observed in Site 685. *D. penultima* specimens are well preserved, and there is no doubt about their identification. However, reworked skeletons are abundant in the same samples, and deposition of this rarely found (in this area) late Miocene interval was probably influenced by strong hydrodynamic patterns. Radiolarian assemblages belonging to the early late Miocene *D. antepenultima* Zone are common in all sites, but the transition from *D. antepenultima* to *D. penultima* was observed only in Site 685. The lower limit of this zone (transition between *D. petterssoni* and *D. hughesi*, and transition between *D. laticonus* and *D. antepenultima*) was observed only in Site 683. In Sites 682, 684, 685, and 688, there are barren intervals at the base of the *D. antepenultima* Zone.

Middle Miocene assemblages are poorly preserved in Sites 682 and 688. Better preservation in Site 685 permitted definition of the boundary between the *D. petterssoni* and *D. alata* Zones. The first appearance of *D. petterssoni* is not clear in Site 682, but assemblages representative of the two zones were observed.

Late early Miocene assemblages can be found only in Site 688. Due to many barren samples, and poor preservation, a precise biozonation of this period cannot be proposed. The *C. costata* and *D. elongata* Zones are probably represented in

Site 688, but their limits, as well as the middle/early Miocene boundary, were not recognized.

Eocene radiolarians are so crystallized in Site 683, that no biozonation can be proposed.

Radiolarian Events

As no absolute ages and no continuous sequences are available in Leg 112 material, only relative ranges of some species can be discussed. Using the last occurrences of *S. universus* and *A. nosicaae*, the first appearances of some species described by Nigrini (1968) in Holocene sediments from the eastern tropical Pacific, can be tentatively dated: (1) *Cypassis irregularis* is restricted to Zones NR1/NR2; (2) the first occurrence of *P. cresmatoplegma* is tentatively placed below the NR3/NR4 zonal boundary; (3) *D. infabricatus* evolves just below the LAD of *A. nosicaae* in Zone NR4; (4) specimens of *P. grandiporus* are rare, but first appearances of the species in Sites 683, 685, and 688, are diachronous (NR4 to NR2). This latter event seems, however, to be unreliable because the species may not be sufficiently well defined (Lazarus, 1985).

The species *P.(?) crustula*, described by Caulet, 1979, from the central Indian Ocean, is abundant in our material. We do not know if this species is extant. Its last common occurrence is located in sediments younger than 0.4 Ma. Observations of its FAD are not conclusive because the earliest specimens occur in the early Pliocene of Site 683, but in early Miocene samples (*D. antepenultima* Zone) from Site 685. However, the *D. antepenultima* interval may be incomplete in Site 685. More observations are needed to clarify these results. Many specimens of *L. daniellae*, described in early Pliocene sediments from the southwest Pacific (Caulet, 1985) were found in early Pliocene levels in Leg 112 material. Unfortunately, early Pliocene sediments are rare, and a continuous sequence from Miocene to Pleistocene was not recorded. Thus, new data for the stratigraphic range of this species are not available. However, it is interesting to note that specimens of *L. daniellae* occur in the same samples as the first *L. neohetero-poros* in Sites 682 and 683. More studies will be necessary to decide if patterns of evolution in the *L. heteroporos—L. nigriniae* lineage should be changed so as to include *L. daniellae*.

Among the species described by Goll (1980), *P. warreni* was abundant in Leg 112 material. The first occurrence of this form was recorded in the early Pliocene samples from Sites 682 and 683. In Site 682, co-occurrences of *P. vema* and *P. warreni* could be indicative of a new lineage, but more observations will be necessary before *P. vema* can be confirmed as the ancestor of *P. warreni*. Phylogenetic relationships in the *A. murrayana/A. trepanata/A. cyrtodon* group are not so clear as those described by Goll, probably because the forms may not be well understood, or are, in fact, conspecific.

New observations about *Eucyrtidium infundibulum*, a form described by Haeckel, 1887, as *Lithomitra infundibulum*, but since forgotten, show that this species might be used for stratigraphy. Its last appearance was recorded in Zone NR1/NR2, but no specimens were found in the most recent sediments. Early representatives of the species are common in early Pliocene sediments of Sites 682 and 683. Rarely, similar forms were observed in the *D. penultima* interval of Site 685. More accurate observations concerning the first occurrence of this species are not available from our material.

REFERENCES

Bailey, J. W., 1856. Notice of microscopic forms found in the soundings of the Sea of Kamtschatka—with a plate. *Am. J. Sci. Arts, Ser. 2*, 22:1–6.

Björklund, K. R., 1977. *Actinomma haysi*, n.sp., its Holocene distribution and size variation in Atlantic Ocean sediments. *Micropaleontology*, 23:114–126.

Björklund, K. R., and Goll, R. M., 1979. Internal skeletal structures of Collosphaera and Trisolenia: a case of repetitive evolution in the Collosphaeridae (Radiolaria). *J. Paleontol.*, 53:1293–1326.

Campbell, A. S. and Clark, B. L., 1944. Miocene radiolarian faunas from southern California. *Geol. Soc. Am., Spec. Pap.*, 51:1–76.

Carnevale, P., 1908. Radiolarie e silicoflagellati di Bergonzano (Reggio Emilia). *Mem. R. Istit. Sci., Lett. Arti*, 28:1–46.

Caulet, J., 1971. Contribution à l'étude de quelques Radiolaires Nassellaires des boues de la Méditerranée et du Pacifique. *Cahiers Micropaléontol.*, Série 2, No. 10, Archives originales, Centre de Documentation C.N.R.S., 498:1–10.

———, 1979. Les dépots à radiolaires d'âge Pliocène supérieur à Pleistocène dans l'océan Indien central: nouvelle zonation biostratigraphique. *Mém. Museum Nat. Hist. Nat.*, 43(C):119–141.

———, 1985. Radiolarians from the Southwest Pacific. *In* Kennett, J. P., von der Borch, C. C., et al., *Init. Repts. DSDP*, 90: Washington (U.S. Govt. Printing Office), 835–861.

———, 1986. A refined radiolarian biostratigraphy for the Pleistocene of the temperate Indian Ocean. *Mar. Micropaleontol.*, 11:217–229.

Chen, P. H., 1975. Antarctic Radiolaria. *In* Hayes, D. E., Frakes, L. A., et al., *Init. Repts. DSDP*, 28: Washington (U.S. Govt Printing Office), 437–513.

Clark, B. L., and Campbell, A. S., 1942. Eocene radiolarian faunas from the Monte Diablo area, California. *Geol. Soc. Am. Spec. Pap.*, 39:1–112.

De Wever, P., 1982. Radiolaires du Trias et du Lias de la Téthys (Systématique, Stratigraphie). *Mem. Soc. Geol. Nord*, 7:1–599.

De Wever, P., Riedel, W., Baumgartner, P., Dumitrica, P., Björklund, K., Caulet, J. P., Drobne, K., Grandlund, A., Kocher, R., and Schaaf, A., 1979. Eurorad '78: Recherches actuelles sur les Radiolaires en Europe. *Annu. Soc. Geol. Nord*, Lille, XCVIII:205–222.

Dogel, V. A., and Reshetnyak, V. V., 1952. Materialy po radiolyariyam severozapadnoi chasti tikhogo okeana (Material on radiolarians of the northwestern part of the Pacific Ocean). *Issledov. Dalnevost. Morei SSSR*, 3:5–36.

Dreyer, F., 1889. Die Pylombildungen in vergleichend-anatomischer und entwicklungsgeschichtlicher Beziehung bei Radiolarien und bei Protisten uberhaupt. *Jenais. Zeits. Naturwiss.*, 23:1–138.

Dumitrica, P., 1973. Cretaceous and Quaternary Radiolaria in deep sea sediments from the northeast Atlantic Ocean and Mediterranean Sea. *In* Ryan, W.B.F., Hsu, K. J., et al., *Init. Repts. DSDP*, 13(Pt. 2): Washington (U. S. Govt. Printing Office), 829–901.

Ehrenberg, C. G., 1838. Uber die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Konig. Akad. Wissen. Berlin, Abhandlungen*, Jahre 1838:59–147.

———, 1844. Uber 2 neue Lager von Gebirgsmassen aus Infusorien als Meeres-Absatz in Nord-Amerika und eine Vergleichung derselben mit den organischen Kreide-Gebilden in Europa und Afrika. *Konig. Preuss. Akad. Wissen. Berlin, Bericht, Jahre* 1844:57–97.

———, 1847. Uber die mikroskopischen kieselschaligen Polycystinen als machtige Gebirgsmasse von Barbados und uber das Verhaltniss der aus mehr als 300 neuen Arten bestehenden ganz eigenthumlichen Formengruppe jener Felsmasse zu den jetzt lebenden Thieren undzur Kreidebildung Eine neue Anregung zur Erforschung des Erdlebens. *Konig. Preuss. Akad. Wissen. Berlin, Bericht, Jahre* 1847:40–60.

———, 1854a. Die systematische Charakteristik der neuen mikroskopischen Organismen des tiefen atlantischen Oceans. *Konig. Preuss. Akad. Wissen. Berlin, Bericht, Jahre* 1854:236–250.

———, 1854b. *Mikrogeologie*: Leipzig (Voss) Vol. xxviii plus Atlas, Fortsetzung (1856).

————, 1860a. Uber die organischen und unorganischen Mischungsverhaltnisse des Meeresgrundes in 19,800 Fuss Tiefe nach Lieut. Brookes Messung. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1860:765–774.

————, 1860b. Uber den Tiefgrund des stillen Oceans zwischen Californien und den Sandwich-Inseln aus bis 15600'Tiefe nach Lieutenant Brooke. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1860:819–833.

————, 1861. Uber die Tiefgrund-Verhaltnisse des Oceans am Einegange der Davisstrasse und bei Island. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1861:275–315.

————, 1872a. Mikrogeologische Studien als Zusammenfassung der Beobachtungen des kleinsten Lebens der Meeres-Tiefgrunde aller Zonen und dessen geologischen Einfluss. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1872:265–322.

————, 1872b. Mikrogeologische Studien uber das kleinste Leben der Meeres-Tiefgrunde aller Zonen und dessen geologischen Einfluss. *Konig. Preusse. Akad. Wissen. Berlin, Abhand., Jahre,* 1872:131–139.

————, 1873. Grossere Felsproben des Polycystinen-Mergels von Barbados mit weiteren Erlauterungen. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1873:213–263.

————, 1875. Fortsetzung der mikrogeologischen Studien als Gesammt-Uebersicht der mikroskopischen Palaontologie gleichartig analysirter Gebirgsarten der Erde, mit specieller Rucksicht auf den Polycystinen-Mergel von Barbados. *Konig. Preuss. Akad. Wissen. Berlin, Abh. Jahre,* 1875:1–225.

Foreman, H. P., 1973. Radiolaria of Leg 10 with systematics and ranges for the families Amphipyndacidae, Artostrobiidae, and Theoperidae. *In* Worzel, J. L. and Bryant, W. et al., *Init. Repts. DSDP,* 10: Washington (U.S. Govt. Printing Office), 407–474.

Goll, R. M., 1968. Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in the Pacific and Caribbean Basins. Part I. *J. Paleontol.,* 42:1409–1432.

————, 1969. Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in the Pacific and Caribbean basins. Part II. *J. Paleontol.,* 43:322–339.

————, 1976. Morphological intergradation between modern populations of Lophospyris and Phormospyris (Trissocyclidae, Radiolaria). *Micropaleontology,* 22:379–418.

————, 1980. Pliocene-Pleistocene Radiolaria from the East Pacific Rise and the Galapagos spreading center, Deep Sea Drilling Project Leg 54. *In* Rosendahl, B. R., Hekinian, R., et al., *Init. Repts. DSDP,* 54: Washington (U. S. Govt. Printing Office), 425–454.

Haeckel, E., 1860a. Uber neue, lebende Radiolarien des Mittelmeeres und . . . die dazu gehorigen Abbildungen. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1860:794–817.

————, 1860b. Fernere Abbildungen und Diagnosen neuer Gattungen und Arten von lebenden Radiolarien des Mittelmeeres. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1860:835–845.

————, 1862. *Die Radiolarien (Rhizopoda Radiaria)*: Berlin (Reimer), Vol. xiv plus Atlas.

————, 1887. Report on the Radiolaria collected by *H.M.S. Challenger* during the years 1873–1876. *Report on the Scientific Results of the Voyage of the H.M.S. Challenger, Zoology,* 18:clxxxviii + 1803.

Hays, J. D., 1965. Radiolaria and late Tertiary and Quaternary history of Antarctic Seas. Biology of Antarctic Seas II. *Am. Geophys. Union, Antarctic Res. Ser.,* 5:125–184.

Johnson, D. A., Caulet, J. P., Nigrini, C., Schneider, D., and Kent, D., in press. Pliocene-Pleistocene radiolarian events and magnetostratigraphic calibrations for the tropical Indian Ocean. *Mar. Micropaleontol.*

Jörgensen, E., 1900. Protophyten und Protozoen im Planktonaus der norwegischen Westkuste. *Bergens Museums Aarbog* (1899), 2 (6):1–112.

————, 1905. The protist plankton and the diatoms in bottom samples. *Bergens Museums Skrifter,* Bergen, 1905:49–151.

Kling, S. A., 1973. Radiolaria from the eastern North Pacific, Deep Sea Drilling Project Leg 18. *In* Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP,* 18: Washington (U.S. Govt. Printing Office), 617–671.

————, 1977. Local and regional imprints on radiolarian assemblages from California coastal basin sediments. *Mar. Micropaleontol.,* 2:207–221.

Knoll, A. H., and Johnson, D. A., 1975. Late Pleistocene evolution of the collosphaerid radiolarian Buccinosphaera invaginata Haeckel. *Micropaleontology,* 21:60–68.

Kruglikova, S. B., 1979. Radiolarians of the bottom sediments as indicators of environmental changes. Pacific Science Association XIV Pacific Science Congress, USSR Khabarovsk, August 1979. Committee F (Marine Sciences), Section F II (Marine Biology), Abstracts:145–147.

Lazarus, D. B., Reed, P. S. and Prothero, D. R., 1985. Evolution of the radiolarian species-complex Pterocanium: a preliminary survey. *J. Paleontol.,* 59:183–220.

Martin, G. C., 1904. Radiolaria. *Maryland Geol. Surv.* (Johns Hopkins Press, Baltimore), 447–459.

Moore, T. C., 1971. Radiolaria. *In* Tracey, J. I., Jr., Sutton, G. H., et al., *Init. Repts. DSDP,* 8: Washington (U.S. Govt. Printing Office), 727–775.

————, 1972. Mid-Tertiary evolution of the radiolarian genus Calocycletta. *Micropaleontology,* 18:144–152.

Morley, J. J., and Shackleton, N. L., 1978. Extension of the radiolarian Stylatractus universus as a biostratigraphic datum to the Atlantic ocean. *Geology,* 6:309–311 .

Müller, J., 1855. Uber die im Hafen von Messina beobachteten Polycystinen. *Konig. Preuss. Akad. Wissens. Berlin, Monat. Jahre,* 1855:671–674.

————, 1857. Uber die Thalassicollen, Polycystinen und Acanthometren des Mittelmeeres. *Konig. Preuss. Akad. Wissen. Berlin, Monat. Jahre,* 1856:474–503

————, 1858. Uber die Thalassicollen, Polycystinen und Acanthometren des Mittelmeeres. *Konig. Preuss. Akad. Wissens. Berlin, Abh. Jahre,* 1858:1–62.

Muizon, C. de, and Bellon, H., 1980. L'âge Mio-Pliocéne de la Formation Pisco, Peru. *C. R. Acad. Sci.,* 290:1063–1066.

Nakaseko, K., 1963. Neogene Cyrtoidea (Radiolaria) from the Isozaki Formation in Ibaraki Prefecture. *Japan Sci. Repts.,* 12:165–198 (College of General Education, Osaka Univ.).

Nigrini, C., 1967. Radiolaria in pelagic sediments from the Indian and Atlantic Oceans. *Bull. Scripps Inst. Oceanogr.,* 11:1–125 (Univ. of California, San Diego.

————, 1968. Radiolaria from eastern tropical Pacific sediments. *Micropaleontology,* 14:1–63.

————, 1970. Radiolarian assemblages in the north Pacific and their application to a study of Quaternary sediments in Core V20-130. *Geol. Soc. Am. Mem.,* 126:139–183.

————, 1971. Radiolarian zones in the Quaternary of the equatorial Pacific Ocean. *In* Funnell, B. M., and Riedel, W. R. (Eds.), *The Micropalaeontology of Oceans:* Cambridge (Cambridge Univ. Press), 443–461.

————, 1977. Tropical Cenozoic Artostrobiidae (Radiolaria) *Micropaleontology,* 23:241–269.

————, 1985, Radiolarian biostratigraphy in the central equatorial Pacific. *In* Mayer, L. A., Theyer, F., et al., *Init. Repts. DSDP,* 85: Washington (U.S. Govt. Printing Office), 511–551.

Nigrini, C., and Moore, T. C., 1979. A guide to modern Radiolaria. *Cushman Found. Foramin. Res. Spec. Publ.,* 16:i–xii, S1–S142, N1–N106.

Petrushevskaya, M. G., 1967. Radiolyarii otryadov i Nassellaria antarkticheskoi oblasti. *Iss. Fauny Morei* 4 (12), Resultaty Biologicheskikh Issledovanii Sovetskoi Antarkticheskoi Ekspeditsii 1955-1958, 3, Zoologicheskii Institut Academiya Nauk SSSR, 1–186.

————, 1971. Radiolyarii Nassellaria v planktone mirovogo okeana. Akademiya nauk SSSR, Zoologicheskii Institut, *Iss. Fauny Morei,* 9 (17):1–294.

————, 1975. Cenozoic radiolarians of the Antarctic, Leg 29, DSDP. *In* Kennett, J. P., Houtz, R. E., et al., *Init. Repts. DSDP,* 29: Washington (U. S. Govt. Printing Office), 541–675.

Petrushevskaya, M. G., and Kozlova, G. E., 1972. Radiolaria: Leg 14, Deep Sea Drilling Project. *In* Hayes, D. E., Pimm, A. C., et al., *Init. Repts. DSDP,* 14: Washington (U.S. Govt. Printing Office), 495–648.

Popofsky, A., 1908. Die Radiolarien der Antarktis (mit Ausnahme der Tripyleen). *Deutsche Sudpolar-Expedition,* 1901–1903, 10 (Zool. vol. 2):183–305.

_____, 1913 Die Nassellarien des Warmwassergebietes. *Deutsche Sudpolar-Expedition*, 1901–1903, 14 (Zool. vol. 6):217–416.

Riedel, W. R., 1953. Mesozoic and late Tertiary Radiolaria of Rotti. *J. Paleontol.*, 27:805–813.

_____, 1957. Radiolaria: a preliminary stratigraphy. *Repts. Swedish Deep-Sea Expedition*, 1947–1948, 6:59–96.

_____, 1958. Radiolaria in Antarctic sediments. *Repts. BANZ Antarctic Res. Expedition, Ser. B*, 6:217–255.

_____, 1959. Oligocene and Lower Miocene Radiolaria in tropical Pacific sediments. *Micropaleontology*, 5:285–302.

Riedel, W. R., and Sanfilippo, A., 1970. Radiolaria, Leg 4, Deep Sea Drilling Project. *In* Bader, R. G., Gerard, R. D., et al., *Init. Repts. DSDP*, 4: Washington (U.S. Govt. Printing Office), 503–575.

_____, 1971. Cenozoic Radiolaria from the western tropical Pacific, Leg 7. *In* Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7: Washington (U.S. Govt. Printing Office), 1529–1672.

_____, 1978. Stratigraphy and evolution of tropical Cenozoic radiolarians. *Micropaleontology*, 24:61–96.

Sanfilippo, A., and Riedel, W. R., 1970. Post-Eocene "closed" theoperid radiolarians. *Micropaleontology*, 16:446–462.

_____, 1973. Cenozoic Radiolaria (exclusive of theoperids, artostrobiids and amphipyndacids) from the Gulf of Mexico, DSDP Leg 10. *In* Worzel, J. L., Bryant, W., et al., *Init. Repts. DSDP*, 10: Washington (U. S. Govt. Printing Office), 475–611.

_____, 1980. A revised generic and suprageneric classification of the Artiscins (Radiolaria). *J. Paleontol.*, 54:1008–1011.

Sanfilippo, A., Burckle, L. H., Martini, E. and Riedel, W. R., 1973. Radiolarians, diatoms, silicoflagellates and calcareous nannofossils in the Mediterranean Neogene. *Micropaleontology*, 19:209–234.

Sanfilippo, A., Westberg-Smith, M. J. and Riedel, W. R., 1985. Cenozoic Radiolaria. *In* Bolli, H. M., Perch-Nielsen, K., and Saunders, J. B. (Eds.), *Plankton Stratigraphy:* Cambridge (Cambridge Univ. Press), 631–712.

Seguenza, G., 1880. Le formazioni terziarie nella provincia di Reggio (Calabria). *Mem. R. Accadem. Lincei. Ser. 3*, 6:1–446.

Stohr, E., 1880. Die Radiolarienfauna der Tripoli von Grotte, Provinz Girgenti in Sicilien. *Palaeontographica*, 26:71–124.

Streeter, L. S., 1988. Two species (one new) of Plio-Pleistocene Radiolaria from the central equatorial Indian Ocean. *Micropaleontology*, 34:63–66.

Strelkov, A. A., and Reshetnyak, V. V., 1971. Kolonialnye radiolyarii Spumellaria Mirovogo okeana (Colonial Spumellarian radiolarians of the world ocean). *Akad. SSSR, Zoologich. Inst. Issl. Fauny Morei*, 9 (17):295–418.

Seuss, E. and Thiede, J. (Eds.), 1983. *Coastal Upwelling. Its sediment record. Part A: Responses of the Sedimentary Regime to Present Coastal Upwelling.* NATO Conf. Ser. IV (Mar. Sci.).

Suess, E., von Huene, R., et al., 1988. *Proc. ODP, Init. Repts.*, 112: College Station, TX (Ocean Drilling Program).

Theide, J. and Seuss, E. (Eds.), 1983. *Coastal Upwelling. Its Sediment Record. Part B: Sedimentary Records of Ancient Coastal Upwelling.* NATO Conf. Ser. IV (Mar. Sci.).

Vinassa de Regny, P. E., 1900. Radiolari Miocenici Italiani. *Mem. R. Accad. Sci. Istit. Bologna, Ser. 5*, 8:227–257 (565–595).

APPENDIX A

Species List

Acanthodesmia micropora (**Popofsky**). *Semantis micropora* Popofsky, 1908, p. 268, Pl. 20, Fig.4. *Acanthodesmia micropora* (Popofsky) *in* Petrushevskaya, 1971, p. 279, Fig. 135, I-IX.

Acanthodesmia viniculata (**Müller**). *Lithocircus viniculatus* Müller, 1857, p. 484. *Acanthodesmia viniculata* (Müller) *in* Müller, 1858, p. 30, Pl. 1, Figs. 1–7.

Acrosphaera cyrtodon (**Haeckel**). *Odontosphaera cyrtodon* Haeckel, 1887, p. 102, Pl. 5, Fig. 6. *Acrosphaera cyrtodon* (Haeckel) *in* Strelkov and Reshetnyak, 1971, p. 344, Pl. 7, Fig. 51; Pl. 8, Fig. 54; Text-Fig. 24.

Acrosphaera murrayana (**Haeckel**). *Choenicosphaera murrayana* Haeckel, 1887, p. 102, Pl. 8, Fig. 4. *Acrosphaera murrayana* (Haeckel) *in* Hilmers, 1906, p. 63.

Acrosphaera pseudarktios **Caulet**, Caulet, 1986, p. 226, Pl. 1, Fig. 8.

Acrosphaera trepanata (**Haeckel**). *Trypanosphaera trepanata* Haeckel, 1887, p. 110, Pl. 5, Fig. 4. *Acrosphaera trepanata* (Haeckel), *in* Goll, 1980, p. 436, Pl. 2, Figs. 6–9.

Actinomma delicatulum (**Dogiel**). *Heliosoma delicatulum* Dogiel, Dogiel and Reshetnyak, 1952, p. 7, Fig. 2.

Actinomma haysi **Bjorklund**, Bjorklund, 1977, p. 117, Pl. 1, Figs. A–L.

Actinomma popofskii (**Petrushevskaya**). *Echinomma popofskii* Petrushevskaya, 1967, p. 23, Fig. 12, I–III.

Amphiplecta acrostoma **Haeckel**, 1887, p. 1223, Pl. 97, Fig. 10.

Amphirhopalum virchowi (**Haeckel**). *Euchitonia virchowi* Haeckel, 1862, p. 503, Pl. 30, Figs. 1–4. *Amphirhopalum virchowi* (Haeckel) *in* Dumitrica, 1973, p. 835, Pl. 9, Figs. 2–4; Pl. 11, Fig. 6; Pl. 21, Figs 2–13.

Amphiropalum ypsilon **Haeckel**, 1887, p. 522; Nigrini, 1971, p.447, Pl. 34, Figs. 7a–c.

Anthocyrtidium ehrenbergi (**Stöhr**). *Anthocyrtis ehrenbergi* Stöhr, 1880, p. 100, Pl. 3, Figs. 21a,b. *Anthocyrtidium ehrenbergi* (Stöhr) *in* Nigrini and Caulet, 1988, p. 345, Pl. 1, Figs. 3, 4.

Anthocyrtidium jenghisi **Streeter**, Streeter, 1988, p. 63, Pl. 1, Figs. 1–4.

Anthocyrtidium nosicaae **Caulet**, 1979, p. 132, Pl. 2, Fig. 6.

Anthocyrtidium ophirense (**Ehrenberg**). *Anthocyrtis ophirensis* Ehrenberg, 1872a, p. 301. *Anthocyrtidium ophirense* (Ehrenberg) *in* Nigrini, 1967, p. 56, Pl. 6, Fig. 3.

Anthocyrtidium pliocenica (**Seguenza**). *Anthocyrtis ehrenbergi* Stöhr var. *pliocenica* Seguenza, 1880, p. 232. *Anthocyrtidium pliocenica* (Seguenza) *in* Nigrini and Caulet, 1988, p. 355, Pl. 2, Figs. 5, 60.

Anthocyrtidium zanguebaricum (**Ehrenberg**). *Anthocyrtis zanguebarica* Ehrenberg, 1872a, p. 301. *Anthocyrtidium zanguebaricum* (Ehrenberg) *in* Nigrini, 1967, p. 58, Pl. 6, Fig. 4.

Axoprunum melpomene (**Haeckel**). *Stylosphaera melpomene* Haeckel, 1887, p. 135, Pl. 16, Fig. 1.

Botryostrobus aquilonaris (**Bailey**). *Eucyrtidium aquilonaris* Bailey, 1856, p. 4, Pl. 1, Fig. 9. *Botryostrobus aquilonaris* (Bailey) *in* Nigrini, 1977, p. 246, Pl. 1, Fig. 1.

Botryostrobus auritus/australis (**Ehrenberg**) gr. *Lithocampe australe* Ehrenberg, 1844, p. 187; 1854a, Pl. 35A, 21, Fig. 18. *Botryostrobus auritus/australis* (Ehrenberg) gr. *in* Nigrini, 1977, p. 246, Pl. 1, Figs. 2–5.

Botryostrobus bramlettei (**Campbell and Clark**). *Lithomitra bramlettei* Campbell and Clark, 1944, p. 53, Pl. 7, Figs. 10–14. *Botryostrobus bramlettei* (Campbell and Clark) *in* Caulet, 1979, p. 129, Pl. 1, Fig. 8.

Botryostrobus bramlettei pretumidulus **Caulet**, 1979, p. 129, Pl. 1, Fig. 5.

Botryostrobus bramlettei tumidulus (**Bailey**). *Eucyrtidium tumidulus* Bailey, 1856, p. 5, Pl. 1, Fig. 11. *Botryostrobus bramlettei tumidulus* (Bailey) *in* Caulet, 1979, p. 131, Pl. 1, Fig. 9.

Botryostrobus miralestensis (**Campbell and Clark**). *Dictyocephalus miralestensis* Campbell and Clark, 1944, p. 45, Pl. 6, Figs. 12–14. *Botryostrobus miralestensis* (Campbell and Clark) *in* Petrushevskaya and Kozlova, 1972, 539, Pl. 24, Fig. 31.

Botryostrobus seriatus (**Jorgensen**). *Eucyrtidium seriatum* Jorgensen, 1902, p. 150. *Stichocorys seriata* (Jorgensen) *in* Jorgensen, 1905, p. 140, Pl. 18, Fig. 102–104.

Calocyclas semipolita group **Clark and Campbell**, Campbell and Clark, 1942, p.83, Pl. 8, Figs. 12, 14, 17–19, 21–23.

Calocycletta caepa **Moore**, Moore, 1972, p. 149, Pl. 2, Figs. 4–7.

Calocycletta costata (**Riedel**). *Calocyclas costata* Riedel, 1959, p. 296, Pl. 2, Fig. 9.

Calocycletta robusta **Moore**, Moore, 1971, p. 743, Pl. 10, Figs. 5, 6.

Calocycletta virginis (**Haeckel**). *Calocyclas virginis* Haeckel, 1887, p. 1381, Pl. 74, Fig. 4. *Calocycletta virginis* (Haeckel) *in* Riedel and Sanfilippo, 1970, p. 535, Pl. 14, Fig. 10.

Calocyloma ampulla (**Ehrenberg**). *Eucyrtidium ampulla* Ehrenberg, 1854b, Pl. 36, Figs. 15a–c; Ehrenberg, 1873, p. 225. *Calocyloma ampulla* (Ehrenberg) *in* Foreman, 1973, p. 434, Pl. 1, Figs. 1–5; Pl. 9, Fig. 20.

Carpocanium sp. A **Nigrini**, Nigrini 1968, p. 55, Pl. 1, Fig. 4.

Carpocanopsis favosa (**Haeckel**). *Cycladophora favosa* Haeckel, 1887, p. 1380, Pl. 62, Figs. 5–6. *Carpocanopsis favosa* (Haeckel) *in* Sanfilippo et al., 1973, p. 224, Pl. 6, Figs. 7–8.

Centrobotrys petrushevskayae **Sanfilippo and Riedel**, Sanfilippo and Riedel, 1973, p. 532, Pl. 36, Figs. 12, 13.

Ceratocyrtis histricosa **group (Jorgensen)**. **Helotholus histricosa** Jorgensen, 1905, p. 137, Pl. 16, Figs. 86–88. *Ceratocyrtis histricosa* (Jorgensen) *in* Petrushevskaya, 1971, p. 98, Fig. 52, II–IV.

Circodiscus microporus **(Stöhr)**. *Trematodiscus microporus* Stohr, 1880, p. 108, Pl. 4, Fig. 17. *Circodiscus microporus* (Stöhr) *in* Petrushevskaya and Kozlova, 1972, p.526, Pl. 19, Figs. 1–7.

Clathrocanium sphaerocephalum **Haeckel**, 1887, p. 1211, Pl. 64, Fig. 1.

Clathrocyclas alcmenae **Haeckel**, 1887, p. 1388, Pl. 59, Fig. 6.

Clathrocyclas cabrilloensis **gr. Campbell and Clark**, 1944, p. 48, Pl. 7, Fig. 1–3.

Collosphaera orthoconus **(Haeckel)**. *Conosphaera orthoconus* Haeckel, 1887, p. 221, Pl. 12, Fig. 2. *Collosphaera* sp. A Knoll and Johnson, 1975, p. 63, Pl. 1, Figs. 1, 2, 7, Pl. 2, Figs. 4–6. *Collosphaera orthoconus* (Haeckel) *in* Bjorklund and Goll, 1979, p. 1317.

Collosphaera polygona **group Haeckel**, 1887, p. 96, Pl. 5, Fig. 13.

Collosphaera tuberosa **Haeckel**, 1887, p. 97; Nigrini, 1971, p. 445, Pl. 34. 1, Fig. 1

Cycladophora davisiana **(Ehrenberg)**. *Cycladophora* (?) *davisiana* Ehrenberg, 1861, p. 297. *Theocalyptra davisiana* (Ehrenberg) *in* Riedel, 1958, p. 239, Pl. 4, Figs. 2, 3, Text-Fig. 10.

Cypassis irregularis **Nigrini**, Nigrini, 1968, p. 53, Pl. 1, Figs. 2a–c.

Cyrtocapsella elongata **(Nakaseko)**. *Theocapsa elongata* Nakaseko, 1963, p. 185, Pl. 3, Figs. 4–5. *Cyrtocapsella elongata* (Nakaseko) *in* Sanfilippo and Riedel, 1970, p. 452, Pl. 1, Figs. 11–12.

Cyrtocapsella cornuta **(Haeckel)**. *Cyrtocapsa (Cyrtocapsella) cornuta* Haeckel, 1887, p. 1513, Pl. 78, Fig. 9. *Cyrtocapsella cornuta* (Haeckel) *in* Sanfilippo and Riedel, 1970, p. 453, Pl. 1.

Cyrtocapsella japonica **(Nakaseko)**. *Eusyringium japonicum* Nakaseko, 1963, p. 193, Pl. 4, Figs. 1–3. *Cyrtocapsella japonica* (Nakaseko) *in* Sanfilippo and Riedel, 1970, p. 452, Pl. 1, Figs. 13–15.

Cyrtocapsella tetrapera **(Haeckel)**. *Cyrtocapsa (Cyrtocapsella) tetrapera* Haeckel, 1887, p. 1512, Pl. 75, Fig. 12. Cyrtocapsella *tetrapera* (Haeckel) *in* Sanfilippo and Riedel, 1970, p. 453, Pl. 1, Figs. 16–18.

Dendrospyris bursa **Sanfilippo and Riedel** *in* Sanfilippo et al., 1973, p. 217, Pl. 2, Figs. 9–13.

Desmospyris biceps **(Ehrenberg)**. *Lithobotrys biceps* Ehrenberg, 1872b, Pl. 9, Fig. 23. *Desmospyris biceps* (Ehrenberg) *in* Caulet, 1979, p. 136, Pl. 4, Fig. 9.

Desmospyris stabilis **(Goll)**. *Dendrospyris stabilis* Goll, 1968, p. 1422, Pl. 173, Figs. 16–18, 20. *Desmospyris stabilis* (Goll), *in* Caulet, 1985, p. 852.

Diartus hughesi **(Campbell and Clark)**. *Ommatocampe hughesi* Campbell and Clark, 1944, p. 23, Pl. 3, Fig. 12. *Diartus hughesi* (Campbell and Clark) *in* Sanfilippo and Riedel, 1980, p.1010, text-Fig. 1 i.

Diartus pettersoni **(Riedel and Sanfilippo)**. *Cannartus* (?) *pettersoni* Riedel and Sanfilippo, 1970, p. 520, Pl. 14, Fig, 3. *Diartus pettersoni* (Riedel and Sanfilippo), *in* Sanfilippo and Riedel, 1980, p. 1010.

Dictyophimus crisiae **Ehrenberg**, Ehrenberg, 1854a, p. 241; Nigrini, 1967, p. 66, Pl. 6, Figs. 7a, b.

Dictyophimus infabricatus **Nigrini**, 1968, p. 56, Pl. 1, Fig. 6.

Dictyophimus splendens **(Campbell and Clark)**. *Pterocorys (Pterocyrtidium) splendens* Campbell and Clark, 1944, p. 46, Pl. 6, Figs 19, 20. *Dictyophimus splendens* (Campbell and Clark) *in* Caulet, 1985, p. 852.

Dictyoprora mongolfieri **(Ehrenberg)**. *Eucyrtidium mongolfieri* Ehrenberg, 1854b, Pl. 36, Fig. 18, B lower. *Dictyoprora mongolfieri* (Ehrenberg) *in* Nigrini, 1977, p. 250, Pl. 4, Figs. 1, 2.

Didymocyrtis antepenultima **(Riedel and Sanfilippo)**. *Ommatartus antepenultima* Riedel and Sanfilippo, 1970, p. 521, Pl. 14, Fig. 4. *Didymocyrtis antepenultima* (Riedel and Sanfilippo) *in* Sanfilippo and Riedel, 1980, p. 1010, text-Fig. 1.

Didymocyrtis avita **(Riedel)**. *Panartus avitus* Riedel, 1953, p. 808, Pl. 84, Fig. 7. *Didymocyrtis avita* (Riedel) *in* Sanfilippo and Riedel, 1980, p. 1010, text-Fig. 1.

Didymocyrtis (?) bassanii **(Carnevale)**. *Cannartidium bassanii* Carnevale, 1908, p. 21, Pl. 3, Fig. 12. *Didymocyrtis (?) bassanii* (Carnevale) *in* Sanfilippo and Riedel, 1980, p. 1011.

Didymocyrtis laticonus **(Riedel)**. *Cannartus laticonus* Riedel, 1959, p. 291, Pl. 1, Fig. 5. *Didymocyrtis laticonus* (Riedel) *in* Sanfilippo and Riedel, 1980, p. 1010, text-Fig. 1e.

Didymocyrtis mammifera **(Haeckel)**. *Cannartidium mammiferum* Haeckel, 1887, p. 375, Pl. 39, Fig. 16. *Didymocyrtis mammifera* (Haeckel) *in* Sanfilippo and Riedel, 1980, p. 1010.

Didymocyrtis penultima **(Riedel)**. *Panarium penultimum* Riedel, 1957, p. 76, Pl. 1, Fig. 1. *Didymocyrtis penultima* (Riedel) *in* Sanfilippo and Riedel, 1980, p. 1010.

Didymocyrtis prismatica **(Haeckel)**. *Pipettella prismatica* Haeckel, 1887, p. 305, Pl. 39, Fig. 6. *Didymocyrtis prismaticus* (Haeckel) *in* Sanfilippo and Riedel, 1980, p. 1010, text-Fig. 1c.

Didymocyrtis tetrathalamus **(Haeckel)**. *Panartus tetrathalamus* Haeckel, 1887, p. 378, Pl. 40, Fig. 3. *Didymocyrtis tetrathalamus* (Haeckel) *in* Sanfilippo and Riedel, 1980, p. 1010, text-Fig. 1g.

Didymocyrtis tubaria **(Haeckel)**. *Pipettaria tubaria* Haeckel, 1887, p. 339, Pl. 39, Fig. 15. *Didymocyrtis tubaria* (Haeckel) *in* Sanfilippo and Riedel, 1980, p. 1010.

Didymocyrtis violina **(Haeckel)**. *Cannartus violina* Haeckel, 1887, p. 358, Pl. 39, Fig. 10. *Didymocyrtis violina* (Haeckel) *in* Sanfilippo and Riedel, 1980, p. 1010, text-Fig. 1.

Dorcadospyris ateuchus **(Ehrenberg)**. *Ceratospyris ateuchus* Ehrenberg, 1873, p. 218; Ehrenberg, 1875, Pl. 21, Fig. 4. *Dorcadospyris ateuchus* (Ehrenberg), Riedel and Sanfilippo, 1970, p. 523.

Dorcadospyris dentata **Haeckel**, 1887, p. 1040, Pl. 85, Fig. 6.

Eucecryphalus cervus **(Ehrenberg)**. *Eucyrtidium cervus* Ehrenberg, 1872a, p. 291; Ehrenberg, 1872b, Pl. 9, Fig. 21. *Eucecryphalus cervus* (Ehrenberg) *in* Petrushevskaya, 1971, p. 223, Fig. 104.

Eucecryphalus gegenbaueri **Haeckel**, Haeckel, 1860, p. 836; Haeckel, 1862, Pl. 5, Figs. 12–15.

Eucyrtidium acuminatum **(Ehrenberg)**. *Lithocampe acuminata* Ehrenberg, 1844, p. 84. *Eucyrtidium acuminatum* (Ehrenberg) *in* Ehrenberg, 1847, p. 43; Ehrenberg, 1854b, Pl. 22, Fig. 27.

Eucyrtidium anniae **Caulet**, 1985, p. 850, Pl. 5, Fig. 10.

Eucyrtidium anomalum **(Haeckel)**. *Lithocampe anomala* Haeckel, 1860, p. 839. *Eucyrtidium anomalum* (Haeckel) *in* Haeckel, 1862, p. 323, Pl. 7, Figs. 11–13.

Eucyrtidium calvertense **Martin**, Martin, 1904, p. 450, Pl. 130, Fig. 5.

Eucyrtidium cienkowskii **Haeckel gr.**, Haeckel, 1887, p. 1493, Pl. 80, Fig. 9.

Eucyrtidium dufresni **Caulet**, 1979, p. 134, Pl. 3, Figs. 8, 9.

Eucyrtidium hexacolum **(Haeckel)**. *Lithocampe hexacola* Haeckel, 1887, p. 1507, Pl. 79, Fig. 7.

Eucyrtidium hexastichum **(Haeckel)**. *Lithostrobus hexastichus* Haeckel, 1887, p. 1470, Pl. 80, Fig. 15. *Eucyrtidium hexastichum* (Haeckel) *in* Petrushevskaya, 1971, p. 220, Fig. 99, III–X.

Eucyrtidium indiensis **Caulet**, 1979, p. 134, Pl. 4, Fig. 5.

Eucyrtidium infundibulum **(Haeckel)**. *Lithomitra infundibulum* Haeckel, 1887, p. 1487, Pl. 79, Fig. 5.

Eucyrtidium monumentum **(Haeckel)**. *Calocyclas monumentum* Haeckel, 1887, p. 1385, Pl. 73, Fig. 9.

Eucyrtidium octocolum **(Haeckel)**. *Lithocampe octocola* Haeckel, 1887, p. 1508, Pl. 79, Fig. 6.

Eucyrtidium punctatum **(Ehrenberg)**. *Lithocampe punctata* Ehrenberg, 1844, p. 84. *Eucyrtidium punctatum* (Ehrenberg) *in* Ehrenberg, 1847, p. 43; Ehrenberg, 1854b, Pl. 22, Fig. 24.

Eucyrtidium teuscheri **(Haeckel)** *orthoporus* **Caulet**, 1985, p. 851, Pl. 5, Fig. 4.

Eucyrtidium teuscheri **(Haeckel)** *teuscheri* **Caulet**, 1985, p. 851, Pl. 5, Figs. 5–8.

Eusyringium fistuligerum **(Ehrenberg)**. *Eucyrtidium fistuligerum* Ehrenberg, 1873, p. 229; 1875, Pl. 9, Fig. 3. *Eusyringium fistuligerum* (Ehrenberg) *in* Riedel and Sanfilippo, 1970, p. 527, Pl. 8, Figs. 8, 9.

Gondwanaria dogieli **(Petrushevskaya)**. *Sethoconus* (?) *dogieli* Petrushevskaya, 1967, p. 95, Pl. 53, Figs. 1, 2. *Gondwanaria dogieli* (Petrushevskaya), *in* Petrushevskaya, 1975, p. 585.

Haliometta miocenica **(Campbell and Clark)**. *Heliosphaera miocenica* Campbell and Clark, 1944, p. 16, Pl. 2, Figs. 10–14. *Haliometta miocenica* (Campbell and Clark), *in* Petrushevskaya and Kozlova, 1972, p. 517, Pl. 9, Figs. 8,9.

Heliodiscus asteriscus **Haeckel**, 1887, p. 445, Pl. 33, Fig. 8.

Histiastrum martinianum **Carnevale group**, Carnevale, 1908, p. 26, Pl. 4, Fig. 11; Sanfilippo et al., 1973, p. 217, Pl. 2, Figs. 7, 8.

Lamprocyclas gamphonycha **(Jorgensen)**. *Pterocorys gamphonyxos* Jorgensen, 1900, p. 86. *Androcyclas gamphonycha* (Jorgensen), *in*

Jorgensen, 1905, p. 139, Pl. 17, Figs. 92–97. *Lamprocyclas gamphonycha* (Jorgensen), *in* Petrushevskaya, 1971, Fig. 117, I–III.

Lamprocyclas hannai (Campbell and Clark). *Calocyclas hannai* Cmapbell and Clark, 1944, p. 48, Pl. 69, Figs. 21, 22. *Lamprocyclas hannai* (Campbell and Clark) *in* Caulet, 1985, p. 852.

Lamprocyclas junonis (Haeckel). *Theoconus junonis* Haeckel, 1887, p. 1401, Pl. 69, Fig. 7. *Lamprocyclas junonis* (Haeckel) *in* Caulet, 1985, p. 852, Pl. 4, Fig. 10.

Lamprocyclas maritali group Haeckel, 1887, p. 1390, Pl. 74, Figs. 13, 14.

Lamprocyclas margatensis (Campbell and Clark). *Calocyclas margatensis* Campbell and Clark, 1944, p. 47, Pl. 6, Figs. 17, 18. *Lamprocyclas margatensis* (Campbell and Clark) *in* Caulet, 1985, p. 852, Pl. 4, Fig. 3.

Lamprocyrtis daniellae Caulet, 1985, p. 850, Pl. 3, Figs. 13–16.

Lamprocyrtis heteroporos (Hays). *Lamprocyclas heteroporos* Hays, 1965, p. 179, Pl. 3, Fig. 1. *Lamprocyrtis heteroporos* (Hays), *in* Kling, 1973, p. 639, Pl. 5, Figs. 19–21, Pl. 15, Figs. 4–5.

Lamprocyrtis neoheteroporos Kling, 1973, p. 639, Pl. 5, Figs. 17, 18, Pl. 15, Figs. 4, 5.

Lamprocyrtis nigriniae (Caulet). *Conarachnium nigriniae* Caulet, 1971, p. 3, Pl. 3, Figs. 1–4, Pl. 4, Figs. 1–4. *Lamprocyrtis nigriniae* (Caulet), *in* Kling, 1977, p. 217, Pl. 1, Fig. 17.

Lampromitra coronata Haeckel, 1887, p. 1214, Pl. 60, Figs. 7, 7a.

Larcospira moschkovskii Kruglikova, Kruglikova, 1978, p. 88, Pl. 27, Figs. 3–6.

Liriospira parkerae Riedel and Sanfilippo, Riedel and Sanfilippo, 1971, p. 1590, Pl. 2C, Fig. 15, Pl. 5, Fig. 4.

Liriospyris stauropora (Haeckel). *Trissocyclus stauropora* Haeckel, 1887, p. 987, Pl. 83, Fig. 5. *Liriospyris stauropora* (Haeckel) *in* Goll, 1968, p. 1431, Pl. 175, Figs. 1–3, 7, text-Fig. 9.

Lithocyclia aristotelis gr. (Ehrenberg). *Astromma aristotelis* Ehrenberg, 1847, p. 55, Fig. 10. *Lithocyclia aristotelis* (Ehrenberg), *in* Riedel and Sanfilippo, 1970, p. 522.

Lithocyclia ocellus gr. Ehrenberg, 1854b, Pl. 36, Fig. 30; 1873, p. 240.

Lithostrobus hexagonalis Haeckel, 1887, p. 1475, Pl. 79, Fig. 20.

(?) *Lithostrobus undulatus* (Popofsky). *Artopilium undulatum* Popofsky, 1913, p. 405, Pl. 36, Figs. 4, 5.

Lychnocanoma elongata (Vinassa de Regny). *Tetrahedrina globosa* Vinassa de Regny, 1900, p. 243, Pl. 2, Fig. 30. *Lychnocanoma elongata* (Vinassa de Regny) *in* Sanfilippo et al., 1973, p. 221, Pl. 5, Figs. 19–20.

Nephrospyris renilla Haeckel, 1887, p. 1101, Pl. 90, Figs. 9, 10.

Octopyle stenozona Haeckel, 1887, p. 652, Pl. 9, Fig. 11.

Periphaena decora Ehrenberg, 1873, p. 246; 1875, Pl. 28, Fig. 6.

Phormostichoartus (?) *crustula* (Caulet). *Lithamphora crustula* Caulet, 1979, p. 131, Pl. 2, Fig. 1.

Phormostichoartus fistula Nigrini, 1977, p. 153, Pl. 1, Figs. 11–13.

Phormostichoartus furcaspiculata (Popofsky). *Lithamphora furcaspiculata* Popofsky, 1913, p. 408, Text-Figs. 138, 139. *Phormostichoartus furcaspiculata* (Popofsky) *in* Caulet, 1985, p. 853.

Phormostichoartus multiseriatus (Ehrenberg). *Eucyrtidium multiseriatum* Ehrenberg, 1860a, p. 768. *Lithocampe* (?) *multiseriata* (Ehrenberg) *in* Petrushevskaya, 1967, p. 135, Fig. 16, I–III. *Phormostichoartus multiseriatus* (Ehrenberg) *in* Caulet, 1985, p. 853.

Phormostichoartus platycephala (Ehrenberg). *Eucyrtidium platycephalum* Ehrenberg, 1872b, Pl. 3, Fig. 16. *Phormostichoartus plateycephala* (Ehrenberg) *in* Caulet, 1985, p. 853, Pl. 3, Figs. 5, 6.

Phormostichoartus pitomorphus Caulet, 1985, p. 850, Pl. 3, Figs. 3, 4, 9, 10, 12.

Phorticium clevei (Jörgensen). *Tetrapylonium clevei* Jorgensen, 1900, p. 64. *Phorticium clevei* (Jörgensen) *in* Petrushevskaya, 1967, p. 58, Figs. 32–34.

Plectacantha cremastoplegma Nigrini, 1968, p. 55, Pl. 1, Fig. 3a–c, text-Fig. 2.

Podocyrtis papalis Ehrenberg, 1847, Fig. 2; 1854d, Pl. 36, Fig. 23; 1873, p. 251.

Prunopyle antarctica Dreyer, Dreyer, 1889, p. 24, Pl. 5, Fig. 75.

Prunopyle hayesi Chen, Chen, 1975, p. 454, Pl. 9, Figs. 3–5.

Pseudocubus vema (Hays). *Helotholus vema* Hays, 1965, p. 176, Pl. 2, Fig. 3, Text-Fig. A. *Pseudocubus vema* (Hays) *in* Petrushevskaya, 1971, p. 46, Fig. 24, I–IV.

Pseudocubus warreni Goll, 1980, p. 437, Pl. 3, Figs. 5–6.

Pterocanium praetextum (Ehrenberg) *eucolpum* (Haeckel). *Pterocanium eucolpum* Haeckel, 1887, p. 1322, Pl. 73, Fig. 4. *Pterocanium praetextum* (Ehrenberg) *eucolpum* (Haeckel) *in* Nigrini, 1967, p. 70, Pl. 7, Fig. 2.

Pterocanium grandiporus Nigrini, 1968, p. 57, Pl. 1, Fig. 7.

Pterocanium korotnevi (Dogiel). *Pterocorys korotnevi* Dogiel, Dogiel and Reshetnyak, 1952, p. 17, Fig. 11. *Pterocanium korotnevi* (Dogiel), Nigrini, 1970, p. 170, Pl. 3, Figs. 10, 11.

Pterocanium praetextum (Ehrenberg). *Lychnocanium praetextum* Ehrenberg, 1872a, p. 316; 1872b, p. 297, Pl. 10, Fig. 2. *Pterocanium praetextum* (Ehrenberg) *in* Nigrini, 1967, p. 68, Pl. 7, Fig. 1.

Pterocanium trilobum (Haeckel). *Dictyopodium trilobum* Haeckel, 1860b, p. 839; 1862, p. 340, Pl. 8, Figs. 6–10. *Pterocanium trilobum* (Haeckel) *in* Haeckel, 1887, p. 1333.

Pterocorys campanula Haeckel, 1887, p. 1316, Pl. 71, Fig. 3.

Pterocorys clausus (Popofsky). *Lithornithium clausum* Popofsky, 1913, p. 393, Text-Fig. 11. *Pterocorys clausus* (Popofsky) *in* Petrushevskaya and Kozlova, 1972, p. 545, Pl. 36, Figs. 16–18.

Pterocorys hertwigii (Haeckel). *Eucyrtidium hertwigii* Haeckel, 1887, p. 1491, Pl. 80, Fig. 12. *Pterocorys hertwigii* (Haeckel), *in* Nigrini, 1967, p. 73, Pl. 7, Figs. 4a, b.

Pterocorys macroceras (Popofsky). *Lithopilium macroceras* Popofsky, 1913, p. 377, Text-Figs. 91–93. *Pterocorys macroceras* (Popofsky) *in* Petrushevskaya, 1971, p. 234, Fig. 120.

Pterocorys minythorax (Nigrini). *Theoconus minythorax* Nigrini, 1968, p. 57, Pl. 1, Fig. 8. *Pterocorys minythorax* (Nigrini) *in* Nigrini and Moore, 1979, p. N87, Pl. 25, Fig. 10.

Pterocorys zancleus (Müller). *Eucyrtidium zanclaeum* Müller, 1855, p. 672; 1858, p. 41, Pl. 6, Figs. 1–3. *Pterocorys zancleus* (Müller) *in* Petrushevskaya, 1971, p. 233, Fig. 119, i–vii.

Rhizosphaera antarctica (Haeckel). *Spongoplegma antarctica* Haeckel, 1887, p. 90. *Rhizosphaera antarcticum* (Haeckel) *in* Caulet, 1985, p. 853.

Rhopalastrum profunda (Ehrenberg) group. *Dictyocoryne profunda* Ehrenberg, 1860a, p. 767; 1872b, Pl. 7, Fig. 23. *Rhopalastrum profunda* (Ehrenberg) gr. *in* Petrushevskaya and Kozlova, 1972, p. 529, Pl. 17, Figs. 4–6, Pl. 20, Fig. 8.

Saturnalis circularis Haeckel, 1887, p. 131.

Siphocampe arachnea (Ehrenberg) group. *Eucyrtidium lineatum arachneum* Ehrenberg, 1861, p. 299. *Lithomitra arachnea* (Ehrenberg) *in* Riedel, 1958, p. 242, Pl. 4, Figs. 7, 8. *Siphocampe arachnea* (Ehrenberg) gr. *in* Nigrini, 1977, p. 255, Pl. 3, Figs. 7, 8.

Siphocampe caryoforma (Caulet). *Lithamphora caryoforma* Caulet, 1979, p. 131, Pl. 2, Fig. 2.

Siphocampe modeloensis (Campbell and Clark). *Lithocampe modeloensis* Campbell and Clark, 1944, p. 59, Pl. 7, Figs. 28–30. *Siphocampe modeloensis* (Campbell and Clark) *in* Caulet, 1985, p. 853.

Siphostichartus corona (Haeckel). *Cyrtophormis* (*Acanthocyrtis*) *corona* Haeckel, 1887, p. 1462, Pl. 77, Fig. 15. *Siphostichartus corona* (Haeckel) *in* Nigrini, 1977, p. 257, Pl. 2, Figs. 5, 6, 7.

Siphostichartus praecorona Nigrini, 1977, p. 258, Pl. 2, Figs. 8, 9.

Spirocyrtis subscalaris Nigrini, 1977, p. 259, Pl. 3, Figs. 1, 2.

Spirocyrtis subtilis Petrushevskaya, 1972, *in* Petrushevskaya and Kozlova, 1972, p. 540, Pl. 24, Figs. 22–24.

Spongaster tetras Ehrenberg, Ehrenberg, 1860b, p.833; 1872b, p. 299, Pl. IV (iii), Fig. 8.

Spongocore puella Haeckel, 1887, p. 347, Pl. 48, Fig. 6.

Spongodiscus osculosus (Dreyer). *Spongopyle osculosa* Dreyer, 1889, p. 42, Figs. 99, 100. *Spongodiscus osculosus* (Dreyer) *in* Petrushevskaya, 1967, p. 42, Figs. 20–22.

Spongodiscus setosus (Dreyer). *Spongopyle setosa* Dreyer, 1889, p. 43, Pl. 6, Figs. 97, 98. *Spongodiscus* (?) *setosus* (Dreyer) *in* Petrushevskaya, 1967, p. 39, Fig. 20, III–V.

Spongotrochus glacialis Popofsky, 1908, p. 228, Pl. 27, Fig. 1, Pl. 28, Fig. 2.

Stichocorys armata (Haeckel). *Cyrtophormis armata* Haeckel, 1887, p. 1460, Pl. 78, Fig. 17. *Stichocorys armata* (Haeckel) *in* Riedel and Sanfilippo, 1971, p. 1595, Pl. 2E, Figs. 13–15.

Stichocorys delmontensis (Campbell and Clark). *Eucyrtidium delmontensis* Campbell and Clark, 1944, p. 56, Pl. 7, Figs. 19, 20. *Stichocorys delmontensis* (Campbell and Clark) *in* Sanfilippo and Riedel, 1970, p. 451, Pl. 1, Fig. 9.

Stichocorys peregrina (**Riedel**). *Eucyrtidium elongatum peregrinum* Riedel, 1953, p. 812, Pl. 85, Fig. 2. *Stichocorys peregrina* (Riedel) *in* Sanfilippo and Riedel, 1970, p. 451, Pl. 1, Fig. 10.

Stichocorys radicula (**Ehrenberg**). *Lithocampe radicula* Ehrenberg, 1838, p. 130, Pl. 4, Fig. 11g.

Stichocorys wolffii **Haeckel**, 1887, p. 1479, Pl. 80, Fig. 10.

Stichopodium biconicum (**Vinassa de Regny**). *Lithocampe biconica* Vinassa de Regny, 1900, Pl. 3, Fig. 30. *Stichopodium biconicum* (Vinassa de Regny) *in* Petrushevskaya, 1975, p. 581, Pl. 14, Figs. 25–27, Pl. 26, Figs. 9, 10.

Stichopilium bicorne **Haeckel**, 1887, p. 1437, Pl. 77, Fig. 9.

Streblacantha circumtexta (**Jörgensen**). *Sorolarcus circumtextus* Jörgensen, 1900, p. 65. *Streblacantha circumtexta* (Jörgensen) *in* Jörgensen, 1905, p. 121, Pl. 11, 12, Fig. 46.

Stylatractus universus **Hays**, 1970, p. 215, Pl. 1, Figs. 1, 2.

Stylosphaera angelina **Campbell and Clark**, 1944, p. 12, Pl. 1, Figs. 15, 20.

Tepka perforata **Sanfilippo and Riedel**, 1973, p. 228, Pl. 6, Figs. 18–20.

Tessarospyris pododendros **Carnevale**, 1908, p. 28, Pl. 3, Fig. 18.

Theocalyptra (?) *cornutoides* (**Petrushevskaya**). *Cycladophora davisiana* (Ehrenberg) *cornutoides* Petrushevskaya, 1967, p. 124, Fig. 70, I–III.

Theocorythium trachelium (**Ehrenberg**). *Eucyrtidium trachelius* Ehrenberg, 1872a, p. 312. *Theocorythium trachelium* (Ehrenberg) *in* Nigrini, 1967, p. 79, Pl. 8, Fig. 2, Pl. 9, Fig. 2.

Theocorythium vetulum **Nigrini**, 1971, p. 447, Pl. 34.1, Figs. 6a, 6b.

Theocyrtis tuberosa **Riedel**, Riedel, 1959, p. 298, Pl. 2, Figs. 10, 11.

Tholospyris capoi (**Goll**). *Phormospyris stabilis capoi* Goll, 1976, p. 392, Pl. 5, Figs. 1–2; Pl. 6; Pl. 7.

Tholospyris scaphipes (**Haeckel**). *Tristylospyris scaphipes* Haeckel, 1887, p. 1033, Pl. 84, Fig. 13. *Tholospyris scaphipes* (Haeckel) *in* Goll, 1969, p. 328, Pl. 58, Figs. 1–6.

Tricolocampe cylindrica **Haeckel**, 1887, p. 1412, Pl. 66, Fig. 21.

Tricolocapsa papillosa (**Ehrenberg**) **group**. *Eucyrtidium papillosum* Ehrenberg, 1872a, p. 310; 1872b, Pl. 7, Fig. 10. *Tricolocapsa papillosa* (Ehrenberg) gr. *in* Petrushevskaya and Kozlova, 1972, p. 537, Pl. 22, Fig. 31.

Tricolospyris baconiana **Haeckel**, 1887, p. 1098, Pl. 88, Fig. 8. *Tympanomma binoctonum* (Haeckel). *Tympanidium binoctonum* Haeckel, 1887, p. 1004, Pl. 94, Fig. 18. *Tympanomma binoctonum* (Haeckel) *in* Petrushevskaya and Kozlova, 1972, p. 533, Pl. 39, Figs. 23–24.

APPENDIX B

Raw Data for Leg 112 Holes 682A, 683A, 685A, and 688A.

The following appendix is composed of raw data tables for some Leg 112 holes. This study does not record species abundances, but rather notes only presence or absence. Overall abundance is given in terms of R = rare, F = few, C = common, and A = abundant. Preservation is given in terms of P = poor, M = moderate, and G = good.

Hole 682A.

Ages	Radiolarian biozonation	Samples	Abundance	Preservation	Calocyclas sp.	Calocycloma ampulla	Dictyoprora mongolfieri	Lithocyclia ocellus	Podocyrtis papalis	Eusyringium fistuligerum	Aerosphaera trepanata	Calocycletta robusta	Calocycletta virginis	Carpocanopsis favosa	Clathrocyclas cabrilloensis	Cyrtocapsella tetrapera	Didymocyrtis mammifera	Didymocyrtis tubaria	Didymocyrtis violina	Eucyrtidium cienkowskii	Phormostichoartus fistula	Siphostichartus praecorona	Stichocorys armata	Stichocorys delmontense	Stichocorys wolffii	Tessarospyris pododenoros	Tympanomma binoctonum	Calocycletta costata
Pleis.	NR 1/2	682A-1-CC	C	G																								
Pleis.	NR 3/5	682A-2-CC	R	G																								
		682A-3-CC	R	M																								
late Plio.	NR 6/7	682A-4-CC	F	G																								
		682A-5-CC																										
		682A-6-CC	F	G																								
		682A-7-CC	F	G						P																		
ear. Plio.	Stichocorys peregrina	682A-8-CC	R	G											P						P		P					
		682A-9-CC	F	G											P													
		682A-10-CC	R	G											P						P							
		682A-11-CC	R	M																								
-- ? --		682A-12-CC																										
		682A-13-CC																										
		682A-14-CC																										
		682A-15-CC																										
		682A-16-CC																										
		682A-17-CC																										
		682A-18-CC																										
		682A-19-CC																										
late Miocene	Didymocyrtis antepenultima	682A-20-CC	R	M													P			P	P		P			P		
		682A-21-CC	R	M													P			P			P					
		682A-22-CC																										
		682A-23-CC	R	M							P									P		P	P		P			
-- ? --		682A-24-CC																										
		682A-25-CC																										
		682A-26-CC																										
		682A-27-CC																										
-- ? --		682A-28-CC																										
	Diartus petterssoni	682A-29-CC	F	M																P			P					
middle Miocene		682A-30-CC																										
		682A-31-CC																										
	Dorcadospyris alata	682A-32-CC	R	M							P				P	P	P		P	P	P	P	P			P	P	
		682A-33-CC																										
		682A-34-CC	C	G							P	P	P	P		P	P		P	P	P	P	P		P	P	P	P
		682A-35-CC	R	M							P	P	P	P	P	P	P		P	P	P	P	P		P	P	P	
-- ? --	Unzoned	682A-36-CC																										
		682A-37-CC																										
		682A-38-CC																										
		682A-39-CC																										
		682A-40-CC																										
		682A-41-CC																										
		682A-42-CC																										
		682A-43-CC																										
		682A-44-CC																										
		682A-45-CC																										
		682A-46-CC	R	P			P	P	P	P																		
		682A-47-CC	R	P	P	P	P	P	P																			

Hole 682A (continued).

Ages	Radiolarian biozonation	Samples	Abundance	Preservation	Clathrocanium sphaerocephalum	Cyrtocapsella cornuta	Cyrtocapsella japonica	Dorcadospyris dentata	Eucyrtidium punctatum	Liriospyris stauropora	Stylatractus universus	Tepka perforata	Dendrospyris bursa	Didymocyrtis laticonus	Liriospyris parkerae	Diartus petterssoni	Larcospyris moschkovskii	Didymocyrtis antepenultima	Stichocorys radicula	Botryostrobus B. pretumidulus	Diartus hughesi	Dictyophimus splendens	Periphaena decora	Siphocampe crustula	Stichocorys peregrina	Lamprocyclas hannai	Pseudocubus vema	Stichopodium biconica	Anthocyrtidium pliocenica
Pleis.	NR 1/2	682A-1-CC	C	G																									
	NR 3/5	682A-2-CC	R	G																									
		682A-3-CC	R	M							P													P					
late Plio.	NR 6/7	682A-4-CC	F	G							P													P					
		682A-5-CC									P													P					
		682A-6-CC	F	G																									
		682A-7-CC	F	G							P															P			
ear. Plio.	Stichocorys peregrina	682A-8-CC	R	G							P									P									P	P
		682A-9-CC	F	G							P									P						P	P	P		
		682A-10-CC	R	G							P															P	P		P	P
		682A-11-CC	R	M							P																P	P	P	
-- ? --		682A-12-CC																											
		682A-13-CC																											
		682A-14-CC																											
		682A-15-CC																											
		682A-16-CC																											
		682A-17-CC																											
		682A-18-CC																											
		682A-19-CC																											
late Miocene	Didymocyrtis antepenultima	682A-20-CC	R	M		P					P				P		P	P	P	P	P	P	P	P	P				
		682A-21-CC	R	M														P												
		682A-22-CC																											
		682A-23-CC	R	M		P	P				P			P		P	P	P											
-- ? --		682A-24-CC																											
		682A-25-CC																											
		682A-26-CC																											
-- ? --		682A-27-CC																											
		682A-28-CC																											
	Diartus petterssoni	682A-29-CC	F	M			P				P			P		P	P												
middle Miocene		682A-30-CC																											
		682A-31-CC																											
	Dorcadospyris alata	682A-32-CC	R	M		P	P				P		P	P	P															
		682A-33-CC																											
		682A-34-CC	C	G	P	P	P	P	P	P	P	P																	
		682A-35-CC	R	M																										
-- ? --	Unzoned	682A-36-CC																											
		682A-37-CC																											
		682A-38-CC																											
		682A-39-CC																											
		682A-40-CC																											
		682A-41-CC																											
		682A-42-CC																											
		682A-43-CC																											
		682A-44-CC																											
		682A-45-CC																											
		682A-46-CC	R	P																									
		682A-47-CC	R	P																									

196

Hole 682A (continued).

Eucyrtidium calvertense	Eucyrtidium teuscheri gr.	Lamprocyclas margatensis	Pseudocubus warreni	Botrystrobus auritus/australis	Eucyrtidium T. orthoporus	Lamprocyrtis daniellae	Spongocore osculosus	Acrosphaera murrayana	Acrosphaera pseudarktios	Anthocyrtidium ehrenbergi	Anthocyrtidium ophirense	Botryostrobus B. tumidulus	Didymocyrtis avita	Eucyrtidium infundibulum	Octopyle stenozoa	Stichopilium bicorne	Acrosphaera cyrtodon	Anthocyrtidium nosicaae	Anthocyrtidium zanguebaricum	Didymocyrtis tetrathalamus	Eucyrtidium indiensis	Lamprocyrtis neoheteroporos	prunopyle antarctica	Theocorythium vetulum	Eucyrtidium T. teuscheri	Pterocanium korotnevi	Siphocampe caryoforma	Theocalyptra davisiana	Phormostichoartus pitomorphus	Amphirophlum ypsilon	Dictyophimus infabricatus	Lamprocyrtis nigriniae	Pterocorys minythorax	Theocorythium trachelium
		P						P				P			P	P			P	P					P	P		P		P	P	P	P	P
		P						P	P			P		P		P		P					P		P	P		P	P			P	P	
		P						P			P	P		P				P	P	P	P	P			P	P	P	P	P	P	P			
		P			P			P			P	P		P				P				P			P	P	P	P						
		P			P	P		P			P	P		P				P						P	P	P	P	P						
P	P		P	P	P	P				P	P	P		P	P	P	P	P	P		P	P	P	P										
P	P		P	P		P		P	P	P	P	P	P	P	P			P	P			P		P										
P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P																		

Hole 683A.

Age	Radiolarian biozonation	Samples	Abundance	Preservation	Acrosphaera trepanata	Calocycletta robusta	Calocycletta virginis	Cyrtocapsella cornuta	Cyrtocapsella tetrapera	Didymocyrtis laticonus	Didymocyrtis mammifera	Eucyrtidium cienkowskii	Eucyrtidium teuscheri gr.	Liriospyris parkerae	Stichocorys sp.	Tympanomma binoctonum	Dictyophimus splendens	Stichocorys wolffii	Anthocyrtidium ehrenbergi	Botryostrobus miralestensis	Desmospyris stabilis	Didymocyrtis bassanii	Phormostichoartus fistula	Stylosphaera angelina
	NR 1	683A-1-CC	A	G																				
		683A-2-CC	A	G	P																			
		683A-3-CC	C	G	P																			
	NR 2	683A-4-CC	A	G	P																			
		683A-5-CC	C	G																				
Pleistocene		683A-6-CC	A	G	P																			
		683A-7-CC	A	G																				
		683A-8-CC	A	G	P																			
		683A-9-CC	C	G																				
		683A-10-CC	C	G																				
		683A-11-CC	C	G	P																			
	NR 3	683A-12-CC	C	G																				
		683A-13-CC	C	G																				
	to	683A-14-CC	C	G																				
		683A-15-CC	C	G	P																			
	NR 7	683A-16-CC	C	G																				
		683A-17-CC	C	G	P																			
		683A-18-CC																						
		683A-19-CC	C	G	P																			
		683A-20-CC	C	G	P																			
		683A-21-CC	C	G																				
early Pliocene		683A-22-CC	C	G	P																			
		683A-23-CC	C	G	P																		P	
	NR 8/9	683A-24-CC	C	G	P								P										P	
		683A-25-CC	C	G	P								P										P	
late Mioc.	Didymocyrtis antepenultima	683A-26-CC	F	M	P					P	P	P					P		P	P			P	
		683A-27-CC	F	M	P						P	P					P	P	P	P	P			
		683A-28-CC	C	M	P				P			P			P		P				P		P	
		683A-29-CC	C	G	P							P			P		P						P	P
middle Miocene	D. petterssoni	683A-30-CC	C	M	P		?		P	P	P				P		P	P			P		P	P
		683A-31-CC	F	M	P				P	P	P				P		P	P	P	P	P		P	P
		683A-32-CC	F	M					P	P	P				P		P	P					P	
		683A-33-CC	F	M	P				P	P	P	P			P	P	P						P	P
		683A-34-CC	F	M	P																			P
		683A-35-CC	F	M	P	P			P	P	P				P		P						P	P
		683A-36-CC	F	M	P						P						P	P						
		683A-37-CC	R	M						P	P				P	P	P							
		683A-38-CC	R	M	P					P	P	P			P		P	P			P	P	P	P
		683A-39-CC	R	M		P				P	P				P		P		P				P	
	Dorcadospyris alata	683A-40-CC	F	G		P			P	P	?	P		P			P		P	P				
		683A-41-CC																						
		683A-42-CC	R	M	P						P	P			P									
		683A-43-CC	R	G		P				P	P	P			P		P	P						
		683A-44-CC	R	M	P	P	P	P	P	P	P	P	P	P	P	P							
		683A-46-CC																						
		683A-45-CC																						
		683A-48-CC																						

Hole 683A (continued).

Calocycletta costata	Stichocorys delmontensis	Stichocorys radicula	Siphostichartus corona	Botryostrobus auritus/australis	Coscinodiscus ellipticus	Calocycletta caepa	Collosphaera polygona	Lamprocyrtis daniellae	Diartus petterssoni	Didymocyrtis antepenultima	Eucyrtidium punctatum	Prunopyle hayesi	Spongocore osculosus	Stylatractus universus	Acrosphaera murrayana	Siphocampe modeloensis	Acrosphaera cyrtodon	Botryostrobus B. bramlettei	Botryostrobus B. tumidulus	Cyrtocapsella elongata	Lamprocyclas hannai	Larcospira moschkovskii	Amphiropalum ypsilon	Anthocyrtidium jenghisi	Anthocyrtidium nosicaae	Anthocyrtidium ophirense	Didymocyrtis penultima	Eucyrtidium calvertense	Eucyrtidium infundibulum
				P															P							P		P	
				P															P				P			P			P
				P															P				P					P	P
				P															P				P			P		P	P
				P															P							P		P	P
				P										P					P				P			P		P	P
				P										P					P				P		?	P			
				P										P					P						P	P			
				P										P					P						P			P	
				P										P					P						P	P		P	
				P										P					P						P	P		P	P
				P										P					P						P			P	P
				P										P					P						P				
				P										P					P				P	P	P	P		P	P
														P					P		P				P			P	
				P										P					P						P	P		P	
				P										P			P		P				P	P	P	P		P	P
				P										P			P		P						P	P	P	P	P
	P	P		P			P		P	P		P		P	P	P	P	P	P	P	P	P							
	P	P		P			P			P				P				P			P	P							
	P		P				P			P					P	P													
	P	P							P		P	P	P	P															
	P	P				P	P	P																					
	P	P	P		P																								
	P	P	P																										
			P																										
	P	P																											
P	P																												

Hole 683A (continued).

Age	Radiolarian biozonation	Samples	Abundance	Preservation	Eucyrtidium T. orthoporus	Lamprocyrtis heteroporos	Lamprocyrtis neoheteroporos	Phormostichoartus pitomorphus	Phorticium clevei	Pseudocubus warreni	Siphocampe crustula	Stichocorys peregrina	Tholospyris capoi	Anthocyrtidium zanguebaricum	Diartus hughesi	Eucyrtidium T. teuscheri	Lamprocyclas maritalis	Theocorythium trachelium	Eucyrtidium indiensis	Pterocanium korotnevi	Theocorythium vetulum	Acrosphaera pseudarktios	Cycladophora davisiana	Prunopyle antarctica
	NR 1	683A-1-CC	A	G					P		P		P	P		P	P			P			P	P
		683A-2-CC	A	G					P	P		P	P		P	P				P			P	P
	NR 2	683A-3-CC	C	G	?				P	P	P		P			P	P			P			P	P
		683A-4-CC	A	G	P				P		P		P	P		P	P			P			P	P
		683A-5-CC	C	G					P	P	P						P			P			P	P
Pleistocene		683A-6-CC	A	G					P	P	P		P	P		P	P		P	P			P	P
		683A-7-CC	A	G					P	P	P		P	P		P	P			P			P	
		683A-8-CC	A	G				P	P	P	P		P	P		P	P			P			P	
		683A-9-CC	C	G				P	P	P	P		P	P		P	P			P		P	P	P
		683A-10-CC	C	G	P		P	P		P	P		P			P	P		P	P		P	P	P
	NR 3	683A-11-CC	C	G			P	P		P	P		P			P	P			P			P	
		683A-12-CC	C	G	P		P	P	P	P	P		P	P		P	P			P			P	P
	to	683A-13-CC	C	G	P		P	P	P	P	P			P		P	P			P			P	P
		683A-14-CC	C	G	P	P	P	P			P		P			P	P		P			P	P	P
	NR 7	683A-15-CC	C	G	P		P	P		P	P		P	P		P	P		P				P	P
		683A-16-CC	C	G			P	P		P	P		P	P		P	P		P				P	P
		683A-17-CC	C	G	P		P						P	P		P	P		P	P	P		P	P
--?--		683A-18-CC																						
		683A-19-CC	C	G	P		P	P		P	P		P	P		P	P	P	P	P	P	P	P	
		683A-20-CC	C	G	P		P	P		P	P		P			P	P	P	P	P			P	P
early Pliocene		683A-21-CC	C	G	P	P	P	P		P	P		P	P		P	P	P					P	P
		683A-22-CC	C	G	P		P	P	P	P	P		P			P	P	P	P	P		P	P	P
		683A-23-CC	C	G	P	P	P	P		P	P	P	P	P		P	P	P	P	P	P			
	NR 8/9	683A-24-CC	C	G	P	P	P	P		P	P	P	P	P	P	P	P	P	P				
		683A-25-CC	C	G	P	P	P	P	P	P	P	P	P										
late Mioc.	Didymocyrtis antepenultima	683A-26-CC	F	M																			
		683A-27-CC	F	M																			
		683A-28-CC	C	M																			
		683A-29-CC	C	G																			
middle Miocene	D. petterssoni	683A-30-CC	C	M																			
		683A-31-CC	F	M																			
		683A-32-CC	F	M																			
		683A-33-CC	F	M																			
		683A-34-CC	F	M																			
		683A-35-CC	F	M																			
		683A-36-CC	F	M																			
		683A-37-CC	R	M																			
		683A-38-CC	R	M																			
		683A-39-CC	R	M																			
	Dorcadospyris alata	683A-40-CC	F	G																			
		683A-41-CC																					
		683A-42-CC	R	M																			
		683A-43-CC	R	G																			
--?-- ----- ? -------		683A-44-CC	R	M																			
		683A-46-CC																					
		683A-45-CC																					
		683A-48-CC																					

Hole 683A (continued).

Stichopilium bicorne	Siphocampe caryoforma	Didymocyrtis tetrathalamus	Lamprocyrtis nigriniae	Acrosphaera sp.	Eucyrtidium dufresni	Pterocorys minythorax	Anthocyrtidium angulare	Octopyle stenozoa	Collosphaera orthoconus	Dictyophimus infabricatus	Eucyrtidium anomalum	Pterocorys hertwigii	Plectacantha cremastoplegma	Rhizosphaera antarctica	Collosphaera tuberosa	Peterocanium grandiporus	Spongaster tetras	Amphiropalum virchowi
P		P	P		P	P				P			P			P		
P		P	P	P	P	P		P		P			P			P		P
P			P		P	P		P		P		P	P			P	P	
P			P	P	P	P				P			P	P	P	P		
P			P		P	P			P	P			P	P				
P		P	P		P	P		P		P			P	P				
P		P	P			P		P	P	P	P	P						
P	P		P		P	P												
P			P	P														
P			P					P										
P		P	P				P											
P		P	P					P										
		P	P		P													
		P	P		P													
			P		P													
P		P	P	P														
P			P															
	P																	
P																		
P																		

Hole 685A.

Age	Radiolarian biozonation	Samples	Abundance	Preservation	Diartus hughesi	Diartus petterssoni	Didymocyrtis antepenultima	Stichocorys delmontense	Stichocorys wolffii	Stylatractus universus	Didymocyrtis laticonus	Dorcadospyris ateuchus	Eusyringium fistuligerum	Lithocyclia aristotelis	Theocyrtis tuberosa	Cyrtocapsella cornuta	Dictyophimus splendens	Lamprocyclas hannai	Siphocampe crustula	Phormostichoartus fistula	Botryostrobus B. bramlettei	Larcospira moschkovskii	Dictyoprora mongolfieri	Stichocorys peregrina	Acrosphaera murrayana	Anthocyrtidium ehrenbergi	Anthocyrtidium pliocenica	Botryostrobus auritus/australis	Cyrtocapsella elongata	Dioymocyrtis penultima	Prunopyle hayesi	Eucyrtidium infundibulum	Eucyrtidium T. orthoporus	Siphocampe modeloensis
	NR 1	685A-1-CC	C	G																					P		P							
	NR 2	685A-2-CC	C	G														P							P		P					P		
		685A-3-CC	C	G														P							P		P					P		
Pleistocene	NR 3 / NR 4	685A-4-CC	C	G						P															P		P					P		
		685A-5-CC	C	G						P																	P					P		
		685A-6-CC	C	G				P		P								P	P						P		P					P	P	
		685A-7-CC																															
		685A-8-CC	A	G						P									P						P		P					P		
		685A-9-CC	F	G						P															P		P					P		
		685A-10-CC	F	G						P									P						P		P					P	P	
		685A-11-CC	F	G						P									P						P		P					P	P	
		685A-12-CC	C	G						P									P								P					P	P	
		685A-13-CC	A	G						P									P						P		P					P	P	
		685A-14-CC	C	G						P									P						P		P					P	P	
		685A-15-CC	A	G						P									P						P		P					P	P	
		685A-16-CC	A	G						P									P								P					P	P	
		685A-17-CC	A	G	P					P									P						P		P					P	P	
		685A-18-CC	C	G						P									P						P		P					P	P	
		685A-19-CC	C	G															P				P		P		P					P	P	
		685A-20-CC	C	G						P									P						P	P	P					P	P	
		685A-21-CC	C	G						P									P						P		P					P		
		685A-22-CC	C	M	P			P		P									P		P			P			P			P		P		
	D. penultima	685A-23-CC	C	G	P			P		P							P	P		P	P			P		P	P			P	P			P
		685A-24-CC																															
		685A-25-CC	F	M	P	P		P		P							P	P		P	P	P					P	P	P	P	P			
		685A-26-CC																															
late Miocene	D. antepenultima	685A-27-CC	F	M	P			P		P							P	P		P	P	P												
		685A-28-CC	C	M	P		P	P		P							P	P	P	P	P	P	P		P	P								
		685A-29-CC	C	M	P		P	P		P							P	P	P	P	P	P	P		P									
		685A-30-CC	C	M	P		P	P		P							P	P	P	P	P	P	P											
		685A-31-CC	C	M	P	P	P	P		P	P						P	P	P	P	P	P												
		685A-32-CC	C	M	P	P	P	P		P							P	P	P		P	P												
		685A-33-CC	R	P				P		P							P	P			P	P												
		685A-34-CC	R	M				P		P							P					P	P											
		685A-35-CC	F	P			P	P		P							P					P	P											
		685A-36-CC	F	P	P		P	P		P							P	P	P	P														
		685A-37-CC	R	P	P		P	P									P	P	P	P	P													
		685A-38-CC	R	M	P		P	P									P	P	P	P														
		685A-39-CC	R	M	P		P	P		P							P	P	P															
		685A-40-CC	F	M	P		P	P	P	P					P																			
		685A-41-CC	F	P	P		P	P	P																									
		685A-42-CC	R	P	P		P	P	P	P																								
		685A-43-CC	R	M								P	P		P																			
		685A-44-CC	R	M	P		P	P	P			P	P																					
		685A-46-CC	F	M	P	P	P	P	P	P	P																							
		685A-45-CC	F	M	P		P	P	P	P																								
		685A-48-CC	R	P	P	P				P																								

Hole 685A (continued).

Anthocyrtidium ophirense	Botryosterobus B. pretumidulus	Cycladophora davisiana	Gondwanaria dogieli	Lamprocyclas junonis gr.	Lamprocyrtis nigriniae	Pterocorys minythorax	Tholospyris capoi	Acrosphaera pseudarkios	Anthocyrtidium nosicaae	Botryostrobus B. tumidulus	Dioymocyrtis tetrathalamus	Eucyrtidium calvertense	Eucyrtidium indiensis	Eucyrtidium T. teuscheri	Lamprocyclas marialis gr.	Lithostrobus hexagonalis	Phormostichoartus pitomorphus	Pranopyle antarctica	Pterocanium koronevi	Pterocorys clausus	Saturnalis circularis	Stichopilium bicorne	Theocorythium trachelium	Carpochanium sp. A	Pseudocubus warreni	Eucyrtidium dufresni	Streblospina circumtexta	Acrosphaera trepanata	Amphiropalum ypsilon	Dictyophimus infabricatus	Rhizosphaera antarctica	Octopyle stenozoa	Pterocanium grandiporus	Anthocyrtidium zanguebaricum	Anthocyrtidium jenghisi	Plectacantha cresmatoplegma	Spongotrochus glacialis	Cypassis irregularis
	P	P	P	P	P	P	P			P		P		P	P	P		P	P	P		P				P			P	P		P			P	P	P	P
	P	P	P	P	P	P	P			P		P	P	P	P	P		P	P	P	P	P				P		P		P	P	P			P	P	P	P
P		P		P	P	P	P		P	P	P		P	P	P	P	P	P	P	P	P	P	P		P	P	P		P	P	P		P		P	P		P
P	P	P	P		P	P	P		P	P	P	P			P	P		P	P	P		P	P	P	P			P				P	P	P				
P	P		P	P	P	P	P	P		P	P		P		P	P		P	P		P	P			P	P			P	P		P	P	P				
P		P			P	P	P			P	P	P	P	P	P	P		P	P		P	P			P				P			P	P					
P	P	P		P	P	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P			P	P			P	P		P	P	P				
P	P		P	P	P	P	P		P	P		P	P	P		P	P	P	P		P	P		P	P			P		P								
P	P	P	P	P	P	P				P			P	P	P	P	P	P	P	P	P	P		P				P				P	P					
P	P	P	P	P	P	P			P	P				P	P	P		P	P	P	P	P	P	P	P					P		P						
P	P	P		P	P	P				P				P	P	P	P	P	P	P	P	P	P	P														
P	P	P	P	P	P	P			P	P	P		P	P	P	P		P	P	P		P	P	P														
P	P	P		P	P	P				P	P	P		P	P	P	P	P	P	P	P		P															
P	P	P		P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P														
P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P															
P	P	P	P	P	P	P	P																															

Hole 688A.

Age	Radiolarian Biozonation	Samples	Abundance	Preservation	Acrosphaera trepanata	Actinomma popofskii	Anthocyrtidium ophirense	Botryostrobus aquilonaris	Botryostrobus auritus/australis	Botryostrobus B. tumidulus	Cycladophora davisiana	Dictyophimus crisiae	Eucyrtidium hexastichum	Eucyrtidium indiensis	Eucyrtidium T. orthoporus	Eucyrtidium T. teuscheri	Lamprocyclas junonis gr.	Lamprocyclas maritalis gr.	Lamprocyrtis neoheteroporos	Octopyle stenozoa	Phormostichoartus furcaspiculata
	NR 1-	688A-1-CC	C	G	P		P	P	P	P	P	P	P			P	P	P		P	P
		688A-2-CC	C	G	P			P	P	P			P			P	P	P			
	NR 2	688A-3-CC	C	G			P	P	P		P	P	P	P		P	P	P			
		688A-4-CC	C	G				P	P	P	P	P				P	P	P			P
	NR 3	688A-5-CC	C	G			P	P	P	P	P	P	P	P		P	P	P			P
		688A-6-CC	C	G			P	P	P	P	P	P	P	P		P		P		P	
	---?---	688A-7-CC	C	G		P			P	P	P	P		P	P	P	P	P			P
		688A-8-CC	C	G			P	P	P	P	P	P		P		P	P	P			P
		688A-9-CC	C	G			P	P	P	P	P	P		P			P	P			P
		688A-10-CC	C	G				P	P	P	P	P	P		P	P	P	P			
		688A-11-CC	C	G	P		P	P	P	P	P	P	P	P	P	P	P	P			P
		688A-12-CC	C	G			P	P	P	P	P	P	P				P	P			P
		688A-13-CC	C	G		P		P	P	P	P	P		P	P	P	P	P			P
		688A-14-CC	C	G	P	P		P	P	P	P	P	P	P	P	P	P	P			P
		688A-15-CC	F	G				P	P	P	P	P		P			P	P			
		688A-16-CC	C	G	P		P	P	P	P	P		P	P		P	P	P		P	
Pleistocene		688A-17-CC	C	G	P		P	P	P	P	P	P	P	P	P		P	P		P	
		688A-18-CC	C	G	P		P	P	P	P	P	P	P	P	P	P	P	P		P	P
	NR 4	688A-19-CC	C	M				P	P	P	P	P					P	P			P
		688A-20-CC	C	G	P		P	P	P	P	P			P	P		P	P			P
		688A-21-CC	C	G			P	P	P	P	P	P	P		P	P	P	P		P	P
		688A-22-CC	C	G		P		P	P	P	P	P				P	P	P	P		P
		688A-23-CC	C	G	P	P	P	P	P	P	P	P		P	P	P	P	P			
		688A-25-CC	C	G			P	P	P	P	P	P		P		P	P	P	P		P
		688A-26-CC	C	G		P		P	P	P	P	P			P	P	P	P	P	P	P
		688A-27-CC	C	G			P	P	P	P	P	P			P	P	P	P	P		P
		688A-28-CC	C	G			P	P	P	P	P	P			P	P	P	P		P	P
		688A-29-CC	C	G			P	P	P	P	P	P		P	P	P	P	P	P		
		688A-30-CC	C	G	P		P	P	P	P	P	P			P	P	P	P	P	P	
		688A-31-CC	C	G	P		P	P	P	P	P	P	P	P	P	P	P	P	P		
		688A-32-CC	C	G	P			P	P	P	P	P		P	P	P	P	P	P		P
	---?---	688A-33-CC	C	G	P			P	P	P	P			P	P	P	P	P	P		P
		688A-34-CC	C	G	P		P	P	P	P	P					P	P	P		P	
	NR 5	688A-35-CC	C	G	P			P	P	P	P	P		P	P	P	P	P	P		
		688A-36-CC	F	M			P	P	P	P	P	P				P	P	P			
		688A-37-CC	F	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Hole 688A (continued).

Phormostichoartus pitomorphus	Pseudocubus warreni	Peterocanium korotnevi	Saturnalis circularis	Siphocampe arachnea	Siphocampe crustula	Stylatractus universus	Theocalyptra cornutoides	Theocorythium trachelium	Tricolocapsa papillosa	Ceratocyrtis histricosa	Eucyrtidium acuminatum	Eucyrtidium calvertense	Lamprocyrtis nigriniae	Lithostrobus undulatus	Lophospyris pentagona	Pterocanium eucolpum	Rhopalastrum profundum	Tholospyris capoi	Antocyrtidium nosicaae	Anthocyrtidium zanguebaricum	Didymocyrtis tetrathalamus	Eucyrtidium infundibulum	Prunopyle antarctica	Pterocorys clausus	Pterocorys minythorax
		P	P	P	P			P	P	P	P	P	P	P	P	P	P	P		P	P		P	P	P
			P		P				P	P	P	P	P	P	P			P	P			P	P		P	P	P
		P	P			P			P			P				P			P		P			P	P	P	P
	P	P	P	P	P	P	P	P	P				P			P	P	P					P	P	P	
	P	P	P		P	P	P	P	P		P	P	P	P	P	P	P				P	P	P	P	
	P	P	P		P	P	P	P	P	P		P					P	P				P	P		
	P	P	P		P	P	P		P	P			P	P		P	P	P	P	P			P	P	P	
P		P	P			P	P		P	P		P	P	P			P	P	P				P	P	
	P	P		P	P	P		P	P	P	P	P				P	P	P			P	P	P	P	P
P	P	P	P	P	P	P		P	P	P	P	P	P	P		P	P	P	P	P		P		P	P	P
	P	P	P		P	P	P		P	P	P		P			P	P	P	P			P	P	P	
	P	P	P			P	P		P			P					P	P	P				P	P	
	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P		P	P	P	P
P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P			P	P	P
P		P	P		P	P	P		P	P	P		P				P	P	P			P		P	P
P	P	P	P		P	P	P		P	P	P	P	P		P		P	P	P	P	P		P	P	P	P
P	P	P	P	P	P	P	P		P	P	P	P	P				P	P	P	P	P		P	P	P
	P	P	P		P	P	P		P	P	P	P	P				P	P	P	P			P	P	P	P
P	P		P	P	P	P	P		P	P	P	P	P		P	P	P	P	P	P	P		P	P	P	P
P	P		P		P	P	P		P	P	P	P	P		P	P	P	P	P	P	P		P	P	
	P	P	P		P	P	P		P	P	P	P	P			P	P	P	P	P	P		P	P	
P	P	P	P		P	P	P		P	P	P	P	P	P		P	P	P	P	P		P	P	P	
P	P	P	P		P	P	P	P	P	P	P	P	P				P	P	P	P	P		P		
P	P		P		P	P	P	P	P	P	P		P			P		P	P			P	P	P	P	
P	P	P	P		P	P	P	P	P	P	P	P	P	P			P	P	P		P		P	P	
P	P	P	P		P	P	P		P	P	P		P		P		P	P	P			P	P	P	
P	P		P		P	P			P			P	P	P	P	P	P	P	P	P		P	
P			P	P			P	P				P				P	P		P	P		P	P	P
	P		P	P	P		P	P		P	P	P	P	P	P	P	P	P						P	P	P
P	P	P	P	P	P	P	P	P	P									P						

Hole 688A (continued).

Age	Radiolarian Biozonation	Samples	Abundance	Preservation	Spongocore puella	Tholospyris scaphipes	Acanthodesmia micropora	Acrosphaera murrayana	Circodiscus microporus	Eucyrtidium hexacolum	Nephrospyris renilla	Pterocanium trilobum	Spirocyrtis subscalaris	Actinomma haysi	Gondwanaria dogieli	Lithostrobus hexagonalis	Spongodiscus setosus	Tricolospyris baconiana	Acrosphaera pseudarktios	Botryostrobus B. seriatus	Eucyrtidium octocolum
Pleistocene	NR 1-NR 2	688A-1-CC	C	G	P	P	P	P		P		P	P		P	P	P	P	P		P
		688A-2-CC	C	G			P	P				P	P			P	P		P	P	
		688A-3-CC	C	G				P				P	P								P
	NR 3	688A-4-CC	C	G		P		P		P						P	P				P
		688A-5-CC	C	G		P	P	P					P		P	P	P				P
		688A-6-CC	C	G	P	P	P	P		P		P	P			P	P	P	P		P
		688A-7-CC	C	G	P	P	P	P		P					P	P	P		P	P	P
	---?---																				
	NR 4	688A-8-CC	C	G	P					P		P			P	P	P				P
		688A-9-CC	C	G	P	P	P	P		P					P		P				P
		688A-10-CC	C	G		P		P					P		P	P					P
		688A-11-CC	C	G	P	P		P				P	P		P						P
		688A-12-CC	C	G	P	P				P		P	P		P	P	P	P			
		688A-13-CC	C	G	P	P	P					P	P		P	P	P		P		
		688A-14-CC	C	G	P	P		P			P	P			P	P	P				P
		688A-15-CC	F	G	P	P		P								P					
		688A-16-CC	C	G	P	P		P		P	P	P		P	P	P	P				P
		688A-17-CC	C	G	P	P		P	P		P	P	P		P	P	P	P			P
		688A-18-CC	C	G	P	P	P	P	P		P	P	P	P	P	P	P	P	P		P
		688A-19-CC	C	M	P	P			P			P	P		P			P			P
		688A-20-CC	C	G		P							P		P					P	P
		688A-21-CC	C	G	P	P			P	P		P	P	P	P	P				P	P
		688A-22-CC	C	G		P						P			P		P		P		P
		688A-23-CC	C	G		P			P	P		P	P		P		P			P	P
		688A-25-CC	C	G	P					P			P	P	P	P	P			P	P
		688A-26-CC	C	G	P							P			P	P	P				P
		688A-27-CC	C	G		P				P		P	P		P	P	P		P		
		688A-28-CC	C	G	P	P	P	P	P			P	P		P		P				P
		688A-29-CC	C	G	P	P		P	P			P	P	P	P		P			P	
		688A-30-CC	C	G	P	P			P	P		P			P		P		P		
		688A-31-CC	C	G						P		P			P					P	P
		688A-32-CC	C	G	P					P		P		P	P		P	P			
		688A-33-CC	C	G		P		P				P	P	P	P	P	P				
	---?---																				
	NR 5	688A-34-CC	C	G		P	P	P	P	P	P	P	P								
		688A-35-CC	C	G	P	P															
		688A-36-CC	F	M																	
		688A-37-CC	F	M																	

Hole 688A (continued).

Phorticium chlevei	*Stichopilium bicorne*	*Carpocanium* sp. A	*Phormostichoartus platycephala*	*Eucecryphalus gegenbaueri*	*Desmospyris B. biceps*	*Spongotrochus glacialis*	*Phormostichoartus multiseriatum*	*Spongaster tetras*	*Lampromitra coronata*	*Pterocanium praetextum*	*Eucyrtidium dufresni*	*Amphiropalum ypsilon*	*Rhizosphaera antarctica*	*Tricolocampe cylindrica*	*Eucecryphalus cervus*	*Eucyrtidium anomalum*	*Eucyrtidium monumentum*	*Acanthodesmia vinculata*	*Amphiropalum virchowi*	*Lamprocyclas gamphonycha*	*Actinomma delicatulum*	*Dictyophimus infabricatus*	*Plectacantha cremastoplegma*	*Pterocanium grandiporus*
P	P	P	P	P	P		P		P			P		P	P	P	P						P	
P	P	P	P	P								P							P				P	P
P		P	P	P			P	P				P			P	P			P	P	P	P	P	P
P				P																			P	
	P	P		P	P				P	P		P		P					P	P			P	P
P	P		P	P			P		P			P	P				P			P	P	P	P	
P	P						P						P									P		
P	P																							
P	P																							
	P				P		P					P			P		P							
	P			P			P		P	P				P						P				
P	P			P									P											
P	P					P							P				P							
	P																							
P	P	P		P						P	P	P	P		P		P	P	P					
P	P		P	P			P		P	P	P	P			P	P	P	P						
P	P	P									P	P	P	P			P							
P		P		P					P	P		P	P											
P	P		P	P					P	P														
P	P			P	P						P	P												
P		P		P			P	P	P	P														
P								P																
P	P				P	P																		
	P			P																				
P		P	P																					
P	P																							