12. NEOGENE RADIOLARIANS FROM THE EASTERN NORTH PACIFIC (OFF ALTA AND BAJA CALIFORNIA), DEEP SEA DRILLING PROJECT LEG 63

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INTRODUCTION

Leg 63 of the Deep Sea Drilling Project extended along the west coast of North America and northern Central America, northwest of Los Angeles to southwest of Mazatlan, Mexico. Holes were drilled at seven sites and Neogene cores recovered, exclusively (Sites 467-473). Sites 467 through 469 are situated within the California Continental Borderland, Sites 470 through 473 within the western continental margin of Baja California (Fig. 1). Leg 63 drilling was intended to study the Neogene paleoceanographical and climatological development of the northeastern Pacific and the evolution of planktonic communities.

METHODS

Light-microscope techniques were used to study the Neogene radiolarians of 429 samples. Radiolarian zonation of the samples, summarized in Fig. 2, follows mainly Hays (1970), Kling (1973), Riedel and Sanfilippo (1971, 1978), Moore (1971), Dinkelman (1973), and Foreman (1975).

The relative abundances of the various species were determined as follows. All individuals of each species were counted. After 15 individuals of one species were noted, the counting stopped, yielding the relative abundances for each species: A, abundant (more than 15 specimens on the counted part of a slide); C, common (10-14 specimens); F, few (5-9 specimens); R, rare (1-4 specimens). B, barren (no recognizable specimens).

The taxonomy, which is alphabetically arranged, references only papers in which the species mentioned are fully described.

SITE SUMMARIES

Site 467

Site 467 is located within the San Miguel Gap (Table 1), about 230 km northwest of Los Angeles. Coring was intended to provide a Miocene through Quaternary reference section that would permit biostratigraphical correlations between the California Borderland and the California province (onshore). Neogene radiolarian-bearing sediments were recovered from Cores 467-2 through 56 (Quaternary through uppermost Miocene); the radiolarian abundance is generally rare to few, the preservation poor to moderate. No datable radiolarians are known from Cores 22, 31, 37, 46, and 57 through 110. The radiolarian assemblages from Cores 2 through 56 are listed in Table 2. The biostratigraphical zonation used here follows Hays (1970) and Kling (1973) for the eastern North Pacific.

Site 468

Hole 468 was drilled on the Patton Escarpment to find clues to the late Cenozoic paleoceanographic-paleoclimatic history and the associated oscillations in the biogeographic patterns of planktonic communities.
Hole 468 was continuously cored to 241 meters, Hole 468A to 35.5 meters, and Hole 468B to 415.5 meters. A relatively thin cover (3.5–40 m) of upper Neogene sediment rich in calcareous microfossils and rather poor in siliceous microfossils overlies a thicker sequence of calcareous and siliceous middle Miocene sediment. This, in turn, overlies a barren sedimentary sequence that may represent either middle or lower Miocene.

The radiolarian abundance in Quaternary through middle Miocene sediments is mostly rare to few and the preservation poor to moderate. Only few cores contain common to abundant, well-preserved radiolarians—Sections 2-1 through 3-1 and Sections 4-5 through 5-1 (Hole 468), and Sections 3-2 through 9-2 (Hole 468B). Core 1 and Core 2, Section 1 (Hole 468A) contain a well-preserved, common Pleistocene radiolarian assemblage. Surface sediment in Hole 468A yields no datable radiolarians as well as Cores 14 through 16 of Hole 468 and Core 5 of Hole 468B. Below Section 468B-18-2, no remains of radiolarians occur (except in Sample 29,CC). Tables 3 and 4 list the radiolarian assemblages from the Neogene sediments of these holes.

The Quaternary sediments of Hole 468A yielded radiolarian assemblages described from the northeastern Pacific, and Kling’s (1973) zonation is applicable. Sections 1 and 2 of Core 1 correlate with the upper Pleistocene Axoprunum angelinum Zone, as indicated by the presence of Lamprocystis nigrinae and the absence of E. matuyamai. The assemblages of Section 1-3 through Section 2-1, containing E. matuyamai and Lamprocystis heteroporos are—at least the upper part—assigned to the lower Pleistocene E. matuyamai Zone. Single specimens of Amphirhopalum ypsilon and Theocorythium vetulum, which are typical of equatorial regions, are included in the Quaternary assemblages. The upper Pliocene sediments of Hole 468A (Section 2-2 through Sample 2,CC) and Hole 468B (Sections 1-1 through 1-2) contain only nondiagnostic radiolarians besides Lamprocystis heteroporos and belong, therefore, to the L. heteroporos Zone. The upper boundary of the lower Pliocene/uppermost Miocene Stichocorys peregrina Zone is indicated by the extinction of S. peregrina. The Pliocene/Miocene boundary is marked by the first appearance of L. heteroporos. From the radiolarian occurrences, it follows that the Quaternary and Pliocene are only thinly represented by sediments, if at all. One or several sedimentation gaps or a very condensed sequence can be assumed between Core 1 and Sample 2,CC of Hole 468A.

Below the Quaternary–Pliocene beds, radiolarians restricted to the upper Miocene are rarely represented. Section 468-2-1 contains few specimens of Ommatartus antepenultimus, a species indicative of deposition in the early late Miocene. Section 468A-4-5 yielded Stichocorys peregrina abundantly and is assigned to the uppermost Miocene. Equivalent layers were found in Sample 468B-2,CC through Section 468B-3-4, which are again characterized by few specimens of S. peregrina and rare occurrences of O. antepenultimus. Only Section 4-1 and
Figure 2. Radiolarian zonation of Neogene and Quaternary sedimentary depositions. After Kling (1973), the Pliocene/Quaternary boundary coincides with the base of the Eucyrtidium matuyamai Zone. According to the results of diatom (J. Barron, this volume) and nannofossil studies (D. Bukry, this volume), the Pliocene/Quaternary boundary presumably must be drawn within the lower part of the E. matuyamai Zone.

Table 1. Locations of Leg 63 Holes from which radiolarians were recovered.

<table>
<thead>
<tr>
<th>Hole</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Location</th>
<th>Water Depth (m)</th>
<th>Cored Section (m)</th>
</tr>
</thead>
<tbody>
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<td>467</td>
<td>33°50.97'N</td>
<td>120°45.47'W</td>
<td>San Miguel Gap</td>
<td>2127.8</td>
<td>1041.5</td>
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<tr>
<td>468</td>
<td>32°37.03'N</td>
<td>120°07.07'W</td>
<td>Patton Escarpment</td>
<td>1849</td>
<td>241</td>
</tr>
<tr>
<td>468A, B</td>
<td>32°37.41'N</td>
<td>120°06.55'W</td>
<td>Patton Escarpment</td>
<td>1737</td>
<td>A = 35.5; B = 415.5</td>
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<tr>
<td>469</td>
<td>32°37.00'N</td>
<td>120°32.90'W</td>
<td>Foot of Patton Escarpment</td>
<td>3790</td>
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</tr>
<tr>
<td>470, 470A</td>
<td>28°54.46'N</td>
<td>117°31.11'W</td>
<td>East of Guadalupe Island</td>
<td>3549</td>
<td>168</td>
</tr>
<tr>
<td>471</td>
<td>23°28.93'N</td>
<td>112°29.78'W</td>
<td>Foot of continental slope</td>
<td>3101</td>
<td>A = 101.5</td>
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<td>472</td>
<td>23°00.35'N</td>
<td>113°59.71'W</td>
<td>South of Site 471</td>
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<tr>
<td>473</td>
<td>20°57.92'N</td>
<td>107°03.81'W</td>
<td>Rivera plate south of Tres Marias Island</td>
<td>3249</td>
<td>287.5</td>
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Table 2. Radiolarians from the Neogene and Quaternary sediments of Hole 467.

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<td>16, CC</td>
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<tr>
<td>17, CC</td>
<td>F</td>
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<tr>
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<td>C</td>
</tr>
<tr>
<td>18-6, 56-56</td>
<td>r</td>
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<td>18-8, 56-56</td>
<td>c</td>
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<td>F</td>
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<td>19-4, 24-26</td>
<td>C</td>
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Note: Preservation: P = poor, M = moderate, G = good. Abundance: B = barren, R = rare, F = few, C = common, A = abundant. * indicates reworked. The upper boundary of the Pliocene is determined on the basis of nannofossils.
were encountered in Holes 468A and 468B. Radiolarian assemblages of the upper Miocene O. antepenultimus Zone could not be recognized in the Site 468 holes; radiolarians of the lower S. peregrina Zone are lacking in Hole 468; those of the O. antepenultimus Zone have not been found in Hole 468A. It is probable, therefore, that the upper Miocene sediments constitute a rather thin, condensed (or incomplete) succession.

Only part of the middle Miocene seems to be well represented by a rather thick succession of sediments at
**NEOCENE RADIOLARIANS FROM EASTERN NORTH PACIFIC**

<table>
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<tr>
<th>479</th>
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</table>

Table 3. (Continued).

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<td><strong>C. japonica</strong></td>
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<td><strong>Dorcadospyris alata</strong></td>
<td><strong>D. simplex</strong></td>
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<td><strong>E. calvertense</strong></td>
<td><strong>E. inflatum</strong></td>
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<tr>
<td><strong>Hymenistrium euclidi</strong></td>
<td><strong>Lamprocyrtis hannai</strong></td>
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<td><strong>Xiphospora sp. cf. X. circularis</strong></td>
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Table 4. Radiolarians from the Neogene and Quaternary sediments of Holes 468A and 468B.

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<th>Sub-bottom Depth (m)</th>
<th>Age</th>
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<th>Sample (interval in cm)</th>
<th>Abundance</th>
<th>Preservation</th>
<th>Acantodinalea</th>
<th>Acroplectinum angelinum</th>
<th>Bathyprocerus woodringi</th>
<th>B. mirabilis</th>
<th>Calyptocorys sp.</th>
<th>C. tuberosa / C. decipiens</th>
<th>Carpocheilidae</th>
<th>Ctenodiscus cuneiformis</th>
<th>C. japonica</th>
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Note: See Table 2 for a key to the symbols.
boundary of the middle Miocene. On the other hand, mainly lower Miocene species, such as Calocycletta costata, C. virginis, and Dorcadospyris simplex, are rare to common in Cores 17 through 21 (Hole 468). According to the results of diatom research, Sample 21, CC still contains middle Miocene species. Therefore the lower Miocene radiolarians are probably reworked.

In the region of Sites 467 and 468, the Quaternary radiolarian assemblages mainly consist of cold-water species. Site 468 differs from Site 467, however, in that some warm-water species (Amphirhopalum ypsilon, Theocorythium vetulum) joined the North Pacific assembly.

Site 469
At Site 469 on the foot of Patton Escarpment, a single hole was continuously cored to a total depth of 453.5 meters, the lower 59.5 meters in the basement. It contains abundant to rare middle Miocene through Quaternary radiolarians of poor to good preservation (Cores 1-25). Very rare and poorly preserved lower middle Miocene radiolarians occur sporadically in Cores 30, 35, 36, and 38, immediately above the basement. The poor remains of siliceous microfossils in some cores of the lower middle Miocene section suggest that the absence or presence of radiolarians in that region is due to diagenesis rather than to the primary lack of siliceous skeletons. Table 5 lists radiolarians from the Neogene and Quaternary sediments of Hole 469.

The Quaternary sediments of Hole 469 yielded radiolarian assemblages containing northeastern Pacific cold-water species as well as less numerous equatorial warm-water species; Kling's (1973) zonation was applicable. Cores 1 through 3, Section 1 can be assigned to the upper Pleistocene Axoprunum angelinum Zone, as indicated by the rare to abundant presence of Lamprocyrtis nigriniae and Lamprocyrtis neoeheteroporus and the absence of Eucyrtidium matuyamai and Lamprocyrtis heteroporus. The upper Pleistocene interval contains sporadically older radiolarians, such as different species of Cyrtocapsella, E. matuyamai, L. heteroporus, and Stichocorys peregrina, which must be considered to be reworked. Characterized by the rare to common occurrence of E. matuyamai and L. neoeheteroporus in the upper part and L. heteroporus in the lowermost part, Section 3-2 through Section 5-5 can be placed into the lower Pleistocene/uppermost Pliocene E. matuyamai Zone.

Deposition in the late Pliocene (L. heteroporus Zone) is indicated for Sample 5, CC through Section 8-1 by the few to abundant presence of L. heteroporus and the absence of E. matuyamai and Stichocorys peregrina. The association of common to abundant individuals of L. heteroporus and rare to common occurrences of S. peregrina suggest that Section 8-3 through Sample 11, CC (S. peregrina Zone, upper part) were deposited in the early Pliocene. The boundary between Miocene and Pliocene seems to be marked by a sudden and abundant appearance of L. heteroporus.

Section 12-1 through Sample 17, CC are upper Miocene. The fact that this interval contains few to abundant S. peregrina but lacks Ommatartus antepenultimus and, except for Sample 17, CC, Ommatartus penultimus suggests that the lower part of the upper Miocene succession (O. antepenultimus and O. penultimus Zones) is partly or totally missing at Site 469.

Cannartus petterssoni has not been found below Core 17. This indicates that the upper middle Miocene C. petterssoni Zone is either not represented at all or represented by a condensed succession only. Cores 19 through 30 are distinguished by the presence of Cannartus laticus, Cannartus mambiferus, various species of Cyrtocapsella, Stichocorys delmontensis, Stichocorys wolffii a.o., which suggests deposition during the early middle Miocene (Dorcadospyris alata Zone). The poor assemblages gained from Cores 32 through 36 were probably deposited in the early middle Miocene. A definite conclusion cannot be drawn, regarding the ages of Cores 38 through 39. Sample 38, CC yielded Cyrtocapsella tetrapera and Cannartus violina. Available evidence suggests that C. violina is restricted to the lower Miocene. Consequently it follows that Samples 38, CC and 39, CC are either lower middle Miocene with C. violina being reworked or upper lower Miocene with C. violina as an authochthonous fossil.

According to the radiolarian zonation, the Quaternary and Pliocene seem to be rather entirely represented at Site 469, perhaps with the exception of the upper Quaternary Botryostrobus mirandus Zone. Upper and middle Miocene, however, seem to be only incompletely represented by sediments, because the assemblages with O. penultimus, O. antepenultimus, and C. petterssoni are partly or totally missing. The Pliocene and Quaternary radiolarian zones introduced by Kling (1973) are restricted to the cold-water regions of the North Pacific; they are associated with few specimens of equatorial species in Cores 1 through 8 at Site 469, such as the Pliocene-Quaternary species Amphirhopalum ypsilon, Ommatartus tetrahalamus, Spongaster tetras, and Theocorythium vetulum. The lower Pliocene and Miocene assemblages are for the most part composed of warm-water species, the number of which decreases from Miocene toward the lower Pliocene. The total lack of the equatorial lower middle Miocene Dorcadospyris alata may be considered an indication of cold-water influence.

Site 470
East of Guadalupe Island, 8 km south-southwest of the Experimental Mohole, Hole 470 was continuously cored to basalt at 167 meters. Hole 470A was cored from 47.5 to 95 meters and from 161.5 to 168 meters in sediment, then continuously cored in basalt to 215.5 meters. Few to abundant middle Miocene through Quaternary radiolarians of moderate to good preservation were recovered from Cores 7 through 17 in Hole 470 (lower Pliocene through middle Miocene) and from Core 1, Section 3 through Core 5 in Hole 470A (lower Quaternary and upper Miocene). Core 1, Section 3 through Core 6 of Hole 470 and Core 1, Section 1 of Hole 470A yielded rare, poorly preserved radiolarians. Sections 1-1, 4-1, 5-1, and 18-2 of Hole 470 are barren.
Tables 6 and 7 list radiolarians from the Neogene and Quaternary sediments of Holes 470 and 470A, respectively.

Except for Section 2-5, the upper layers of Hole 470 from Cores 1 through 6 are so poor in radiolarians that only incomplete zonal classification is possible. Section 2-5 must be assigned to the lower Pleistocene–upper Pliocene Eucyrtidium matuyamai Zone, because it contains rare to few individuals of the zone fossil and of Lamprocyrtis neoheteroporos and L. heteroporos as well as rare members of the equatorial species Ommatartus tetrathalamus, Spongaster tetras, and Theocorytium vetulum. A very thin cover of Quaternary sediments was encountered at Site 470A. Section 1 of Core 1 contains nondiagnostic radiolarians only and is tentatively assumed to have been deposited in the late Quaternary. Sediments from below this section can be assigned to the lower Quaternary E. matuyamai Zone, because they yielded both Lamprocyrtis neoheteroporos and L. heteroporos.

There are enough equatorial species in the Pliocene and Miocene cores of Hole 470 to permit recognition of equatorial zones. The first rare appearance of L. heteroporos, the last occurrences of S. peregrina, and the absence of the diagnostic Pleistocene and Miocene species indicate that deposition took place in the early Pliocene (upper part of S. peregrina Zone, Core 6, Section 2 through Core 7 of Hole 470). The Miocene/Pliocene boundary is placed between Cores 8 and 7 below the first appearance of L. heteroporos, which follows in that region immediately above the last presence of Ommatartus penultimus. In Hole 470A, the upper part of the S. peregrina Zone could not be recognized.

The upper Miocene lower part of the S. peregrina Zone cannot be separated from the underlying Ommatartus penultimus Zone. Both of them comprise Section 8-1 through Section 9-1 of Hole 470 and Section 2-1 through Section 4-3 of Hole 470A. They are distinguished by few to abundant occurrences of S. peregrina and by rare individuals of O. penultimus. Besides several nondiagnostic radiolarians, there are rare to abundant occurrences of Lithopera neotaera and Stichocorys wolffi, which are presumably reworked, according to present knowledge. Stichocorys delmontensis joins the assemblage in the lower part of the uppermost Miocene section.

According to Riedel and Sanfilippo (1978) and in accordance with Kling (1973), the O. antepenultimus Zone is defined by the evolutionary bottom and the morphotypic top of O. hughesi. Consequently, the lower boundary of the lower upper Miocene O. antepenultimus Zone can tentatively be placed between the main occurrences of O. hughesi and Cannartus petterssoni in Hole 470 (either below Section 12-1 or below Section 12-7). Various species of Cyrtocapsella, Lithopera, Stichocorys delmontensis, and S. wolffi complete the radiolarian assemblage of the O. antepenultimus Zone. The succession of Hole 470A ends with Core 6 in the lower upper Miocene O. antepenultimus Zone, immediately above basalt.

The boundary between middle and late Miocene is thus defined by the first appearance of the typical O. hughesi (below Section 12-7). The transition between C. petterssoni and O. hughesi, however, cannot always be clearly recognized, and it is sometimes difficult to separate one species from the other. At Site 470, the upper middle Miocene C. petterssoni Zone comprises Section 13-1 through Section 15-5. Its lower boundary is defined by the first appearance of C. petterssoni, which is associated with Cannartus laticonus, various species of Cyrtocapsella, Lithopera, and Stichocorys.

The lowermost part of the succession encountered at Site 470 (Sample 15,CC through Core 17) contains few to abundant, well-preserved radiolarians of the lower middle Miocene Dorcadospyris alata Zone: C. laticonus, various species of Cyrtocapsella, Lithopera, and Stichocorys etc., without C. petterssoni. Core 18, immediately overlying the basalt, is barren.

The Pliocene and Miocene radiolarian assemblages of Site 470 are for the most part composed of equatorial warm-water species. Nevertheless, as at Site 469, the total lack of the equatorial middle Miocene Dorcadospyris alata suggests that a certain cold-water influence prevailed during that time. As far as we can conclude from the sparse evidence, the Quaternary assemblage consists of mixed cold- and warm-water species.

**Site 471**

Hole 471 was drilled on the distal portion of a deep-sea fan west of the foot of the continental slope off Baja California. Hole 471 was continuously cored to the top of the diabase at 741.5 meters.

The interval between Section 1-5 and Section 5-4 is barren at Site 471. Sections 3 and 5 of Core 1 contain only rare, nondiagnostic radiolarians, and Section 1 yielded with Amphirhopalum ypsilon and Ommatartus tetrathalamus—two species of the Quaternary–Pliocene. The latter section (5-4) does contain only rare individuals of Stichocorys peregrina and can be tentatively assigned to the Quaternary. The Quaternary/Pliocene boundary can be placed on top of the youngest fossiliferous layers (Section 5-6) with Lamprocyrtis heteroporos. It must be emphasized, however, that the true position of that boundary at Site 471 cannot be found by means of radiolarians. Table 8 lists radiolarians from the Neogene and Quaternary sediments of Hole 471.

Deposition in the late Pliocene is indicated for Section 5-6 through Section 6-1 by rare occurrences of L. heteroporos and the absence of Eucyrtidium matuyamai; otherwise there are only rare, nondiagnostic radiolarians. The extinction of Stichocorys peregrina marks the boundary between the upper Pliocene L. heteroporos Zone and the lower Pliocene S. peregrina Zone (upper part), which comprises the interval between Section 6-3 and Section 10-1. Mostly few to common, moderately to well-preserved radiolarians are significant for
Table 5. Radiolarians from the Neogene and Quaternary sediments of Hole 469.

<table>
<thead>
<tr>
<th>Sub-bottom Depth (m)</th>
<th>Age</th>
<th>Zone</th>
<th>Ma</th>
<th>Sample (interval in cm)</th>
<th>Abundance</th>
<th>Eucyrillidium matuyamai</th>
<th>Lamprocystis heteroporos</th>
<th>Stichocorys perigrina (upper part)</th>
<th>late Miocene (lower part) to Ommatarrus penultimus/antiepenultimus</th>
<th>S. perigrina</th>
<th>Cannartus petterssoni to Dorcadospirys alata</th>
</tr>
</thead>
<tbody>
<tr>
<td>484</td>
<td>1-2</td>
<td>Quaternary</td>
<td>A</td>
<td>1-1, 30-32</td>
<td>A G F R R F F</td>
<td>A G R R F F</td>
<td>A R R F</td>
<td>A R R F</td>
<td>A R R F</td>
<td>A R R F</td>
<td>A R R F</td>
</tr>
<tr>
<td>625</td>
<td>3-4</td>
<td>80-82</td>
<td>C</td>
<td>3-1, 40-42</td>
<td>F M R R R R R</td>
<td>C M R R R R</td>
<td>C M R R R</td>
<td>C M R R R</td>
<td>C M R R R</td>
<td>C M R R R</td>
<td>C M R R R</td>
</tr>
<tr>
<td>706</td>
<td>5-6</td>
<td>Pliocene</td>
<td>F</td>
<td>5-1, 80-82</td>
<td>F C G R C F F F</td>
<td>F C G R C F F</td>
<td>F C G R C F F</td>
<td>F C G R C F F</td>
<td>F C G R C F F</td>
<td>F C G R C F F</td>
<td>F C G R C F F</td>
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<tr>
<td>100</td>
<td>7-8</td>
<td>70-80</td>
<td>G</td>
<td>7-1, 30-32</td>
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<td>G C R R C F F F</td>
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<td>150</td>
<td>9-10</td>
<td>90-100</td>
<td>H</td>
<td>9-1, 60-62</td>
<td>H F M R F F F F</td>
<td>H F M R F F F F</td>
<td>H F M R F F F F</td>
<td>H F M R F F F F</td>
<td>H F M R F F F F</td>
<td>H F M R F F F F</td>
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<tr>
<td>200</td>
<td>11-12</td>
<td>100-110</td>
<td>I</td>
<td>11-1, 70-72</td>
<td>I C F R A R R R R</td>
<td>I C F R A R R R R</td>
<td>I C F R A R R R R</td>
<td>I C F R A R R R R</td>
<td>I C F R A R R R R</td>
<td>I C F R A R R R R</td>
<td>I C F R A R R R R</td>
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<tr>
<td>300</td>
<td>15-16</td>
<td>120-130</td>
<td>K</td>
<td>15-1, 70-72</td>
<td>K F M R C F F F</td>
<td>K F M R C F F F</td>
<td>K F M R C F F F</td>
<td>K F M R C F F F</td>
<td>K F M R C F F F</td>
<td>K F M R C F F F</td>
<td>K F M R C F F F</td>
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<tr>
<td>350</td>
<td>17-18</td>
<td>130-140</td>
<td>L</td>
<td>17-1, 40-42</td>
<td>L F M R C F F F</td>
<td>L F M R C F F F</td>
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<td>L F M R C F F F</td>
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<td>140-150</td>
<td>M</td>
<td>19-1, 50-50</td>
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<td>M F M R C F F F</td>
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<td>M F M R C F F F</td>
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<td>450</td>
<td>21-22</td>
<td>150-160</td>
<td>N</td>
<td>21-1, 60-60</td>
<td>N F M R C F F F</td>
<td>N F M R C F F F</td>
<td>N F M R C F F F</td>
<td>N F M R C F F F</td>
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<td>500</td>
<td>23-24</td>
<td>160-170</td>
<td>O</td>
<td>23-1, 70-70</td>
<td>O R M R C R R R</td>
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<td>O R M R C R R R</td>
<td>O R M R C R R R</td>
<td>O R M R C R R R</td>
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<td>600</td>
<td>27-28</td>
<td>180-190</td>
<td>Q</td>
<td>27-1, 90-90</td>
<td>Q F M R C F F F</td>
<td>Q F M R C F F F</td>
<td>Q F M R C F F F</td>
<td>Q F M R C F F F</td>
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<td>29-30</td>
<td>190-200</td>
<td>R</td>
<td>29-1, 100-100</td>
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<td>700</td>
<td>31-32</td>
<td>200-210</td>
<td>S</td>
<td>31-1, 110-110</td>
<td>S F M R C F F F</td>
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<td>S F M R C F F F</td>
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<td>750</td>
<td>33-34</td>
<td>210-220</td>
<td>T</td>
<td>33-1, 120-120</td>
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<td>800</td>
<td>35-36</td>
<td>220-230</td>
<td>U</td>
<td>35-1, 130-130</td>
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<td>U F M R C F F F</td>
<td>U F M R C F F F</td>
<td>U F M R C F F F</td>
<td>U F M R C F F F</td>
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<tr>
<td>850</td>
<td>37-38</td>
<td>230-240</td>
<td>V</td>
<td>37-1, 140-140</td>
<td>V R M R C R R R</td>
<td>V R M R C R R R</td>
<td>V R M R C R R R</td>
<td>V R M R C R R R</td>
<td>V R M R C R R R</td>
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<td>900</td>
<td>39-40</td>
<td>240-250</td>
<td>W</td>
<td>39-1, 150-150</td>
<td>W R M R C R R R</td>
<td>W R M R C R R R</td>
<td>W R M R C R R R</td>
<td>W R M R C R R R</td>
<td>W R M R C R R R</td>
<td>W R M R C R R R</td>
<td>W R M R C R R R</td>
</tr>
<tr>
<td>950</td>
<td>41-42</td>
<td>250-260</td>
<td>X</td>
<td>41-1, 160-160</td>
<td>X R M R C R R R</td>
<td>X R M R C R R R</td>
<td>X R M R C R R R</td>
<td>X R M R C R R R</td>
<td>X R M R C R R R</td>
<td>X R M R C R R R</td>
<td>X R M R C R R R</td>
</tr>
<tr>
<td>1000</td>
<td>43-44</td>
<td>260-270</td>
<td>Y</td>
<td>43-1, 170-170</td>
<td>Y B R P R R R</td>
<td>Y B R P R R R</td>
<td>Y B R P R R R</td>
<td>Y B R P R R R</td>
<td>Y B R P R R R</td>
<td>Y B R P R R R</td>
<td>Y B R P R R R</td>
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</table>

Note: See Table 2 for a key to the symbols.
Table 5. (Continued).

<table>
<thead>
<tr>
<th>NEogene Radiolarians from Eastern North Pacific</th>
</tr>
</thead>
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<tr>
<td>E. calvertense</td>
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<tr>
<td>E. inflatum</td>
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<tr>
<td>E. matuyamai</td>
</tr>
<tr>
<td>Hymenaias inulae</td>
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<tr>
<td>Lamprocyclus maritimus polypora</td>
</tr>
<tr>
<td>Lamprocyclus hannai</td>
</tr>
<tr>
<td>L. nigrinae</td>
</tr>
<tr>
<td>L. heteroporos</td>
</tr>
<tr>
<td>L. neoheteroporos</td>
</tr>
<tr>
<td>Lipmanella dicyoceras</td>
</tr>
<tr>
<td>Lithomitra lineata</td>
</tr>
<tr>
<td>Lithopera bacca</td>
</tr>
<tr>
<td>L. neota</td>
</tr>
<tr>
<td>L. renze</td>
</tr>
<tr>
<td>L. thorburgi</td>
</tr>
<tr>
<td>Lychnosoma grande</td>
</tr>
<tr>
<td>Ommatarius huxley</td>
</tr>
<tr>
<td>O. penulis</td>
</tr>
<tr>
<td>O. tetrathylium</td>
</tr>
<tr>
<td>Periprymatis circumtexta</td>
</tr>
<tr>
<td>Pierocanium korotsvi</td>
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<tr>
<td>Saturnalis circularis</td>
</tr>
<tr>
<td>Sethocorys sp.</td>
</tr>
<tr>
<td>Siphocorys sp. cf. S. corona</td>
</tr>
<tr>
<td>Spirocyclus sp. aff. S. scalaris</td>
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<tr>
<td>Spongaster terebralis</td>
</tr>
<tr>
<td>Spongocorys puella</td>
</tr>
<tr>
<td>Spongistichocorys sp. S. corona</td>
</tr>
<tr>
<td>Stichocorys delmontiens</td>
</tr>
<tr>
<td>S. sp. cf. S. diplononis</td>
</tr>
<tr>
<td>S. peregrina</td>
</tr>
<tr>
<td>S. wolfii</td>
</tr>
<tr>
<td>Stichopera pectinata</td>
</tr>
<tr>
<td>Styloconterium aquilonium</td>
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<tr>
<td>S. bispiculum</td>
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<tr>
<td>Theocyclus davisiun</td>
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<tr>
<td>Theocorys sp. aff. T. zancleus</td>
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<tr>
<td>Theocorys redondoensis</td>
</tr>
<tr>
<td>Theocorythium trachelium</td>
</tr>
<tr>
<td>T. vetulum</td>
</tr>
<tr>
<td>Xiphospira sp. cf. X. circularis</td>
</tr>
</tbody>
</table>
The equatorial zonation is therefore applicable. Deposition in the late late Miocene (lower part of the S. peregrina Zone) is suggested for Section 10-3 through 5. Besides S. peregrina, with rare to abundant occurrences, Ommatarius penulimus is another rare to common species that survived the Miocene/Pliocene boundary.

The upper Miocene cores of Hole 471 contain a radiolarian assemblage that is rather rich in species and almost exclusively composed of warm-water species. The equatorial zonation is therefore applicable. Deposition in the late late Miocene (lower part of the S. peregrina Zone) is suggested for Section 10-3 through 5. Besides S. peregrina, with rare to abundant occurrences, Ommatarius penulimus is another rare to common species that survived the Miocene/Pliocene boundary.

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species left to define the upper limit of a possible O. penultimus Zone. The lower boundary can be defined rather exactly, however, by the extinction of O. hughesi and by the first appearance of O. penultimus. The boundary can therefore be placed below Section 17-1, provided that the two events are not simulated by dissolution or reworking. Besides several nondiagnostic species, Sample 17,CC contains S. delmontensis, S. wolffii, and O. antepenultimus, and Section 23-1 yielded rare to few specimens of O. antepenultimus, O. hughesi, and Cannartus petterssoni (O. antepenultimus Zone). Samples 23,CC and 28,CC contain very rare and poorly preserved lower upper Miocene radiolarian assemblages. All of the remaining cores of Site 471 lack radiolarians or bear only indeterminable fragments, frequently with heavy crystalline overgrowths.

Site 472

Hole 472 was drilled to the west of Site 471 to obtain a pelagic upper Neogene record at this latitude away
from terrigenous influences such as those affecting Site 471. Hole 472 was continuously cored to the basaltic base at 112 meters.

The uppermost Sample 472-1-1, 1-2 cm contains a typical equatorial radiolarian assemblage deposited in the early Quaternary (7 through late Pliocene), which is composed of Amphirhopalum ypsilon, Ommatartus tetraphalum, Pterocanium praetextum, P. prismatium, Theocorythium trachelium, T. vetulum, etc. The usually more frequent equatorial species Spongaster tetras is lacking.

Rare to common, poorly preserved nondiagnostic radiolarians were recovered from Section 1-1 through Sample 1,CC. Cores 2 through 3 are barren, Cores 5 through 12 contain rare to abundant, poorly to well-preserved radiolarian assemblages deposited in the early late through middle middle Miocene. Sample 13,CC consists only of downhole contaminants. Radiolarians from the Neogene and Quaternary sediments of Hole 472 are listed in Table 9.

The Miocene radiolarian assemblages are also composed of warm-water species. Section 4-1 yielded few, nondiagnostic radiolarians; Section 5-1 through Section 6-1 contain Ommatartus penultimus, O. antepenultimus, O. hughesi, Stichocorys peregrina, S. delmontensis, and S. wolffii and can be assigned, therefore, to the O. penultimus Zone. Riedel and Sanfilippo (1978) placed the boundary between O. penultimus and O. antepenultimus Zones immediately above the last occurrence of O. hughesi. Therefore the O. penultimus Zone would only comprise Section 5-1 at Site 472. Alternatively, this boundary can be drawn below the first appearance of O. penultimus. Deposition in the early late Miocene (O. antepenultimus Zone) is indicated by the rare to common presence of O. antepenultimus, O. hughesi, rare to abundant occurrences of S. delmontensis and S. wolffii (Section 6-3 through Section 9-1), and by the absence of O. penultimus and S. peregrina. The boundary between middle and upper Miocene (i.e., the boundary between C. petterssoni and O. antepenultimus Zone) may just as well be placed immediately below the first appearances of O. hughesi and O. antepenultimus (below Section 9-1) as above the last presence of C. petterssoni (Section 8-1).

Deposition in the late middle Miocene (C. petterssoni Zone) is suggested for Section 9-3 (or Section 8-3) through Section 10-1 by the presence of C. petterssoni and C. laticonus, as well as by less diagnostic species such as S. delmontensis, S. wolffii, and Cyrtocapsella japonica.

The deepest part of the succession at Site 472, below Section 10-1, possibly belongs to the Dorcadospyrus alata Zone, because it contains C. laticonus and various species of Cyrtocapsella and lacks S. petterssoni.

Site 473

Hole 473 on the Rivera Plate south of Tres Marias Islands was cored continuously to obtain an upper Neogene reference section at the mouth of the Gulf of California east of the crest of the East Pacific Rise. The hole penetrated 287.1 meters to the basaltic rocks.

Rare to common, poorly to moderately preserved upper Quaternary radiolarians were recovered from Cores 1 through 4. Cores 5 through 16 were barren or contain only very rare, mainly nondiagnostic radiolarians. Cores 17 through 21, Section 1 yielded rare to abun-
dant, poorly to well-preserved lower Pliocene radiolarian assemblages. The rare and poorly preserved radiolarians from Section 21-3 through Section 23-3 indicate that deposition took place in the late Miocene. Cores 24 through 28 are entirely barren. Table 10 lists radiolarians from the Neogene and Quaternary sediments of Hole 473.

Samples 1,CC through 4,CC contain a mixed radiolarian assemblage composed of the typical equatorial species Amphirhopalum ypsilon, Anthocyrtidium angulare, Ommatartus tetrathalamus, Pterocanium prae-textum, Spongaster pentas, Theocorythium trachelium, and T. vetulum and of the Northeast Pacific cold-water species Lamprocyrtis nigriniae, L. neoheteroporos, and L. heteroporos. According to Dinkelman (1973), the presence of A. angulare and T. vetulum suggests deposition in the early Quaternary, because both species are assumed to be restricted to the basal Quaternary A. angulare Zone and because Collosphaera tuberosa and Buccinosphaera invaginata, which make their earliest appearance in late Quaternary sediments, are absent. Nannofossils, diatoms, and L. nigriniae indicate, however, that Cores 1 through 4 were deposited in the late Quaternary. Consequently, A. angulare and T. vetulum could not have become extinct during the early Quaternary but continued until the late Quaternary (0.45-0.7 Ma), unless they were reworked. This means that the radiolarian zonation of the equatorial Quaternary cannot be used in the region of Site 473.

Section 16-5 through Section 21-1 can be assigned to the lower Pliocene (upper part of the Stichocorys peregrina Zone), because this succession yielded rare to abundant individuals of S. peregrina, some rare specimens of Spongaster pentasia(?), Ommatartus tetratalam-
Table 8. Radiolarians from the Neogene and Quaternary sediments of Hole 471.

<table>
<thead>
<tr>
<th>Sub-bottom Depth (m)</th>
<th>Age</th>
<th>Zone</th>
<th>Sample (interval in cm)</th>
<th>Abundance</th>
<th>Preservation</th>
<th>Acantodeiodontidae</th>
<th>Amphipolpate ypsilon</th>
<th>Asplograpthus woodriffi</th>
<th>Bottropohus australis</th>
<th>Botryocystis sp.</th>
<th>Ceramocystis (sp.)</th>
<th>Ctenocystididae</th>
<th>Cyrtocystis profunda</th>
<th>C. japonica</th>
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</thead>
<tbody>
<tr>
<td>50</td>
<td>?</td>
<td>?</td>
<td>1.8</td>
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<td>P</td>
<td>R</td>
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<td>R*</td>
<td>R*</td>
</tr>
<tr>
<td>100</td>
<td>Pliocene</td>
<td>Stichocorys peregrina (upper part)</td>
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<td>5</td>
<td>10-1, 30-32</td>
<td>F</td>
<td>M</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>F</td>
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<td>F</td>
<td>R</td>
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<td></td>
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<td></td>
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<td>10-3, 30-32</td>
<td>R</td>
<td>P</td>
<td>R</td>
<td>F</td>
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<td>F</td>
<td>R</td>
<td>R</td>
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<td></td>
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<td></td>
<td></td>
<td>10-5, 30-32</td>
<td>F</td>
<td>P</td>
<td>F</td>
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<td>F</td>
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<td></td>
<td>10-7, 30-32</td>
<td>F</td>
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<td>R</td>
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<td>F</td>
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<td>11-1, 30-32</td>
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<td>12-1, 40-42</td>
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Note: See Table 2 for a key to the symbols.
<table>
<thead>
<tr>
<th>Neoegen Radialarians from Eastern North Pacific</th>
</tr>
</thead>
</table>

**Table 8. (Continued)**

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dictyophimus crisiae</td>
<td>Euchitonia sp.</td>
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<tr>
<td></td>
<td>Eucyrtidium acuminatum</td>
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<tr>
<td></td>
<td>E. calvertense</td>
</tr>
<tr>
<td></td>
<td>Hymeniacrastum euclidi</td>
</tr>
<tr>
<td></td>
<td>Lamprocythis hannah</td>
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<tr>
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<td>L. helioporus</td>
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<tr>
<td></td>
<td>Lipmanella dictyoceras</td>
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<td>Lithopera bacca</td>
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<td>L. neotera</td>
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<td>Lychnocanoma grande</td>
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<td>Ommatartus antepenultimus</td>
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<td>O. hughesi</td>
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<td></td>
<td>O. penultimus</td>
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<tr>
<td></td>
<td>O. tetrathalamus</td>
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<td></td>
<td>Peripiramis circuntexta</td>
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<tr>
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<td>Pterocanum korotnevi</td>
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<tr>
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<td>P. triabum</td>
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<tr>
<td></td>
<td>Saturnalis circularis</td>
</tr>
<tr>
<td></td>
<td>Seihocorys sp.</td>
</tr>
<tr>
<td></td>
<td>Siphostichourius sp. cf. S. corona</td>
</tr>
<tr>
<td></td>
<td>Spiroma sp.</td>
</tr>
<tr>
<td></td>
<td>Sponagaster tetras irregularis</td>
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<tr>
<td></td>
<td>Sponogycor puella</td>
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<td>Sponotrochus glacialis</td>
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<td>Stichocorys armata</td>
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<td></td>
<td>S. deimontensis</td>
</tr>
<tr>
<td></td>
<td>S. peregrina</td>
</tr>
<tr>
<td></td>
<td>S. wolffi</td>
</tr>
<tr>
<td></td>
<td>Stichocorys pectinata</td>
</tr>
<tr>
<td></td>
<td>Stylocontarium acquilonium</td>
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<tr>
<td></td>
<td>Theocalyptra deviania</td>
</tr>
<tr>
<td></td>
<td>Theoconas sp. aff. T. zancleus</td>
</tr>
<tr>
<td></td>
<td>Theocorys redondoensis</td>
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<tr>
<td></td>
<td>Theocorythium vetulum</td>
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<tr>
<td></td>
<td>Xiphosira sp. cf. X. circularis</td>
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</table>

**Note:** The table continues with similar entries for various species of radiolarians found in the Eastern North Pacific region.
Table 9. Radiolarians from the Neogene and Quaternary sediments of Hole 472.

<table>
<thead>
<tr>
<th>Sub-bottom Depth (m)</th>
<th>Age</th>
<th>Zone</th>
<th>Sample (interval in cm)</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
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<td>early Quaternary</td>
<td></td>
<td>1.8</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>Pliocene</td>
<td>?</td>
<td>5</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>late Miocene</td>
<td>Ommatarius antepenultimus</td>
<td>5.7</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>middle Miocene</td>
<td>Cannartus petterssoni</td>
<td>11.5</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dorcaspyris alata</td>
<td>10</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>downhole material</td>
<td>112</td>
<td>R</td>
</tr>
</tbody>
</table>

**Eucyrtidium matuyamai Zone** Hays, 1970

This zone is defined by the range of *E. matuyamai*. It includes the last occurrences of *Lamprocystis heteroporos* and the first appearance of *Lamprocystis neoheteroporos*.

**Lamprocystis heteroporos Zone** Hays, 1970

The base is defined by the occurrence of *L. heteroporos* subsequent to the extinction of *Stichocorys peregrina* and *Ommatartus penultimus* and the top by the first appearance of *Eucyrtidium matuyamai*.

**Stichocorys peregrina Zone** Riedel and Sanfilippo, 1970

The top of the zone is approximately indicated by the last occurrence of *S. peregrina* and by the first occurrences of *Amphirhopalum ypsilon* and *A. wirchoewi*. The zone includes the boundary between Miocene and Pliocene, which is tentatively identified as the earliest appearance of *Lamprocystis heteroporos* (Kling, 1973). Consequently, the *S. peregrina* Zone can be divided into an upper part with, and a lower part without, *L. heteroporos*. There are also several species (such as *Anthocystidium angulare*, *Ommatartus tetrathalamus*, *Pterocarinum praetextum*, *Spongaster tetras*, and *Theocorythium vetulum*) that have their first occurrences as well as several species (such as *Theocorys redondensis*, *Stichocorys delmoniensis*, and *Ommatartus antepenultimus*) that have their last occurrences in the lower part of the *S. peregrina* Zone in the Leg 63 area.

The base of the *Stichocorys peregrina* Zone is difficult to recognize. It is approximately indicated by decreasing abundances of *T. redondensis*, *S. delmoniensis*, and *O. antepenultimus*. There is apparently a considerable overlap in morphotypic ranges of *Stichocorys delmoniensis* and *S. peregrina* (Kling 1973), the latter of which first appears in the *O. antepenultimus* Zone.

**Ommatartus penultimus Zone** Riedel and Sanfilippo, 1970

The base of the zone is defined by the first appearance of *O. penultimus*, the top, by the base of the *S.*
Table 9. (Continued).

| peregrina | Zone. The zone includes the final extinction of Lithopera neota, Ommatartus Hughesi, and Stichocorys wolffii within the Leg 63 region. |
| Ommatartus antepenultimus Zone |
| Riedel and Sanfilippo, 1970 |
| The base is defined by the first appearance of O. antepenultimus Zone. Numerous species have their last appearance within this zone: Cannartus latonius, C. mammiferus, C. petterssoni, Crytocapsella cornuta, C. japonica, C. tetrapera, Eucyrtidium inflatum, and Lithopera renzae. |
| Cannartus petterssoni Zone |
| Riedel and Sanfilippo, 1970 |
| The base of the zone is defined by the first appearance of C. petterssoni, the top by the base of the O. antepenultimus Zone. It is also approximately indicated by the earliest occurrence of Eucyrtidium acuminatum. The zone includes the first occurrence of Ommatartus Hughesi. |

| Dorcaspyris alata Zone |
| Riedel and Sanfilippo, 1970, 1971 |
| The bottom of the zone was not encountered in the Leg 63 area; the top is defined by the base of the C. petterssoni Zone. In the Leg 63 area, several species make their first appearance within the D. alata Zone, such as Cannartus latonius, C. mammiferus, Eucyrtidium inflatum, Lithopera bacca, L. thornburgii, and Theocorys redondoensis. Some lower Miocene species (Calcycocella costata, C. virginis, and Cannartus violina) are still present in the lower part of the D. alata Zone, if they are not reworked. |
Table 10. Radiolarians from the Neogene and Quaternary sediments of Hole 473.

<table>
<thead>
<tr>
<th>Sub-bottom Depth (m)</th>
<th>Age</th>
<th>Zone</th>
<th>Ma</th>
<th>Sample (interval in cm)</th>
<th>Abundance</th>
<th>Preservation</th>
<th>Acanthocyrtidium</th>
<th>Amphicyrtidium ypsilon</th>
<th>Amphicyrtidium angulare</th>
<th>Acanthocyrtidium angulare</th>
<th>Balanocyrtus robustus</th>
<th>B. miralestensis</th>
<th>B. miralestensis</th>
<th>Balanocyrtus robustus</th>
<th>Balanocyrtus robustus</th>
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</thead>
<tbody>
<tr>
<td>50</td>
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<td>B. miralestensis/Axoprunum angelinum</td>
<td>0.9</td>
<td>1, CC</td>
<td>C</td>
<td>M</td>
<td>R</td>
<td>F</td>
<td>R</td>
<td>F</td>
<td>R</td>
<td>R</td>
<td>R</td>
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</tr>
<tr>
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<td>early Quaternary</td>
<td>Eucyrtidium matuyamai</td>
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<td>R</td>
<td>R</td>
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<td>100</td>
<td>Pliocene</td>
<td>Lamprocyrtis heteroporos</td>
<td>1.8</td>
<td>10-1, 90-92</td>
<td>B</td>
<td>R</td>
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<td>150</td>
<td>Pliocene</td>
<td>Stichocorys peregrina</td>
<td>3</td>
<td>16-5, 80-82</td>
<td>R</td>
<td>P</td>
<td>F</td>
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<td>200</td>
<td>late Miocene</td>
<td>Stichocorys peregrina</td>
<td>5</td>
<td>23-1, 75-77</td>
<td>R</td>
<td>P</td>
<td>C</td>
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Note: See Table 2 for a key to the symbols.
Table 10. (Continued).

| Clathrocysta calathoides | Cornucopia parvula | Dictyophorus cristae | Eucyrtidium acuminatum | E. calvertense | Lancrocysta hattai | L. nitidula | L. neortegorensis | Lobatella dacrycera | Lychnocysta penicillata | Omphalosma terebellum | O. peripatium punctatum | P. trilobum | Sactumellus circularis | Scolochoceras sp. | Sibolosphaernea sp. | S. corona | Spongiocysta pessula | Spongiscyrtids glacialis | Stichocystis peregrina | Stylomphalus sp. aff. T. simonius | Thecosphaera spinulosa | Thecosphaera vernalis | Xyphoypsella sp. cf. X. circularis |
|--------------------------|------------------|---------------------|----------------------|-------------|----------------|-------------|----------------|----------------|------------------|------------------|------------------|----------|---------------|-------------|----------------|-------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
Figure 3. Generalized range chart for Neogene and Quaternary radiolarians from Sites 467 to 473.

**TAXONOMY**


*Amphithopalum wirchowii* (Haeckel) (Plate 3, Figs. 1-3)

*Euchitonia wirchowii* Haeckel, 1862, p. 503, pi. 30, figs. 1-4.

*Amphithopalum wirchowii* (Haeckel), Dumitrică, 1973, p. 835, pi. 9, figs. 2 and 4; pi. 11, fig. 6; pi. 21, figs. 2-13.

*Amphithopalum ypsilon* Haeckel

*Amphithopalum ypsilon* Haeckel, 1867, p. 522; Nigrini, 1967, p. 35, pl. 3, figs. 3a-d; 1970, pl. 2, fig. 2; Dinkelman, 1973, p. 768, pl. 10, fig. 10.

*Anthocyrtidium* sp. cf. *A. angulare* Nigrini

*Anthocyrtidium angulare* Nigrini, 1971, p. 445, pl. 34.1, figs. 3a, b; Dinkelman, 1973, p. 788, pl. 10, fig. 5.

*Axoprunum angelinum* (Campbell and Clark)

*Stylosphaera angelina* Campbell and Clark, 1944, p. 12, pl. 1, figs. 14-20.

*Axoprunum angelinum* (Campbell and Clark), Kling, 1973, p. 634, pl. 1, figs. 13-16, pl. 6, figs. 14-18.

496
Calocyctecta costata (Riedel)  
(Plate 4, Fig. 6)

Calocycles costata Riedel, 1959, p. 296, pl. 2, fig. 9.
Calocyctecta costata (Riedel), Riedel and Sanfilippo, 1971, p. 1598, pl. 2H, figs. 12-14.

Calocyctecta virginis (Haeckel)
Calocycles (Calocyctecta) virginis Haeckel, 1887, pl. 74, fig. 4.
Calocyctecta virginis (Haeckel), Riedel and Sanfilippo, 1971, pl. 2H, figs. 5-11.

Cannartus laticonus Riedel  
(Plate 5, Figs. 6-7)
Cannartus laticonus Riedel, 1959, p. 291, pl. 1, fig. 5.
Cannartus laticonus Riedel, Riedel and Sanfilippo, 1971, p. 1587, pl. 1C, figs. 13, 14.
Cannartus laticonus Riedel, Moore, 1971, p. 736, pl. 12, fig. 6.
Cannartus laticonus Riedel, Kling, 1973, p. 634, pl. 7, fig. 7.
Cannartus sp. cf. C. mammiferus (Haeckel)  
(Plate 5, Figs. 11-12)
Cannartidium mammiferum Haeckel, 1887, p. 375, pl. 39, fig. 16.
Cannartus mammiferum (Haeckel), Riedel, 1959, p. 291, pl. 1, fig. 4.
Cannartus mammiferum (Haeckel), Moore, 1971, p. 736, pl. 12, fig. 5.
Cannartus mammiferus (Haeckel), Riedel and Sanfilippo, 1971, p. 1587, pl. 2C, figs. 1-3.

Cannartus petterssoni Riedel and Sanfilippo  
(Plate 5, Figures 11-12)
Cannartus? petterssoni Riedel and Sanfilippo, 1970, p. 520, pl. 14, fig. 3.
Cannartus? petterssoni Riedel and Sanfilippo, Moore, 1971, p. 737, pl. 12, fig. 7.

Cannartus violina Haeckel
Cannartus violina Haeckel, 1887, p. 538, pl. 39, fig. 10.
Cannartus violina Haeckel, Riedel, 1959, p. 290, pl. 1, fig. 3.
Cannartus violina Haeckel, Moore, 1971, p. 736, pl. 12, fig. 4.
Cannartus violina Haeckel, Riedel and Sanfilippo, 1971, p. 1588, pl. 2C, figs. 4-7.

Cannartus? sp.  
(Plate 4, Fig. 9)
Ommatartus sp. B, Foreman, 1975, p. 618, pl. 8, figs. 24-25.


Members of this family are illustrated but not further identified.

Clathrocyctecta cabrilloensis Campbell and Clark
Clathrocyctecta cabrilloensis Campbell and Clark, 1944, p. 48, pl. 7, figs. 1-3.
Clathrocyctecta cabrilloensis Campbell and Clark, Kling, 1973, p. 635, pl. 9, figs. 23-25.

Clathrocyctects sp.

Cornutella profunda Ehrenberg
Cornutella clathrata profunda Ehrenberg, 1854, pl. 35B, fig. 21.
Cornutella profunda Ehrenberg, Nigrini, 1967, p. 60, pl. 6, figs. 5a-c.
Lamprocyrtis neoheteroporos
Kling, 1973, p. 639, pi. 5, figs. 17, 18;
Lamprocyrtis heteroporos
Lamprocyclas heteroporos
Hays, 1965, p. 179, pi. 3, fig. 1.
Lamprocyrtis nigriniae
Kling, 1973, pi. 5, fig. 7.

Lamprocyclas maritalis maritalis
Haeckel
Hymeniastrum euclidis
Eucyrtidium matuyamai
Eucyrtidium matuyamai
Nigrini, Kling, 1973, pl. 636, pl. 4, fig. 17.

Hymeniastrum euclidis
Haeckel, 1887, p. 531, fig. 13.
Hymeniastrum euclidis
4188, pls. 191/192, fig. 3.
Hymeniastrum euclidis
Nigrini, 1970, p. 168, pl. 2, fig. 4.

Lamprocyclas maritalis maritalis
Haeckel
Lamprocyclas maritalis polypora
Nigrini, 1970, p. 171, pl. 4, fig. 8.

Lamprocyclas maritalis polypora
Nigrini, 1967, p. 76, pl. 7, fig. 6.
Lamprocyclas maritalis polypora
Nigrini, 1970, p. 171, pl. 4, fig. 9.
Lamprocyclas maritalis polypora
Kling, 1973, pl. 5, fig. 7.

Lamprocyclas maritalis (Campbell and Clark)
(Plate 1, Fig. 4)

Lamprocyclas maritalis maritalis
Haeckel, 1887.

Lamprocyclas maritalis maritalis
Haeckel, Nigrini, 1970, p. 171, pl. 4,
fig. 8.

Lamprocyclas maritalis polypora
Lamprocyclas maritalis polypora
Nigrini, 1967, p. 76, pl. 7, fig. 6.

Lamprocyclas maritalis polypora
Nigrini, 1970, p. 171, pl. 4, fig. 9.

Lamprocyclas maritalis polypora
Kling, 1973, pl. 5, fig. 7.

Lamprocyclas maritalis (Campbell and Clark)
(Plate 2, Figs. 1-2)

Conarachnium nigriniae
Caulet, 1971, p. 3, pl. 3, figs. 1-4; pl. 4, figs.
1-3.

Lamprocyclas maritalis
Kling, 1973, p. 639, pl. 5, figs. 15, 16;
pl. 15, figs. 1-3.

Lamprocyclas maritalis nigriniae
(Caullet), Kling, 1979, p. 309, pl. 2, fig. 26.

Lamprocyclas maritalis heteroporos
(Hays)
(Plate 2, Figs. 4, 6, 7)

Lamprocyclas maritalis heteroporos
Hays, 1965, p. 179, pl. 3, fig. 1.

Lamprocyclas maritalis heteroporos
(Hays), Kling, 1973, p. 639, pl. 5, figs. 19-
21; pl. 15, fig. 6.

Lamprocyclas maritalis neoheteroporos
Kling
(Plate 2, Figs. 3 and 5)

Lamprocyclas maritalis neoheteroporos
Kling, 1973, p. 639, pl. 5, figs. 17, 18;
pl. 15, figs. 4, 5.

Lipmanella dictyoceras
Haeckel
Lithornithium dictyoceras
Haeckel, 1860, p. 840.
Lipmanella virchovii
(Haeckel), Petrushevskaya, 1971, p. 220, fig.
198.

Lipmanella dictyoceras
(Haeckel), Kling, 1973, p. 636, pl. 4, figs.
24-26.
Ommatarius tetrathalamus (Haeckel), Riedel and Sanfilippo, 1971, p. 1588, pl. 1C, figs. 5-7.

Ommatarius sp. cf. Cannartus bassanii (Carnevale) (Plate 4, Fig. 4)

Ommatarius sp. cf. Cannartus bassanii (Carnevale), cf. Foreman, 1975, p. 619, pl. 8, figs. 11-12.

Peripyramids circumtexta Haeckel (Plate 3, Fig. 11)

Peripyramids circumtexta Haeckel, 1887, p. 1162, pl. 54, fig. 5.

Peripyramids circumtexta Haeckel, Kling, 1973, p. 637, pl. 2, figs. 15, 16; pl. 9, figs. 1-3.

Phormostichoartus doliolum (Riedel and Sanfilippo)

Artostrobium doliolum Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, figs. 1-3; pl. 8, figs. 14, 15.

Phormostichoartus doliolum (Riedel and Sanfilippo), Nigrini, 1977, p. 252, pl. 1, fig. 14.

Pterocanium korotnevi (Dogiel and Reshetnyak) (Plate 4, Fig. 3)

Pterococcus korotnevi Dogiel and Reshetnyak, 1952, p. 17, fig. 11.

Pterocanium korotnevi (Dogiel and Reshetnyak), Nigrini, 1970, p. 170, pl. 3, figs. 10, 11.

Pterocanium korotnevi (Dogiel and Reshetnyak), Kling, 1973, p. 638, pl. 4, figs. 1-4.

Pterocanium praetextum (Ehrenberg)

Lycocanium praetextum (Ehrenberg), 1872a, p. 316.

Pterocanium praetextum (Ehrenberg), Haeckel, 1887, p. 1330.

Pterocanium praetextum (Ehrenberg), Nigrini, 1970, p. 3, fig. 7.

Pterocanium praetextum (Ehrenberg), Moore, 1971, pl. 13, fig. 3.

Pterocanium prismatum Riedel

Pterocanium prismatum Riedel, 1957, p. 87, pl. 3, figs. 4-5.

Pterocanium prismatum Riedel, Riedel and Sanfilippo, 1971, p. 1595, pl. 8, fig. 1.

Pterocanium prismatum Riedel, Moore, 1971, pl. 13, figs. 1, 2.

Pterocanium trilobum (Haeckel)

Dictyopodium trilobum Haeckel, 1860, p. 839; 1862, p. 340, pl. 8, figs. 6-10.

Pterocanium trilobum (Haeckel), Nigrini, 1970, p. 170, pl. 3, fig. 9.

Pterocanium trilobum (Haeckel), Kling, 1973, pl. 4, figs. 5-8.

Saturnalis circularis Haeckel

Saturnalis circularis Haeckel, 1887, p. 131.

Saturnalis circularis Haeckel, Nigrini, 1967, p. 25, pl. 1, fig. 9.

Saturnalis circularis Haeckel, Kling, 1973, p. 635, pl. 1, figs. 21-25; pl. 7.

Stichocorys sp. (Plate 1, Fig. 3)

Stichocorys Haeckel, 1881, p. 430.


Stichocorys sp. cf. S. corona (Haeckel) (Plate 1, Fig. 15)

Cynthiaon corona Haeckel, 1887, p. 1462, pl. 77, fig. 15.

Phormostichoartus corona (Haeckel), Riedel and Sanfilippo, 1971, p. 1600, pl. 13, figs. 13-15; pl. 22, figs. 1-5.

Siphostichoartus corona (Haeckel), Nigrini, 1977, p. 257, pl. 2, figs. 5, 6.

Sphaeropyle langii Dreyer

Sphaeropyle langii Dreyer, 1889, p. 13, pl. 4, fig. 54.

Sphaeropyle langii Dreyer, Kling, 1973, p. 634, pl. 1, figs. 5-10; pl. 13, figs. 6-8.

Spongaster pentas Riedel and Sanfilippo

Spongaster pentas Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 3.

Spongaster pentas Riedel and Sanfilippo, 1971, p. 1589, pl. 1D, figs. 5-7.

Spongaster tetras Ehrenberg

Spongaster tetras Ehrenberg, 1860, p. 833; 1872(b), pl. 6, fig. 8.

Spongaster tetras Ehrenberg, Riedel and Sanfilippo, 1971, p. 1589, pl. 1D, figs. 2-4.

Spongaster tetras irregularis Nigrini (Plate 4, Fig. 1)

Spongaster tetras irregularis Nigrini, 1967, p. 43, pl. 5, fig. 2.

Spongaster tetras irregularis Nigrini, Foreman, 1975, p. 619, pl. 9, fig. 27.

Spongocore puella Haeckel

Spongocore puella Haeckel, 1887, p. 347, pl. 48, fig. 6.

Spongocore lata Campbell and Clark, 1944, p. 22, pl. 3, figs. 7-9.

Spongocore puella Haeckel, 1973, p. 635, pl. 7, figs. 18-22.

Spongostrochus? glacialis Popofsky

Spongostrochus glacialis Popofsky, 1908, p. 228, pl. 26, fig. 8; pl. 27, fig. 1; pl. 28, fig. 2.

Spongostrochus? glacialis Popofsky, Riedel, 1958, p. 227, pl. 2, figs. 1, 2.


Stichocorys armata (Haeckel) (Plate 1, Fig. 9)

Cynthia armata Haeckel, 1887, p. 1460, pl. 78, fig. 17.

Stichocorys armata (Haeckel), Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, figs. 13-15.

Stichocorys armata (Haeckel), Kling, 1973, p. 638, pl. 13, fig. 11.

Stichocorys delmontensis (Campbell and Clark) (Plate 1, Figs. 10-11)

Eucyrtidium delmontensi Campbell and Clark, 1944, p. 56, pl. 7, figs. 19, 20.

Stichocorys delmontensis (Campbell and Clark), Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, figs. 5-7; pl. 2E, figs. 10, 11.

Stichocorys delmontensis (Campbell and Clark), Dinkelman, 1973, p. 783, fig. 9, fig. 1.

Stichocorys delmontensis (Campbell and Clark), Kling, 1973, p. 638, pl. 11, figs. 8-10.

Stichocorys diploconus (Haeckel)

Cynthia diploconus Haeckel, 1887, p. 1513, pl. 78, fig. 6.

Stichocorys diploconus (Haeckel), Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, fig. 16.

Stichocorys diploconus (Haeckel), Kling, 1973, p. 638, pl. 11, fig. 11; pl. 13, fig. 12.

Stichocorys peregrina (Riedel) (Plate 1, Figs. 6-8)

Eucyrtidium elongatum peregrinum Riedel, 1953, p. 812, pl. 85, fig. 2.

Stichocorys peregrina (Riedel), Riedel and Sanfilippo, 1971, p. 1595, pl. 1F, figs. 2-4; pl. 8, fig. 5.

Stichocorys peregrina (Riedel), Riedel and Sanfilippo, 1971, p. 1595, pl. 1F, figs. 2-4; pl. 8, fig. 5.
ACKNOWLEDGMENTS
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REFERENCES


Plate 1. (The figures on Plates 1 through 5 cover the 11 different horizons of the Pleistocene through middle Miocene. Magnifications are ×240. The samples used for the illustrations are noted for each figure. All slides have BGR numbers; they are deposited in the Bundesanstalt für Geowissenschaften und Rohstoffe, BGR (Federal Institute for Geosciences and Natural Resources), Postfach 510153, D-3000 Hannover, 51, Federal Republic of Germany.)