ABSTRACT

Site 173 was drilled to explore Delgada Fan and to penetrate and sample the basement; however, the drill encountered lower continental slope deposits consisting of Pleistocene to upper Miocene grayish green mud with very fine sand horizons (0-138 m), upper to lowermost Miocene pale olive to grayish olive green diatomites (138-285 m), gray nanno ooze (285-320 m), and andesite basement (320-333.5 m).

The basement is broken by steep faults whereas little deformation is seen in the sediments. Basement deformation may correlate with a late Oligocene or early Miocene episode of major tectonism along the California coast. The occurrence of andesite below a sequence of continental slope deposits is unexplained.

SITE SUMMARY

Date Occupied: 10-12 June 1971.
Position (Satellite):
Latitude: 39°57.71'N; Longitude: 125°27.12'W.
Number of Holes: One
Water Depth: 2927 meters.
Penetration: 333.5 meters below sea floor.
Number of Cores: 38
Total Core Recovered: 196 meters, 58.7% recovery.
Age of Oldest Sediment: Lowermost Miocene.
Acoustic Basement:
Depth: 320 meters.
Nature: Andesite.
Inferred Velocity: 1.57 km/sec.
Basement: Andesite.

BACKGROUND AND OBJECTIVES

Site Description

Site 173 is on a large conical feature of the continental slope southwest of Cape Mendocino. It was thought that the whole feature was part of Delgada Fan but this was discounted after drilling.

Seismic records (Figure 1) obtained by Silver, Curray, and Cooper (1971) show a thick series of stratified rocks near shore that thin over the lower continental slope and then increase in thickness at the foot of the slope to form Delgada Fan. The distal part of the fan was drilled on Leg 5 and DSDP Holes 32 and 34 encountered fine sediments ranging from upper Oligocene and lower Miocene nannofossil ooze to Pleistocene clastic deposits including sand.

It was thought that since the previous holes were drilled near the edge of Delgada Fan, they did not penetrate an expected typical sequence of turbidites and fan deposits. Possibly these materials could be found closer to the source of sediment on the upper fan. Coarse and fine clastic fan deposits were presumed to make up the sediments at Site 173 on the basis of the discontinuous and somewhat irregular reflectors in seismic records. Individual reflectors are short, they occasionally pinch and become discontinuous, and they have variable reflectivities (Silver, Curray and

---

1 R. von Huene, U.S. Geological Survey, Menlo Park, California; L. D. Kulm, Oregon State University, Corvallis, Oregon; J. R. Duncan, ESSO Production and Research Company, Houston, Texas; J. C. Ingle, Stanford University, Palo Alto, California; S. A. Kling, City Service Oil Company, Tulsa, Oklahoma; L. M. Musich, Scripps Institution of Oceanography, La Jolla, California; D. J. W. Piper, Dalhousie University, Halifax, Nova Scotia; R. M. Pratt, NOAA, Rockville, Maryland; Hans-Joachim Schrader, Geologisch Institut und Museum der Universität Kiel, Kiel, Germany; O. Weser, Scripps Institution of Oceanography, La Jolla, California; and S. W. Wise, Jr., Geologisches Institut-Zurich, Zurich, Switzerland.
Cooper, 1971). Sediments were expected to have accumulated continuously since at least middle Miocene time. They were thought to be equivalent in age to the onshore late Tertiary Humbolt Basin section.

Below the stratified unit is an irregular acoustic basement with major relief. A short distance south, Silver and Curray dredged an outcrop in Noyo Sea Valley from which rocks resembling the Franciscan assemblage were recovered. The authors proposed that basement at Site 173 is probably a Franciscan type of rock.

Site Objectives

The objectives at this site were threefold. First, it seemed possible to study displacement along the San Andreas Fault by determining the changing provenance of Delgada Fan deposits since Miocene time which would indicate if the fan first formed off San Francisco and if it was moved north past successive sources for 500 km to its present position. It was also hoped that presumed Franciscan basement might indicate whether an early Tertiary compressional and metamorphic history was followed by quiescence. Secondly, sediments of the fan might help in understanding the mechanisms of fan deposition such as the conditions that produce sandy or silty phases and various distinctive sedimentary structures.

The third objective was to establish a continuous integrated biostratigraphy for the northeast Pacific upper Tertiary with emphasis on diatoms and radiolarians. Such a stratigraphic section is not available for cooler waters such as those found in the California current.

LITHOLOGIC SUMMARY

General Statement

The upper 138 meters of the section is dominated by terrigenous muds. Very thin fine sands are found at a few horizons. From 138 to 285 meters, the section is dominated by diatomite, in places with a high nannofossil content. At 285 meters, a thin sandy mudstone or chert is underlain by up to 35 meters of nannofossil ooze. Andesite (a thick flow or basement) is found at 320 meters. Light ashes (RI = 1.55) are found throughout the section.

Lithologic Units

Unit 1 (0-66.5 m; Cores 1-8)

Unit 1 is grayish green fine mud, with 1 to 5 percent biogenous components, mainly diatoms and sponge spicules, except from 5 to 40 meters where foraminifers constitute up to 2 to 4 percent of the core. Two thin
bioturbated ash layers occur at around 4 meters, and a 5-cm bed of sand occurs at 58 meters.

**Unit 2 (66.5-100.5 m; Cores 8-11)**

Unit 2 consists of grayish olive green muds, as before, but with never more than 1 percent foraminifers. About thirteen interbedded thin arkosic fine and very fine sand laminae are concentrated in the upper and lower parts of the unit.

**Unit 3 (100.5-138 m; Cores 12-15)**

Grayish green muds occur which usually have more than 1 percent biogenous components, mainly diatoms. Diatoms make up as much as 15 percent of some samples. Very occasional thin arkosic very fine sands and rare glass shards occur in the muds.

**Unit 4 (138-165 m; Cores 16-18)**

Light olive diatomite, rich in nannofossils (around 10-15 percent) make up this unit.

**Unit 5 (165-198 m; Cores 19-22)**

Light olive diatomite, rich in nannofossils (around 10-15 percent) makes up the bulk of this unit, with about five interbedded thin ash beds, and occasional glass shards in other parts of the diatomite. A thin fine sand occurs at 169 meters. A few darker beds with very few nannofossils are found.

**Unit 6 (198-224 m; Cores 22-24)**

This unit is a pale olive nannofossil diatomite, with at least two interbedded thin ash beds. The nannofossil content is around 30 to 40 percent.

**Unit 7 (224-254.5 m; Cores 25-28)**

This unit contains interbedded pale olive nannofossil diatomite and light olive nannofossil-rich diatomite with several thin ash beds. The nannofossil diatomite has around 40 percent nannofossils; the nannofossil-rich diatomite 20 to 30 percent. The sediment is frequently mottled, indicating bioturbation to various degrees. The ash is often pyritized.

**Unit 8 (254.5-263 m; Core 28)**

A grayish olive muddy diatomite occurs here with 1 to 5 percent calcareous nannofossils.

**Unit 9 (263-285 m; Cores 29-31)**

This unit consists of a grayish olive diatomite, with some muddy diatomite in places near the top and some nannodiatomite near the base. A 3-cm partly chertified bed, and a 2.5-cm ash were recovered. Core recovery in this unit is low.

**Unit 10 (285-186 m; Core 32)**

This short interval contains calcareous glauconite-bearing sandy (?) mudstone or chert and possibly a basalt flow. A single rounded pebble of very altered basalt was found (see "Petrography of the Volcanics," Chapter 31, this volume).

**Unit 11 (186-320 m; Cores 32-35)**

Dark greenish gray nannofossil ooze was recovered. Core recovery from this unit (especially the upper part) is low. Chert chips occur in the core catcher but not in the cores. At 320 meters, ash-bearing clayey dolomite was found in the core catcher with the first andesite.

**Unit 12 (Below 320 m; Core 36)**

Unit 12 is andesite, amygdaloidal and altered at the surface, with some brecciation, becoming coarser and fresher with depth. Petrologically, it contains feldspar phenocrysts and altered pyroxene phenocrysts, in a fine-grained groundmass.

**Notes on Specific Lithologies**

1. **Lithification.** One well-lithified ash was found, a 2.5-cm bed in Core 30. Its lithification compared with the other ashes may be due to (a) depth of burial and (b) its thickness preventing bioturbation and thus allowing more flux of interstitial water.

The cherts recovered in Section 29-2 are rather muddy and contain about 20 percent very fine sand, mainly angular to subrounded quartz and plagioclase feldspar. The calcareous glauconite-bearing sandy (?) mudstone or chert is not broken down by acid, suggesting at least part of the cement is chert or silicate. In thin section, the groundmass is difficult to resolve, but resembles that of the chert.

2. **Dolomite.** A hard, partly lithified, glass-bearing dolomite mud was found in the core catcher of Core 31, probably closely overlying the andesite. (In nearby Site 32, abundant dolomite rhombs were found in red clay closely overlying basalt basement). The carbonate source may have been nannofossils—they are absent from the mud, although nanno ooze is found in overlying cores. Dolomite commonly develops in carbonate rocks near major boundaries with Mg-rich rocks, and its occurrence need not indicate an intrusive andesite. No metamorphosed sediments were recovered but recovery was poor.

3. **Calcareous glauconite-bearing sandy (?) mudstone or chert.** The only example of this lithology is found in the core catcher of Cores 31 and 32. In thin section, about 60 to 80 percent of the rock is fine-grained groundmass. It was not determined whether this is chert, mud, or altered ash, but it is most probably chert. Glauconite, mainly of very fine grade, comprises about 10 percent of the rock. Some grains are pseudomorphs of foraminifer tests. A few radiolarians, mostly pseudomorphed by pyrite, and rare diatoms are also present. Sand grains (making up around 20 percent of the rock) are mainly angular to sub-rounded quartz and plagioclase feldspar, with rare dark brown biotite, all of very fine grade. There is a 1-cm bed of fine sand with abundant glauconite in the diatomite section in Section 19-2. Glauconite is occasionally found elsewhere in the diatomite, and there is at least one sandy ash.

4. **Pyritized ash.** Pyrite is abundant in most ash beds, and in a few sand beds, but is otherwise only rarely noted in the sediments. Some glass shards are partly replaced by pyrite along cracks, and others are completely pseudomorphed.

5. **Colors in diatomites.** The section from 224 to 254.5 meters in the diatomite has much interbedding of different-colored sediment. Beds more than 20 cm thick are indicated schematically in the barrel summaries. In places, there are alternations of beds on the scale of 3 to 10 cm.
In any one barrel, there is the following correspondence between color and lithology:

a) Pale olive is richest in nannofossils (often around 40 percent);

b) Light olive has fewer nannofossils (often 20-30 percent); and

c) Grayish olive usually has few nannofossils (less than 10 percent) and some clay (10-35 percent).

However, this correspondence is not infallible. A pale olive diatomite in Sample 28-2-100 has 5 percent nannofossils and 10 percent clay. In Core 21, pale olive has only about 10 percent nannofossils and light grayish olive has none.

Small (2 mm) black mottles are found in places, and are probably pyritic.

6. **Bioturbation in the diatomites.** Where there is variation in color of the diatomites, motting is common. This is not due to core disturbance, since some color boundaries are sharp and sometimes even show no downbowing. Motting on the scale of 1 to 2 mm are the most common, but those 5 to 10 mm thick are more prominent. Visible motting on this scale is observed up to 30 cm from a contact between different-colored beds. There is an 8-cm-long vertical pyrite-margined burrow 12 mm in diameter in Core 18-3.

Most of the sharp color boundaries are between grayish olive (usually mud rich) and diatomites of other pyritic types.

7. **Bioturbation of sand and ash beds.** With the possible exception of the thicker ash beds in Cores 7 and 34, all ash and sand beds are partially bioturbated. All the beds are penetrated by burrows, except for the 16-cm sand bed in Core 11. This bed has completely undisturbed alternating 2-mm laminae of "clean" and "dirty" sand over 1 cm in the middle of the bed, but both the top and the base are disturbed.

With the observed amounts of bioturbation, the ash found in small amounts in many smear slides could have all been derived from bioturbation of ash beds.

8. **Emplacement of sand beds in the terrigenous section.**

The following observations were made:

a) Sand beds and grains are generally absent from the section.

b) The only well-preserved sand has alternating clean and dirty laminae.

c) There is no visible grading in this sand.

d) The sand-sized component of the mud is almost exclusively biogenic.

The general absence of sand from the section suggests that the occasional sand beds are turbidites rather than a residue from the winnowing of the sands. The high proportion of biogenous material in the sand fraction of the muds also rules out a bottom current-winnowing origin.

9. **Origin of the non-biogenic sandy material in the diatomites and nannofossil oozes section.** The nonbiogenic sandy materials are almost all of very fine grade and consist of (a) glauconite, often pseudomorphing foraminifers, (b) glass, and (c) angular to subrounded quartz and plagioclase feldspar grains and rare brown biotite. These materials could be of volcanic origin.

The only bed of clean very fine sand (in Section 19-2) is 5 to 10 percent glauconite, and otherwise mainly quartz, with some feldspar. This high glauconite content suggests that it is unlikely to be a crystal tuff.

**Introduction**

Site 173 proved to be exceptionally productive in terms of abundance and preservation of planktonic foraminifera, radiolarians, diatoms, and silicoflagellates. Indeed, diatomites and diatom-rich muds comprise well over 50 percent of the 333 meters of sediment penetrated at this site. Calcareous nannofossils are sparse to common in most cores, becoming abundant only at the base of the hole (Cores 34 and 35; 304.5-320 m). Spores and pollen are common to abundant only in the upper portion of the column (Cores 1 to 18; 0-170 m). Zonation of calcareous and siliceous microfossils indicates that the sequence penetrated at Site 173 represents an essentially continuous record of deposition during an interval spanning the latest Oligocene or lowest Miocene to the late Pleistocene. Thus, Site 173 constitutes an excellent biostratigraphic reference section for the eastern North Pacific Ocean and provides a record of planktonic events over a 23 m.y. interval within a dominantly cool temperate to subarctic zoogeographic province.

Low species diversity characterizes calcareous and siliceous microfossil assemblages at Site 173 and is a direct function of the relatively high latitude of this site, together with its location beneath the path of a major eastern boundary current (California Current). In turn, the low species diversity and absence of well-known planktonic index species of lower latitudes creates problems in biostratigraphic zonation of some groups. For example, only portions of the well-established calcareous nannoplankton and planktonic foraminifer zones of tropical latitudes can be recognized and utilized at Site 173, requiring supplementary regional zonations based on high-latitude species to provide control within many intervals. Conversely, major oscillations of surface temperature during the late Oligocene-Pleistocene interval are clearly expressed in brief appearances of tropical elements as well as incursions of exclusively boreal biofacies; these events provide a means for correlation often unavailable at low latitudes.

The multiple biostratigraphic zonations delineated at Site 173 provide an exceptional opportunity to refine high latitude correlations between the various calcareous and siliceous planktonic groups. In addition, the multiple zonations provide a means of subdividing the column into relatively short intervals of time, a feat which is often difficult in cool water provinces where long ranging and morphologically simple forms tend to dominate the biota. Significantly, correlations can also be made with regional biostratigraphic zonations established in the middle to late Tertiary marine sections exposed on land in California, Oregon, and Washington. However, the first-order nature of some zonations defined and utilized at Site 173 must be tested further, and, as might be expected, there are discrepancies in placement of epoch boundaries between various groups; further study of this sequence is imperative.

The Pliocene/Pleistocene boundary at Site 173 is placed at 74 meters (Core 9) at the base of the *Eucyrtidium matuyamai* Zone (radiolarian). This zone is currently correlated with the base of the Olduvai geomagnetic event...
Dictyocha asper and Reticulofenestra pseudoumbilicata

The Miocene/Pliocene boundary is placed at 129 meters (Core 15) based upon the first occurrence of Dictyocha asper. This zone is approximately equivalent to Zone N. 18 of Blow (1969), and is thought to fall within the interval corresponding to Blow’s Zone N. 19. This zone is in turn equated with a planktonic foraminiferal zone which occurs at 150 meters (Core 17) at Site 173. Various species of Globigerina, such as G. pachyderma, are present in this interval, indicating a planktonic foraminiferal isotope stage 2 or 3.

The Middle Miocene/Upper Oligocene boundary is arbitrarily placed at 281 meters (Core 27) based upon the first occurrence of Orbitolina suturalis, a planktonic foraminifera commonly used to mark this boundary (Zones N. 9/N. 8) at low and mid latitudes. Berggren (1972) correlates this horizon with an estimated radiometric age of 16 m.y. The base of the Sphenolithus heteromorphus calcareous nannoplankton zone of tropical latitudes is correlated with the first appearance of Discoaster exilis in Core 28 (264 m) at Site 173, in turn marking the base of the newly defined Cylindricalithus floridanus range zone of Wise (Chapter 15, this volume). The base of the S. heteromorphus zone is currently correlated with an interval falling midway between the final appearance of the planktonic foraminifer Catapsydrax stainforthi and the initial appearance of Orbitolina suturalis essentially compatible with the sequence observed at Site 173. However, it should be noted that portions of Cores 28, 29, and 30 are barren or contain only sparse planktonic foraminiferal assemblages. Consequently, it is conceivable that the Orbuitina datum (base of planktonic foraminiferal Zone N. 9) may occur below Core 27 but no lower than the base of Core 30 (281 m) where abundant assemblages barren of this species reappear. Moreover, the base of North Pacific Diatom Zone XXIV equates with the Lower Miocene/Middle Miocene boundary and occurs at 281 meters (base of Core 30) and the estimated base of the Dorcadiospiris alata radiolarian zone also equated with this epoch boundary occurs within the 252-281-meter interval (Cores 28 to 31). Thus an alternate conservative case can be made for placing the Lower Miocene/Middle Miocene boundary as low as 218 meters (base of Core 30) at Site 173.

No sediment was recovered from the 285.5 to 304.5 meter interval (Cores 32 and 33) with the exception of a glauconitic sand at 295.5 meters which is barren of microfossils.

The Lower Miocene/Upper Oligocene boundary is arbitrarily placed at 312 meters (bottom of Core 34) based upon the top of the Reticulofenestra bisecta-Triquetrorhabdus carinatus Range-zone (combination calcareous nannofossil-silicoflagellate) at this horizon. Moderately to poorly preserved planktonic foraminifera in Cores 34 and 35 (304.5 to 320 m) include Globigerina angulisuturalis, G. euaperta, Globorotalia nana, and Catapsydrax dissimilis suggesting assignment to the lowermost Miocene or uppermost Oligocene (Zone N.3 or N.4). This epoch boundary is currently correlated with an estimated radiometric age of 22.5 m.y. (Berggren, 1972). Diatoms are absent from 281 meters to the base of the hole whereas radiolarians are absent or poorly preserved from 285 meters to the base of the hole.

Finally, it is important to note that three major sedimentologic/paleocologic events are represented at Site 173:

1. The Miocene/Pliocene boundary is placed at 252.5 meters (bottom of Core 27) based upon the first occurrence of Orbitolina suturalis, a planktonic foraminifera commonly used to mark this boundary (Zones N. 9/N. 8) at low and mid latitudes. Berggren (1972) correlates this horizon with an estimated radiometric age of 16 m.y. The base of the Sphenolithus heteromorphus calcareous nannoplankton zone of tropical latitudes is correlated with the first appearance of Discoaster exilis in Core 28 (264 m) at Site 173 in turn marking the base of the newly defined Cylindricalithus floridanus range zone of Wise (Chapter 15, this volume). The base of the S. heteromorphus zone is currently correlated with an interval falling midway between the final appearance of the planktonic foraminifer Catapsydrax stainforthi and the initial appearance of Orbitolina suturalis essentially compatible with the sequence observed at Site 173. However, it should be noted that portions of Cores 28, 29, and 30 are barren or contain only sparse planktonic foraminiferal assemblages. Consequently, it is conceivable that the Orbuitina datum (base of planktonic foraminiferal Zone N. 9) may occur below Core 27 but no lower than the base of Core 30 (281 m) where abundant assemblages barren of this species reappear. Moreover, the base of North Pacific Diatom Zone XXIV equates with the Lower Miocene/Middle Miocene boundary and occurs at 281 meters (base of Core 30) and the estimated base of the Dorcadiospiris alata radiolarian zone also equated with this epoch boundary occurs within the 252-281-meter interval (Cores 28 to 31). Thus an alternate conservative case can be made for placing the Lower Miocene/Middle Miocene boundary as low as 218 meters (base of Core 30) at Site 173.

2. The Lower Miocene/Upper Oligocene boundary is arbitrarily placed at 312 meters (bottom of Core 34) based upon the top of the Reticulofenestra bisecta-Triquetrorhabdus carinatus Range-zone (combination calcareous nannofossil-silicoflagellate) at this horizon. Moderately to poorly preserved planktonic foraminifera in Cores 34 and 35 (304.5 to 320 m) include Globigerina angulisuturalis, G. euaperta, Globorotalia nana, and Catapsydrax dissimilis suggesting assignment to the lowermost Miocene or uppermost Oligocene (Zone N.3 or N.4). This epoch boundary is currently correlated with an estimated radiometric age of 22.5 m.y. (Berggren, 1972). Diatoms are absent from 281 meters to the base of the hole whereas radiolarians are absent or poorly preserved from 285 meters to the base of the hole.

3. The Miocene/Pliocene boundary is placed at 129 meters (top of Core 15) based upon the first occurrence of Pliocene (Zone 19) foraminiferal index species at 122 meters (Core 14), the base of the Pliocene Lampsycyris heteroporus Zone (radiolarian) at 131 meters (Core 15), and the tentative placement of the base of the Pliocene Distephanus spectulum Zone (silicoflagellate) at 130 meters (Core 15). This horizon is in turn correlated with an estimated radiometric age of 5.0 m.y. (Berggren, 1972). Correlations based upon diatom biostratigraphy place the Miocene/Pliocene boundary at the North Pacific Diatom Zone XI which occurs at 150 meters (Core 17) at Site 173.

The Middle Miocene/Upper Miocene boundary is arbitrarily placed at 186 meters (Core 20) at the base of the Dictyocha asper-Reticulofenestra pseudoumbilicata silicoflagellate-calcareous nannofossil combination zone. The approximate base of the Pliocene Dictyocha pseudofibula silicoflagellate zone occurs within the 170-179-meter interval (Cores 19 and 20) and the approximate base of the basal Pliocene Ommatulites antepenultimus radiolarian zone occurs within the 186-196-meter interval (Cores 20 and 21) compatible with the epoch boundary cited above. The earliest occurrence of a dominantly sinistral population of Globigerina pachyderma s.l. currently correlated with planktonic foraminiferal zone N. 15 (Bandy and Ingle, 1970; and Bandy, 1971, 1972) takes place at 180 meters (Core 20) and marks a horizon approximately equivalent to the Middle Miocene/Upper Miocene boundary as defined by Blow (1969), Berggren (1969, 1972) and others. Berggren (1972) correlates this latter horizon with an estimated radiometric age of 10.5 m.y. It should be noted, however, that Bandy and Ingle (1970), Bandy, Casey and Wright (1971); and Bandy (1972) place the Miocene/Middle Miocene boundary at 195.5 meters (base of Core 21) at Site 173. Interesting volumes (Chapter 17).

North Pacific Diatom Zones of Schrader as defined in this volume (Chapter 17).

The Lower Miocene/Upper Oligocene boundary is arbitrarily placed at 312 meters (bottom of Core 34) based upon the top of the Reticulofenestra bisecta-Triquetrorhabdus carinatus Range-zone (combination calcareous nannofossil-silicoflagellate) at this horizon. Moderately to poorly preserved planktonic foraminifera in Cores 34 and 35 (304.5 to 320 m) include Globigerina angulisuturalis, G. euaperta, Globorotalia nana, and Catapsydrax dissimilis suggesting assignment to the lowermost Miocene or uppermost Oligocene (Zone N.3 or N.4). This epoch boundary is currently correlated with an estimated radiometric age of 22.5 m.y. (Berggren, 1972). Diatoms are absent from 281 meters to the base of the hole whereas radiolarians are absent or poorly preserved from 285 meters to the base of the hole.

Finally, it is important to note that three major sedimentologic/paleocologic events are represented at Site 173:

4. This zone is encompassed within the longer Cylindricalithus floridanus Zone (combination range) of Wise (Chapter 15, this volume).
SITE 173

Deposition of calcareous nannofossil ooze ceased and a lengthy period of prolific diatom productivity and deposition commenced during the Lower Miocene (Core 31; 282 m). The 138 meters of diatomites penetrated at Site 173 span almost the entire Lower Miocene-Upper Miocene interval. Tentative placement of epoch boundaries at Site 173 and their alignment with the radiometric and paleomagnetic time scales of Berggren (1972) and Opdyke (1972) indicate rates of deposition within the diatomaceous interval varied as follows: Lower Miocene—4.8 m/m.y.; Middle Miocene—17.4 m/m.y.; and Upper Miocene—9.5 m/m.y. Significantly, Lower Miocene through Upper Miocene laminated diatomites and siliceous shales assigned to the Monterey Shale and coeval units of similar lithology are exposed in coastal California, Oregon, Washington and Baja California, Mexico, emphasizing the regional nature of this event. A third major event occurred at the beginning of the Pliocene (Core 15; 129 m) when a massive influx of terrigenous clays, silts, and sands appear in the record diluting biogenic deposits. The estimated rate of deposition during the Pliocene interval based on the correlations noted above is 25.8 m/m.y., whereas the estimated rate for the Pleistocene interval is 62.5 m/m.y., emphasizing the acceleration of sedimentation during a period of severe climatic deterioration.

Calcareous Nannofossils and Silicoflagellates

Small to moderate numbers of calcareous nannofossils were recovered from diatomaceous green muds. These Neogene assemblages are highly diluted by silicic microfossils and terrigenous clays, especially those assemblages within the Pliocene/Pleistocene interval. Calcareous nannofossils only become abundant at the base of the hole where the lithology changes to gray mud. Silicoflagellate assemblages are common at various horizons and are most abundant within Miocene diatomites.

Species diversity of both calcareous nannofossils and silicoflagellates is low at Site 173 compared with coeval assemblages at tropical latitudes. This is directly attributable to the relatively high latitudinal position of this site (39°57.7′N). Indeed, it has been well documented that species diversity among Quaternary coccoliths in the Atlantic and Pacific oceans decreases dramatically from low to high latitude (McIntyre and Bé, 1967; McIntyre et al., 1970). Thus, at Site 173 it is not surprising to find that many tropical, subtropical, and transitional species are conspicuously absent. Conversely, some species encountered are clearly indicative of cool temperatures; Coccolithus pelagicus, which is common within the Pleistocene interval at Site 173, can only tolerate seasonal surface water temperatures of between 6° and 14°C (McIntyre et al., 1970).

Low species diversity characterizing the cool water assemblages of Site 173 presents an acute problem for the biostratigrapher because many key marker species of lower latitudes are absent, especially among the discoasters, sphenoliths, and helicopontosphaerids. In fact, few of the twenty-six calcareous nannofossil zones and subzones defined for the Neogene of the equatorial Pacific (Bukry, 1971) can be recognized at Site 173. Therefore, it has been necessary to employ a broader zonal concept in order to subdivide this section utilizing techniques such as combining two or more zones recognized in equatorial regions into one zone and using secondary marker species. Furthermore, ranges of selected species of silicoflagellates are used in conjunction with zonation by calcareous nannofossils in order to provide control in Upper and Middle Miocene intervals lacking significant calcareous nannofossil floras at Site 173. One Middle Miocene silicoflagellate datum level (the Corbisera triacantha datum) proposed by Martini (1971) for the equatorial Pacific can be recognized at Site 173 and is used here in combination with datum levels provided by calcareous nannofossils to define new subzones ultimately resulting in “combination range zones” (see Wise, this volume).

The three “standard” calcareous nannofossil zones commonly used to subdivide the Pleistocene (Martini and Worsley, 1968) can be recognized in Cores 1 through 4 (0-34 m) at Site 173 and the first appearance of Geophyrocapsa can be used to approximate the Pliocene/Pleistocene boundary at the base of Core 4 (34 m) in the absence of Discoaster. However, this tentative boundary is in conflict with the Pliocene/Pleistocene boundary defined on the basis of radiolarian and diatom zonations. Unfortunately, only sparse floras are present in Cores 3 through 13 (34 to 119.5 m) and the virtual absence of discoasters and ceratolitids makes it difficult to subdivide this portion of the column. Indeed Bukry (Chapter 19, this volume) assigns a portion of this interval (44 to 97 m) to an undifferentiated Pliocene/Pleistocene zone. It is important to note that Pliocene discoaster assemblages are better represented at more westerly DSDP Sites 34 and 36 (McManus et al., 1970).

Cores 15 to 23 (129-214.5 m) contain Miocene cool water assemblages dominated by Reticulofenestra pseudounblica, Discoaster variabilis, and Discoaster exilis. A new discoaster species, Discoaster mendomobensis Wise, is used to define two new Miocene nannofossil zones in this interval. This geographically restricted species flourished at Site 173 during an unusually warm interval during the late Miocene as evidenced by paleoecologic interpretations based on planktonic foraminifera, diatoms, and silicoflagellates. Assemblages encountered between the bottom of Core 22 (205 m) and the top of Core 30 (271.5 m) are little changed from those immediately above this interval except for the addition of Cyclicargolithus floridanus with the Middle Miocene/Lower Miocene boundary placed within the lower portion of the Cyclicargolithus floridanus-Discoaster exilis Zone. Samples below 273 meters (Core 30), however, contain abundant Sphenolithus mortiformis, Discoaster deflandrei, and an assortment of discoaster forms which show signs of secondary calcite overgrowths. The presence of Helicopontosphaera kamptneri indicates somewhat warmer water conditions during the Middle Miocene than prevailed at this site during later intervals.

A glauconitic (?) interval barren of all microfossils is represented in Cores 32 to 33 (285.5-304.5 m). Cores 34 and 35 do contain calcareous nannofossils and those found

---

5 See Chapter 15 by Wise and Chapter 19 by Bukry for detailed discussion of calcareous nanoplanктон и silicoflagellate zonation.
in Core 35 (310.5-320 m) are placed in the Reticulofenestra bisecta-Triquetrorhabdulus carinatus Zone of the uppermost Oligocene.

In summary, the calcareous nannoflora at Site 173 went through three major transitions, two of which were accompanied by a marked change in the depositional pattern at the site. The first occurs in the Lower Miocene (Cores 31 and 30) where a reasonably diverse assemblage containing some discoasters showing secondary calcite overgrowths is replaced by a somewhat more restricted assemblage which lived in surface waters that, for the first time, were dominated not by calcareous nannoplankton, but by diatoms. The second change occurs in the Upper Miocene (Core 16; Discoaster mendombensis Zone) where an atypical assemblage of heavily constructed discoasters dominated a calcareous nannoflora which thrived in surface waters usually warm for this locality. The third major change occurs in the Lower Pliocene (Cores 14 and 13) at a point above which, the calcareous nannofossils are severely restricted in numbers and their preservation is generally poor.

### Planktonic Foraminifera

Well-preserved planktonic foraminifera are abundant to common within the Pleistocene and Pliocene terrigenous muds encountered from 0 to about 130 meters (Core 15). Moderately to well-preserved faunas are generally common within Miocene diatomites and diatom-rich muds encountered from 130 to 285 meters (Cores 15 to 31). However, the number of planktonic specimens per unit volume of sediment is generally low due to dilution by prolific numbers of diatom frustules. Cores 32 and 33 (285.5 to 304.5 m) are completely barren. Common to rare numbers of foraminifera occur in the lower Miocene/Upper Oligocene nannofossil ooze encountered in Cores 34 and 35 (304.5 to 320 m). An anomalous Pliocene assemblage is present within disturbed sediment at the base of Core 35 (313 to 320 m) apparently representing downhole slumping or displacement by drilling operations.

The planktonic foraminiferal sequence at Site 173 represents a nearly continuous record of planktonic productivity within a cooler portion of the California Current system during the late Oligocene to Pleistocene interval. The boreal aspect of these faunas precludes the common occurrence of the critical index species of planktonic foraminifera recognized in tropical regions. However, a series of cool, temperate, and subtropical planktonic biofacies have been recognized in the mid-Tertiary to Recent interval of this region (Lips, 1964, 1967; Ingle, 1967, 1972; Bandy and Ingle, 1970; Bandy et al., 1971; Bandy, 1971, 1972) which, together with occasional occurrences of tropical species, allow epoch boundaries to be recognized and the faunas to be placed within the context of Blow's (1969) planktonic zones. Biostratigraphic resolution is in fact enhanced by the periodic latitudinal migrations of planktonic faunas in this region representing distinct paleo-oceanographic events. This sort of phenomenon is characterized by the well-established changes in coiling direction of Globigerina pachyderma s.l. within Neogene surface sections exposed along the Pacific Coast of North America representing variations in surface temperature within this region. These trends were utilized in recognizing various stratigraphic horizons at Site 173 and other sites drilled during DSDP Leg 18.

Late Pleistocene assemblages representing zone N.23 at Site 173 are dominated by sinistral coiling populations of Globigerina pachyderma (Cores 1 to 4; 0-34 m) whereas early Pleistocene and Pliocene populations exhibit alternating dextral and sinistral coiling (Cores 5 to 9; 34-74 m). Globigerina bulloides increases in abundance within warmer intervals marked by dextral populations of G. pachyderma. Indeed, the predominance of the transitional water mass species Globorotalia inflata at some horizons indicates that the northward adjustment of the 20°C isotherm relative to its present position off Baja California occurred several times during this interval. Significantly, Globorotalia truncatulinoides was not found within the Pleistocene interval at this site although rare specimens of G. tosaensis were encountered at 54 meters (Core 7). However, this bioseries is present at Site 36 northwest of Site 173 and correlations with this sequence reinforce placement of the Pliocene/Pleistocene boundary at the base of Core 9 (74 m).

Pliocene assemblages encountered in Cores 9 through 14 (74 to 122 m) contain significant populations of Globorotalia puncaticula and Globoquadrina humerosa along with Globorotalia crassaformis s.s., G. crassaformis oceanica, G. crassaformis ronda, and Globigerina decoraperia representing zones N.22 through N.19.

Upper Miocene assemblages dominated by Globigerina bulloides and G. pachyderma s.l. representing zones N.18 to N.16 occur from 131 to 164 meters (Cores 15 to 19). Rare specimens of Globigerina apertura, G. decoraperta, Globorotalia acostaensis, G. cf. margaritae, G. minutissima, G. mioea, G. tumida, and Globoquadrina dehiscens occur within this interval. The base of the oldest dominantly sinistral population of Globigerina pachyderma s.l. occurs at 164 meters (Core 18) and reflects a major period of Miocene polar refrigeration sensed as far south as 28°N (Mohole cores) and known to be correlative with a portion of the Mohnian Stage of California (Ingle, 1967; Bandy and Ingle, 1970) and zone N.16 (Bandy, 1971).

Middle Miocene populations representing zones N.15 through N.9 and correlative with the lower Mohnian, Luisian, and Relizan stages of California occur from 176.5 to 252.5 meters (Cores 20 to 27). Globigerina angustiumbilicata and Globigerinita glutinata var. dominate faunas in the early portion of this interval (Cores 27 to 23; 252.5 to 218 m) with the initial appearance of Orbulina suturalis (218 m) at 252.5 meters (Core 27). Late Middle Miocene faunas are dominated by Globigerina bulloides, G. praebulloides, and G. concinna. Assemblages dominated by Globorotaloides trema occur from 215 to 218 meters (Core 24) and represent a significant planktonic event correlative with zone N.11 and the Luisian Stage of California. Rare specimens of Globigerina obesa, Globorotalia continens, G. peripheroronda, G. praescutula, and Globoquadrina venezuelana also occur within the Middle Miocene interval.

Core 28 (252.5 to 262 m) contains only sparse foraminifera and Cores 29 and 30 are barren of planktonic foraminifera. Distinctly Lower Miocene faunas representing zones N.7 through N.5 first occur in Core 31 (285.5 m) marked by well-developed specimens of Catapsydrax dissimilis. This fauna is correlative with a portion of the Saucesian Stage of California (Lips, 1967; Bandy, et al.,
Melonis pompilioides, M. barleeanus, Gyroidina soldani, Radiolaria present in the Rectouvigerina ("Siphogenerina") kleinpelli, Benthonic nana, Catapsydrax dissimilis, C. unicava and ina angulisuturalis, G. officinalis, G. euaperta, Globorotalia 38 common in the Zemorrian Stage of m) and R. smithi, spanning the Lower Miocene/Upper Oligocene boundary as

Benthonic Foraminifera

Pleistocene through Upper Oligocene benthonic foraminiferal assemblages encountered at Site 173 exhibit a remarkable similarity considering the length of time represented by this interval. Important bathymetric index species are present in almost every sample and include Melonis pompilioides, M. barleeanus, Gyroidina soldani, Ulvigerina senticosa, Pulemenia bulloides, Hoeglundina elegans, Buliminina rostrata, Eggerella bradyi, and several species of Stilostomella. All of these species are common in Recent faunas found at depths between 2500 to 3500 meters in the eastern North Pacific Ocean. However, persistent admixtures of species representative of slightly shallower depths occur in many samples and include Buliminina striata mexicana, Ulvigerina peregrina dirupta, U. hispida-costata, U. hispida, and Globobullinina affinis indicating continuous downslope displacement of sediments onto this site. Percentages of displaced species are highest in the Lower Miocene/Upper Oligocene interval.

The benthonic assemblages encountered at Site 173 are typical of a continental shelf environment, some distance from the shelf and main avenues of downslope transport of shallow water sediments. They are not representative of a typical proximal deep-sea fan environment.

Most of the benthonic species recovered are not stratigraphically significant. Nevertheless, one specimen of Vahlculina californica, an index species of the Luisian Stage of California (Kleinpell, 1938), was found in Core 23 (110 m) and one specimen of Gyroidina reliziesis indicative of the Relizian Stage was recovered in Core 27 (250 m). Moreover, rare specimens of Ulvigerina gallowayi and Rectovigerina ("Siphogenerina") kleinpelli, present in the Saucesian Stage of California, were found in Core 28 (262 m) and R. smithi, common in the Zemorrian Stage of California, was found in Core 35 (312 m). Further study of the benthonic foraminifera at Site 173 will likely reveal additional but rare specimens of other stratigraphically diagnostic species.

Radiolaria

Cores 1 through 31 (0-285.5 m) are rich in radiolarians of Neogene age. Cores 32, 34, and 35 (285.5-320 m) contain poorly preserved recrystallized specimens including some probable Cretaceous species with minor quantities of well-preserved Tertiary species. Core 36 was not examined and Core 37 (322.5-328 m) contains no radiolarians.

Core 1 and the upper portion of Core 2 (0-8.3 m) contain assemblage lacking Druppactrauct actequitranus and Stylactactus universus indicating this interval is within the upper Pleistocene Astostrobium miraelense Zone of Hays (1970). The base of this zone, as identified in Samples 173-2-2 (118-120 cm) to 173-2-3 (40-42 cm), corresponds to a radiometric-paleomagnetic age of 0.4 m.y. in the North Pacific according to Hays (1970). The lower part of Core 2 through Core 8 (8.3-73 m) represents the next older Stylactactus universus Zone whose base (Samples 173-8-5, 57-59 cm, to 173-8-6, 57-59 cm) is thought to represent 0.9 m.y. (Hays, 1970). Interestingly, Llampycyclatus heteroporus ranges up into Stylactactus universus Zone at Site 173 unlike the subarctic Pacific where it reaches an upper limit at the base of this zone according to the interpretation presented here. Cores 9 through 14 (73-129 m) contain Llampycyclatus heteroporus below the lower limit of L. heteroporus near the Miocene-Pliocene boundary of California.

Cores 15 through 31 (129-285.5 m) contain radiolarians diagnostic of the Miocene epoch. Riedel and San Filippo's (1970) "Onommatinus antepennilimus Zone, Canavrinus petterssoni Zone, Dorsodunysis alata Zone, and Calocyctetca costata Zone can be recognized in this interval, however, precise zonal boundaries cannot be established. The oldest zone recognized indicates an upper lower Miocene age for Core 31 (281-285.5 m).

Diatoms

Diatoms are common to abundant and moderately well preserved in the terrigenous muds from 0 to 130 meters (Cores 1 to 15) at Site 173. They are abundant and well preserved within diatomaceous sediments of the 130 to 280 meter (Cores 15 to 30) interval. Lower horizons from 282 to 333.5 meters (Cores 31 to 38) are barren of diatoms. Reworked older species are common in the Pleistocene interval (0-66 m as defined on the basis of diatom biostratigraphy), as well as in the lower portions of the hole where displacement occurred due to slumping during coring. The abundance of ecologically displaced diatoms (littoral marine, fresh-water benthonic, and planktonic forms) increases abruptly within the Pleistocene terrigenous muds.

The abundant and diverse Pleistocene through Early Miocene diatom floras encountered at Site 173 provided the basis for definition of the North Pacific Diatom Zones (NPD Zones) utilized in this report (Schrader, Chapter 17, this volume) the following NPD zonal boundaries were recognized: base of NPD Zone I at 17 meters (173-2-2, 104-105 cm), base of NPD Zone II at 28 meters (173-4-2, 55-56 cm), base of NPD Zone III at 53 meters (173-6-3, 55-56 cm), base of NPD Zone IV at 67 meters (173-8-2, 55-56 cm), base of NPD Zone V at 77 meters (173-9-4, 55-56 cm), base of NPD Zone VI at 90 meters (173-10-5, 55-56 cm), base of NPD Zone VII at 104 meters (173-12-2, 55-56 cm), base of NPD Zone VIII at 123 meters (173-14-1, 55-56 cm), base of NPD Zone IX at 130 meters (173-14, CC), base of NPD Zone X at 139 meters (173-15, CC), base of NPD Zone XI at 152 meters (173-17-2, 55-56 cm), base of NPD Zone XII at 160 meters (173-17, CC), base of NPD Zone XIII at 168 meters (173-18-4, 56-57 cm), base of NPD Zone XIV at 173 meters (173-19-2, 55-56 cm), base of NPD Zone XV at 177 meters (173-20-2, 55-56 cm), base of NPD Zone XVI at 182 meters (173-21-1, 99-100 cm), base of NPD Zone XVII at 197 meters (173-22-2, 55-56 cm), base of NPD Zone XVIII at 205 meters (173-23-1, 110-222 cm), base of NPD Zone XIX at 225 meters (173-24, CC), base of NPD Zone XX at 234 meters (173-25, CC), base of NPD Zone XXI at 244
meters (173-26, CC), base of NPD Zone XXII at 254 meters (173-27, CC), base of NPD Zone XXIII at 264 meters (173-29-1, 55-56 cm), and the base of NPD Zone XXIV at 281 meters (173-30, CC). The base of NPD Zone XXV has not been defined.

The base of NPD Zone IV at 67 meters is correlated with the Pleistocene-Pliocene boundary of Donahue (1970) and is thought to represent the top of the Olduvai paleomagnetic event. The Miocene-Pliocene boundary is placed at the base of NPD Zone XI at 152 meters in turn correlated with an interval thought to represent the top of magnetic epoch 5 equivalent to an estimated radiometric age of 5.5 m.y. (Berggren, 1962, 1972).

**Pollen and Spores**

Palynomorphs are common to abundant in Cores 1 through 18 (0-167 m) and in Core 25 (224-233.5 m) of Site 173, but are essentially absent from all other horizons sampled. The absence of pollen in the majority of cores sampled is probably due to dilution of terrigenous sediment by the high frequency of marine microfossils, particularly diatoms (Korneva, 1964) and by the lack of preservation of the grains at the base of the hole. This latter phenomenon is reflected by the increasing amount of apparently poorly preserved pollen downhole, where it forms 90 percent of the sample in Core 25. Corrosion and yellow staining of pollen may be a product of overburden pressure and high temperature (Staplin, 1969).

Composition of assemblages encountered indicates fluctuating cooler and warmer horizons, but most dramatic is the sharp break at the base of Core 8 (72 m) indicating a warm period which continues to the base of the section studied. Pine frequency decreases from a maximum of 85% at 55 meters to a minimum of 10% at 100 meters. Correspondingly, there is an increase in species diversity. This break corresponds to the Pliocene-Pleistocene boundary as determined by marine microfossils.

Lack of detail in climatic trends at Site 173 is likely the product of relatively widely spaced sampling which precludes the detection of small-scale climatic events.

The appearance of *Ephedra* in Core 12 (110 m) marks the only occurrence of a genus extinct in this area since Pliocene time.

**PHYSICAL PROPERTIES**

Physical properties were measured on only two sections of most cores because the cores were coming aboard at a rate of one core per hour. Porosity and bulk density were measured with the GRAPE and by shipboard laboratory methods on Sections 2 and 5 of most cores. Sonic velocity was measured on the same sections with the Hamilton frame instrument. After Core 10, the consistency of the sediments allowed velocity measurements to be made out of the core liner. The three velocity measurements made on the most consolidated part of each section had insignificant variation between the values.

The relatively low disturbance of cores below 50 meters probably makes the measurements at Site 173 more reliable than usual. This impression is obtained from the correlation between GRAPE and sonic velocity measurements with the described lithology. For instance, the change from mud to diatom-rich sediment between 100 meters and 138 meters correlates with a distinct event in the three physical properties curves plotted. There is also a distinct change in the level of natural gamma radiation. A similar situation is seen near the bottom of the drill hole at Core 29 where a change from diatomite to nannofossil ooze occurs. The physical properties suggest that the changes from diatomaceous to nondiatomaceous sediment was more gradual than color changes indicate.

**CORRELATION BETWEEN REFLECTION RECORDS AND STRATIGRAPHIC COLUMN**

Two seismic reflection records along a track perpendicular to the continental slope were made during the predrilling site survey (see Appendix I). One was made at 8 knots and the other at 4 knots (Figure 2).

Based largely on the reflectivity shown in the 4-knot record and a stationary record, the sedimentary section is divided into two acoustic units. The upper unit is composed of weak reflections that generally parallel the ocean floor. Its lower contact conforms with a lower unit which has stronger reflections of variable intensity. The lower unit conforms to the acoustic basement where basement slopes are near horizontal and abuts unconformably against steeper basement slopes. The unit has filled lows and its thicker basal portions on either side of Site 173 may be older than the section drilled.

The acoustic basement is marked by a highly reverberant reflector and possibly crude layering. The basement has large steps and steep slopes that suggest tectonism rather than original topography. If the steps are faults, little of this tectonism is expressed in the overlying sedimentary section.

The reflection records suggest the following sequence of events: (a) formation of basement followed by probable faulting and tilting, (b) after most of the tectonism occurred, deposition of a thick layered sequence on the irregular surface, and (c) deposition of the upper unit.

The upper acoustic unit correlates well with the Pleistocene and Pliocene section of grayish green muds from 0 to 138 meters (see "Lithologic Summary"). If 138 meters is the lower boundary, an interval velocity of 1.57 km/sec is calculated, which compares favorably with velocities measured on the cores (see "Physical Properties"). A discrepancy of about 15 meters occurs in the
lower unit-basement contact if laboratory velocities are used. This discrepancy is probably within the limits of error for the seismic- and velocity-measuring techniques.

**SUMMARY AND CONCLUSIONS**

Site 173 is located on the lower continental slope off Cape Mendocino, northern California at a water depth of 2927 meters. It was continuously cored to a total depth of 333.5 meters below the sea floor (Table 1). Andesite was encountered at 320 meters. Fossils suggest continuous deposition from at least upper to middle Pleistocene through the lowermost Miocene. This hole provides an important biostratigraphic section for the northeast Pacific.

The upper 138 meters of the sedimentary section is dominated by Pleistocene to late Miocene grayish green muds with a few horizons of very thinly bedded fine sands. Sedimentation rates of 22 m/m.y. are calculated on the basis of planktonic foraminiferal zonations determined according to the Berggren (1969) time scale. The bulk of the section (138-285 meters) consists of upper-to-lowermost Miocene pale olive to grayish olive diatomites. It is underlain by up to 35 meters of gray nannofossil ooze which rests upon the andesite. Thin ash beds are found through the entire sedimentary section. The middle Miocene to lower Miocene diatomaceous unit has an extrapolated sedimentation rate of 13 m/m.y.

Thin section and hand specimen analysis of the volcanic rock fragments shows that they have a diverse composition but most of them appear to be andesitic in character. Rocks of this composition are atypical of a deeper ocean environment which raises the possibility that the lower slope has subsided. The small fragments recovered are dark colored with greenish and purplish hues. Some hand specimens have vesicles that are several millimeters in diameter. Good glass in some samples suggests emplacement in a submarine environment.

Site 173 is characterized paleontologically by the abundance, preservation, and diversity of foraminifers, radiolarians, and diatoms throughout the entire section cored. Spores and pollen are sparse, but more common to the Pleistocene. Calcaceous nannofossils become more abundant in the middle to lower Miocene section. Variable species composition indicates a significant series of climatic oscillations throughout the late Tertiary in this area. Prolific diatomites represent a response to vigorous upwelling, similar to that of today, and a much lower influx of terrigenous sediments during the Miocene. The rain of diatom frustules became diluted as the rate of terrigenous sedimentation increased significantly at the end of the Miocene and beginning of the Pliocene. This may have been a delayed response to the large-scale tectonic activity along the Pacific coast of North America during the Oligocene-Miocene interval. The seaward advance of terrigenous sedimentation may be reflected in the grayish green muds that began to accumulate rapidly at the site near the end of the Miocene and beginning of the Pliocene. The benthonic foraminiferal assemblages are typical of a continental slope environment. The fine-grained nature of the deposits also suggests that most of the deposition was some distance beyond the continental shelf either by hemipelagic sedimentation and/or slow downslope movement of bottom-seeking turbid layers. The presence of shallower-water benthonic foraminifers in the slope deposits indicates displacement, most likely from the upper slope. An alternative but less attractive explanation is that downslope displacement is minimal and that subsidence has occurred throughout the late Tertiary at Site 173.

Cretaceous radiolarians occur in the lower Miocene sediments. Apparently, they were contributed from a nearby source because they show little or no evidence of surface abrasion. Their state of preservation suggests an origin from rocks of the Franciscan Formation. A Franciscan type of rock was dredged a short distance south of Site 173 in Noyo Sea Valley (Silver, Curray, and Cooper, 1971).

---

[^6]: All sedimentation rates uncorrected for compaction in this chapter.
Information relating to tectonics near Site 173 fits most easily into a rather static unifying scheme. In sequence, the principal deductions are the following:

1) The Franciscan Formation may form a basement in this area.

2) Above the possible Franciscan is an andesite. Since the occurrence of andesite is rare in deep water, this unit may have been extruded and altered in shallow water. However, no other evidence reinforces this interpretation and it seems equally likely that the andesite has a deep-water origin.

3) The basement complex was broken by large steep faults no later than late Oligocene or early Miocene time. This deformation may correlate with an episode of major tectonism that began along the adjacent California coast in late Oligocene or early Miocene time. Subsequent layered units are not deformed and no local tectonism is apparent in the area after this event but later regional deformation is possible.

4) Unabraded Cretaceous radiolarians incorporated in the early Miocene sediments are most easily explained by an exposure of Franciscan rock in submarine outcrop nearby.

5) Terrigenous sedimentation was low at Site 173 from late Oligocene through most of the Miocene. During this time nannofossil ooze and then diatomaceous sediments accumulated at a relatively slow rate. The environments deduced from lithologic and paleontologic data indicate continental slope conditions prevailed at this site throughout the Miocene.

6) At the end of Miocene time, an influx of terrigenous sediment dominated the depositional history at Site 173 with rates of accumulation about twice previous rates. This influx may have been a function of a progressive seaward prograding of terrigenous sediments in addition to any climatic fluctuations.

REFERENCES


APPENDIX A. OPERATIONS

Pre-drilling Survey

The predrilling site survey was made along a track connecting Site 34 of Leg 5 with Site 173. The attempt to make a seismic record in which stratigraphy could be correlated between the two holes failed when the seismic instruments did not function properly.

It was difficult to find the site picked on Silver's record along the first Challenger track and a 1525 navigational satellite position indicated the track was 2 km north of the course plotted by Silver (Figure 3). The line was continued until 1645 to outline structure after which Challenger turned to a reciprocal of 240° T on the proposed Silver course. At 1730, basement depth and structure looked favorable and at 1800 a “basement” bench was selected as the site. The ship continued on course until 1813 to detail structure. After coming to a reciprocal course and slowing to 4 knots for good seismic control, a presoaked beacon was dropped underway along with a spar buoy. The course was continued until the whole bench was again recorded by the seismic system whereupon geophysical gear was retrieved and the ship came back to the beacon. In the hour between the beacon and spar buoy drop and the return to the beacon, the buoy drifted relative to the beacon 0.8 miles, 080°T. It was thought that winds prevailing at the time could not have driven the buoy this far and since the ship did not experience difficulty in holding position the only explanation was that deep water currents may have carried the beacon off position. From a stationary seismic record it appeared that the beacon may have drifted shoreward during its 26-minute descent about 50 meters because the basement is deeper and the sea floor is shallower. The position of Site 173 from nine satellite fixes is 39°57.71'N; 125°27.12'W.

Post-drilling Survey

A course crossing the predrilling survey track at right angles was run to obtain better control on structure. Challenger got underway at 2330, on a course of 155° T on June 12 and streamed geophysical gear. About 2 miles southwest of the site, at 2345, the seismic system was tuned up and the ship came about to 335° T at 4 knots passing over the beacon at 0015 T, June 13. A good record was made for 2 more miles and speed was increased at 0049 to 10 knots and course was changed to 000° ending the site survey (Figure 3).

Drilling Program

Site 173 was continuously cored (10-12 June) until an andesite flow was encountered at 320 meters below the sea floor. Repeated drilling to 333.5 meters produced only fragments of andesite that were lodged in the core catcher and extended barrel. The new bit assembly, described in the drilling specifications section, was used successfully on this site. However, one of the cone bearings was worn out.

The drill pipe was lowered at 1930 hours June 9. Bottom depth was originally picked at 1572 fathoms (uncorrected) (2921 meters corrected by Mathews tables) at the transducer or a depth of 2937 meters to the derrick floor. Three empty core barrels were pulled before it was realized that the bottom slope of 2 to 3 degrees had a 30-meter effect on the total depth. Even with the 30 meter correction, the pipe was still about 16 meters from the sea floor. North Pacific velocity values from Latham (personal communication) reduce the discrepancy to 2 meters. The bottom was encountered at 2984.5 meters.

Punch cores were taken on barrels 1 through 5. On barrel 6, the drill string was rotated at 35 RPM (both the inner and outer barrels rotate with this type of system). Most cores taken with rotation showed only moderate distortion and disturbance. For example, a laminated sand was perfectly preserved. Some diatomites showed only a little downbowing of laminae near the edges of the core. Minimum circulation was used in cutting Core 7 with no adverse effects on recovery and on subsequent cores, circulation was used as necessary. Flows up to 200 gal/min were used in cutting Core 28. It is difficult to say whether or not large amounts of water washed the core away from the extended barrel, but it seemed they were not badly washed. On several occasions, good recovery was obtained when a high flow of water circulated around the bit.

Core 33 came up empty with the exception of one small ball of sand on the side of the core catcher. Marks on the extended barrel indicated abrasive action and it was surmised that the nonreversing circulation valve about 0.5 meters from the bit had jammed and prevented the core barrel from bottoming. The next core (34) recovered 4.0 meters of consolidated and soupy material; 6 meters were drilled. Barrel 35 was similar with 3.5 meters recovered in the 9.5 meters drilled. Drilling conditions during coring of

Figure 3. Seismic profile across Site 173 taken aboard Glomar Challenger.
the three barrels was similar. Circulation was required to keep the bit clean and drilling time increased over previous intervals. Drilling for Core 36 was even longer since the bit balled up easily. The drill string was raised and lowered to clean the bit—the hole appeared to stand up well with no caving or excess drilling torque. Mud was used on Core 36. After approximately 11 hours of drilling the andesite, the drill string was pulled.

A total of 196 meters of core was recovered from the 333.5-meter section. The recovery was 58.77 percent. This value was lowered by the repeated attempts to penetrate the volcanic floor first encountered in Core 34. Also, the diatomites were quite sticky and difficult to core; this lithology roughly corresponds with the lower recovery.

**Drilling Specifications**

The bottom hole assembly consisted of an 11⅝-inch Smith 4 cone seal bearing button bit and bit sub, core barrel, three 8⅛-inch drill collars, one 7⅞-inch drill collar, and one joint of heavy wall drill pipe. Site 173 was the first time this particular assembly was run. The unique part of this system is the extended inner core barrel that projects 4 inches below the 11⅝-inch Smith core bit. Holding the inner barrel in the extended position is a spring mandrel at the upper end of the inner barrel. While coring in ooze to medium hard formations the inner barrel is penetrating the formations before the core bit disturbs the area.
<table>
<thead>
<tr>
<th>METERS</th>
<th>DIATOMS</th>
<th>FORAMINIFERA</th>
<th>NANNOFOSILS</th>
<th>RADIO-LARIANS</th>
<th>BIOSTRATIGRAPHY</th>
<th>CHRONO-STRATIGRAPHY</th>
<th>GRAPHICAL LITHOGRAPHY</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>N23</td>
<td>EMILIANIA HUXLEYI</td>
<td>A. MIRALESI</td>
<td></td>
<td></td>
<td>PLEISTOCENE</td>
<td></td>
<td>Grayish-green SILTY CLAY</td>
</tr>
<tr>
<td>25</td>
<td>N22</td>
<td>EMILIANIA ANNULA</td>
<td></td>
<td></td>
<td></td>
<td>LATE PLEISTOCENE</td>
<td></td>
<td>Grayish, olive green SILTY CLAY with rare thin beds of arkosic sand</td>
</tr>
<tr>
<td>50</td>
<td>N21</td>
<td>EUCYRTIDIUM MATUYMAI</td>
<td></td>
<td></td>
<td></td>
<td>LATE PLEISTOCENE</td>
<td></td>
<td>Grayish green SILTY CLAY</td>
</tr>
<tr>
<td>75</td>
<td>N20</td>
<td>LAMPROCYRTIS HETEROPOROS</td>
<td></td>
<td></td>
<td></td>
<td>LATE PLEISTOCENE</td>
<td></td>
<td>Grayish-green SILTY CLAY and rare thin beds of arkosic sand</td>
</tr>
<tr>
<td>100</td>
<td>N19/20</td>
<td>DISCOASTER BROWERI</td>
<td></td>
<td></td>
<td></td>
<td>EARLY PLEISTOCENE</td>
<td>D</td>
<td>Grayish-green SILTY CLAY</td>
</tr>
<tr>
<td>125</td>
<td>N18</td>
<td>G. RUGOSUS</td>
<td></td>
<td></td>
<td></td>
<td>EARLY PLEISTOCENE</td>
<td>D</td>
<td>Grayish-green DIATOM-RICH SILTY CLAY</td>
</tr>
<tr>
<td>150</td>
<td>N17/18</td>
<td>DISCOASTER MENDOMOSENSIS</td>
<td>?</td>
<td></td>
<td></td>
<td>EARLY PLEISTOCENE</td>
<td>D</td>
<td>Light olive DIATOMITE</td>
</tr>
<tr>
<td>175</td>
<td>N17</td>
<td>DICTYOCAS A. ASPER</td>
<td>RETICULINA PSEUDOMINUTA</td>
<td></td>
<td></td>
<td>LATE HOLOCENE</td>
<td></td>
<td>Pale olive and light olive NANNOF-RICH DIATOMITE</td>
</tr>
<tr>
<td>200</td>
<td>N16</td>
<td></td>
<td>OMMATARTUS ANTEPENULTIMUS</td>
<td></td>
<td></td>
<td>LATE HOLOCENE</td>
<td></td>
<td>Pale olive and light olive NANNOF-RICH DIATOMITE</td>
</tr>
<tr>
<td>225</td>
<td>N15</td>
<td></td>
<td>Cannartus Petterssoni</td>
<td></td>
<td></td>
<td>HOLOCENE</td>
<td></td>
<td>Pale olive and light olive NANNOF-RICH DIATOMITE</td>
</tr>
<tr>
<td>250</td>
<td>N14</td>
<td></td>
<td>Dorcadospyris ALATA</td>
<td></td>
<td></td>
<td>HOLOCENE</td>
<td></td>
<td>Pale olive and light olive NANNOF-RICH DIATOMITE</td>
</tr>
<tr>
<td>SAND SHALE RATIO</td>
<td>CLAY % (&lt;2µ)</td>
<td>VOLCANIC ASH</td>
<td>DENSITY g/cm³</td>
<td>POROSITY %</td>
<td>NATURAL GAMMA</td>
<td>SOUND VELOCITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>--------------</td>
<td>--------------</td>
<td>---------------</td>
<td>------------</td>
<td>---------------</td>
<td>---------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRAPE ASECTION WT.</td>
<td>~GRAPE</td>
<td>10³ counts/75 sec</td>
<td>km/sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SYRINGE SAMPLE</td>
<td>SYRINGE SAMPLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 2.0 | 1.6 | 1.2 | 1.0 | 0.8 | 0.6 | 0.4 | 0.2 | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.6 | 2.0 |

| 0   | 25  | 50  | 75  | 100 | 125 | 150 | 175 | 200 | 225 | 250 |

SITE 173
<table>
<thead>
<tr>
<th>METERS</th>
<th>BIOSTRATIGRAPHY</th>
<th>FORAMINIFERA</th>
<th>NANNOFOSILS</th>
<th>RADIOSTRATIGRAPHY</th>
<th>GRAPHICAL LITHOLOGY</th>
<th>RECOVERY</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>Diatoms</td>
<td>N7/8</td>
<td>C. Floridanus</td>
<td>D. Alata</td>
<td></td>
<td></td>
<td>Silty clay-rich diatomite</td>
</tr>
<tr>
<td>275</td>
<td>NPD XIX</td>
<td>N7</td>
<td>DISCOASTER</td>
<td>CALOCYLETTA</td>
<td></td>
<td></td>
<td>Gray diatomite</td>
</tr>
<tr>
<td>300</td>
<td>NPD XXV</td>
<td>N6</td>
<td>DEFLANDREI</td>
<td>COSTATA</td>
<td></td>
<td></td>
<td>Chert</td>
</tr>
<tr>
<td>325</td>
<td>NPD XXV</td>
<td>N3/4</td>
<td>T. Carinatus</td>
<td>R. Bisepta</td>
<td></td>
<td></td>
<td>Late oligocene</td>
</tr>
<tr>
<td>350</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AnDESITE</td>
</tr>
</tbody>
</table>

Ash layers scattered throughout section.
### Core 1

<table>
<thead>
<tr>
<th>Cored Interval</th>
<th>Fossil Character</th>
<th>Lithology</th>
<th>Lithologic Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5-15.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lithologic Description**

- Grayish olive green
- Silty clay and clayey silt
- Color becoming grayish-green below here.

**Smear Slide** (Sect. 2, 100 cm)

- Clay 48%
- Silt 38%
- Forams 4%
- Radiolarians Tr.

Explanatory notes in chapter 1

### Core 2

<table>
<thead>
<tr>
<th>Cored Interval</th>
<th>Fossil Character</th>
<th>Lithology</th>
<th>Lithologic Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5-15.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lithologic Description**

- Dark greenish-gray and grayish-green silt
- Becoming richer in forams and finer grained below this level.

**Smear Slide** (Sect. 3, 100 cm)

- Clay 60%
- Silt 36%
- Forams 4%
- Siliceous microfossils Tr.

Explanatory notes in chapter 1
<table>
<thead>
<tr>
<th>Site 173 Hole Core 3 Cored Interval: 15.0-24.5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOSSIL CHARACTER</strong></td>
</tr>
<tr>
<td>C/M</td>
</tr>
<tr>
<td>C/M</td>
</tr>
<tr>
<td>F/M</td>
</tr>
<tr>
<td>C/G</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>R/G</td>
</tr>
<tr>
<td>C/G</td>
</tr>
<tr>
<td>Core Catcher</td>
</tr>
</tbody>
</table>

**Explanatory notes in chapter 1**

**LITHOLOGIC DESCRIPTION**

- Greenish-gray SILTY CLAY and CLAYEY SILT
- Smear Slide (Sect. 3, 100 cm)
- Clay 4KS
- Silt 48%
- Forams 2%
- Diatoms IX
- Sponge spicules 1%

<table>
<thead>
<tr>
<th>Site 173 Hole Core 4 Cored Interval: 24.5-34.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOSSIL CHARACTER</strong></td>
</tr>
<tr>
<td>C/G</td>
</tr>
<tr>
<td>C/G</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>A/G C/M</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>-., G</td>
</tr>
<tr>
<td>A/G C/G</td>
</tr>
<tr>
<td>Core Catcher</td>
</tr>
</tbody>
</table>

**Explanatory notes in chapter 1**

**LITHOLOGIC DESCRIPTION**

- Dark greenish gray SILTY CLAY
- Smear Slide (Sect. 3, 100 cm)
- Clay 57%
- Silt 40%
- Sponge spicules 2%
- Diatoms 3%
- Forams Tr.
- Radiolaria Tr.
<table>
<thead>
<tr>
<th>Site 173</th>
<th>Core 5</th>
<th>Cored Interval: 34.0-43.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil Character</td>
<td>Lithology</td>
<td>Lithologic Description</td>
</tr>
<tr>
<td>Age</td>
<td>Zone</td>
<td>Fossil</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>FOSSIL</td>
</tr>
<tr>
<td>1.0</td>
<td>0</td>
<td>DARK GREENISH-GREY</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>FOSSIL</td>
</tr>
<tr>
<td>1.0</td>
<td>0</td>
<td>DARK GREENISH-GREY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 173</td>
<td>Core 6</td>
<td>Cored Interval: 43.5-53.0</td>
</tr>
<tr>
<td>Fossil Character</td>
<td>Lithology</td>
<td>Lithologic Description</td>
</tr>
<tr>
<td>Age</td>
<td>Zone</td>
<td>Fossil</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>FOSSIL</td>
</tr>
<tr>
<td>1.0</td>
<td>0</td>
<td>DARK GREENISH-GREY</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>FOSSIL</td>
</tr>
<tr>
<td>1.0</td>
<td>0</td>
<td>DARK GREENISH-GREY</td>
</tr>
</tbody>
</table>

**Lithologic Description**
- Dark greenish-gray silty clay
- Possible sand layer
- Clay 50%
- Silt 45%
- Siliceous 5%
- Forams 2%
- Microfossils Tr.
- Silty clay with trace glass shards and glauconite.

Explanatory notes in chapter 1.
### Site 173, Hole 7, Cored Interval: 50.0-62.5

<table>
<thead>
<tr>
<th>AGE</th>
<th>ZONE</th>
<th>FOSSIL CHARACTER</th>
<th>HORIZONTAL切れ</th>
<th>DEPTH (METERS)</th>
<th>LITHOLOGICAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Dark greenish-gray Silt Clay

**Lithological Description**

- Dark greenish-gray Silt Clay
- Smear Slide

**Explanatory notes in chapter 1**

### Site 173, Hole 8, Cored Interval: 62.5-72.0

<table>
<thead>
<tr>
<th>AGE</th>
<th>ZONE</th>
<th>FOSSIL CHARACTER</th>
<th>HORIZONTAL切れ</th>
<th>DEPTH (METERS)</th>
<th>LITHOLOGICAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Grayish olive-green Silt Clay
- A few bioturbated thin beds of Fine Sand
- Some clayey silt

**Lithological Description**

- Grayish olive-green Silt Clay
- Upper silty clay is dk. grish. gy.

**Explanatory notes in chapter 1**
# Site 173 Hole

## Core 12

### Cored Interval: 100.5 - 110.0

#### FOSSIL CHARACTER

<table>
<thead>
<tr>
<th></th>
<th>C/M</th>
<th>F/P</th>
<th>C/M</th>
<th>A/M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>A/G</td>
</tr>
</tbody>
</table>

#### LITHOLOGIC DESCRIPTION

- **Upper part of core**
  - About 3% diatoms.
  - Grayish olive-green Silt 25%
  - In part diatom-rich.
  - Where few diatoms, color is grayish-green.

- **Middle part of core**
  - About 1% diatoms.
  - V. fn. sand, 1 cm thick.

- **Lower part of core**
  - About 5% diatoms.
  - Smear Slide (Sect. 3, 100 cm)
  - Clay 70%
  - Silt 25%
  - Diatoms 3%
  - Sponge spicules 1%
  - Radiolaria Tr.

---

# Site 173 Hole

## Core 21

### Cored Interval: 91.0 - 100.5

#### FOSSIL CHARACTER

<table>
<thead>
<tr>
<th></th>
<th>F/M</th>
<th>A/M</th>
<th>A/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>A/G</td>
<td>A/G</td>
</tr>
</tbody>
</table>

#### LITHOLOGIC DESCRIPTION

- **Grayish olive-green Silty Clay and Clay**
  - V. fn. sand, 1 cm thick.
  - V. fn. sand, 16 cm thick.

- **Smear Slide (Sect. 2, 100 cm)**
  - Silty Clay

---

**Explanatory notes in chapter 1**
Site 173 Hole 13 Cored Interval: 110.0-119.5

**LITHOLOGIC DESCRIPTION**

Upper half of core: color is dusky yellow-green.

- Smear Slide (Sect. 2, 100 cm)
  - Clay 54%
  - Silt 35%
  - Diatoms 11%
  - Sponge spicules 1%

Lower half of core: color is grayish-olive-green. Irregular 3 cm thick layers of pale grayish-green clay about every 50 cm.

- Smear Slide (Sect. 5, 128 cm)
  - Clay 90%
  - Silt 10%
  - Diatoms 1%
  - Sponge spicules 1%

Explanatory notes in chapter 1

---

Site 173 Hole 14 Cored Interval: 119.5-129.0

**LITHOLOGIC DESCRIPTION**

Grayish-green SILTY CLAY

Very fine sand, 1 cm thick.

- Smear Slide (Sect. 2, 100 cm)
  - Clay 54%
  - Silt 35%
  - Diatoms 11%
  - Sponge spicules 1%

Very fine sand, 0.5 cm thick.

- Smear Slide (Sect. 5, 128 cm)
  - Clay 90%
  - Silt 10%
  - Diatoms 1%
  - Sponge spicules 1%

Explanatory notes in chapter 1

*Lamprocystis heteroporos*
<table>
<thead>
<tr>
<th>Age</th>
<th>Zone</th>
<th>Fossil Character</th>
<th>Lithology</th>
<th>Lithologic Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C/M</td>
<td>Void</td>
<td>R/G</td>
<td>English olive-green</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R/P</td>
<td>Silty clay, in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R/M</td>
<td>places diatom bearing.</td>
</tr>
</tbody>
</table>

**Core Interval:** 129.0-138.5

**Lithologic Description:**
- Fine sand, 1 cm thick.
- Very fine sand.
- Basal 20 cm of core:
  - Light olive clay rich in diatoms and nannofossils.

**Smear Slide (Sect. 4.100 cm):**
- Diatoms 60%
- Clay 20%
- Silt 5%
- Nannos 5%
- Sponge spicules 2%

**Lower part of core has more silt and clay.**

---

**Explanatory notes in Chapter 1**
- *Ceratolithus tricarinatus*
- *Discoaster mendocinensis*
### Site 173 Hole Core 17 Cored Interval: 148.0-157.5

<table>
<thead>
<tr>
<th>Layer</th>
<th>Zone</th>
<th>Fossil Character</th>
<th>Lithology</th>
<th>Lithologic Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Light Olive</td>
<td>Nannophycal Diatomite</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Light Olive</td>
<td>Nannophycal Diatomite</td>
</tr>
</tbody>
</table>

#### Explanatory notes in chapter 1

### Site 173 Hole Core 18 Cored Interval: 157.5-167.0

<table>
<thead>
<tr>
<th>Layer</th>
<th>Zone</th>
<th>Fossil Character</th>
<th>Lithology</th>
<th>Lithologic Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Light Olive</td>
<td>Nannophycal Diatomite</td>
</tr>
</tbody>
</table>

#### Explanatory notes in chapter 1

**Explanatory notes in chapter 1**

---

**Site 173**

**Hole Core 17**

**Cored Interval:** 148.0-157.5

- **Light Olive Diatomite**
  - Bed of very pale green nanno-rich diatomite:
  - Smear Slide (Sect. 3, 100 cm)
    - Diatoms: 70%
    - Nannos: 20%
    - Clay: 7%
    - Silt: 2%
    - Radiolaria: 1%
  - Typical Smear Slide of diatomite:
    - Smear Slide (Sect. 3, 60 cm)
      - Diatoms: 75%
      - Nannos: 15%
      - Clay: 5%
      - Silt: 3%
      - Radiolaria: 2%

**Explanatory notes in chapter 1**

---

**Site 173**

**Hole Core 18**

**Cored Interval:** 157.5-167.0

- **Light Olive Nanno-Rich Diatomite**
  - Bed of very pale green nanno-rich diatomite:
    - Smear Slide (Sect. 2, 100 cm)
      - Diatoms: 70%
      - Nannos: 20%
      - Clay: 7%
      - Silt: 2%
      - Radiolaria: 1%
  - Lt. colored bed, 5 cm thick
  - Basal 110 cm of core is pale olive color
  - Ash bearing diatomite
## Site 173
### Hole Core 19 Cored Interval: 167.0-176.5

<table>
<thead>
<tr>
<th>AGE</th>
<th>ZONE</th>
<th>FOSSIL CHARACTER</th>
<th>LITHOLOGY</th>
<th>DEPOSITIONAL ENVIRONMENT</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>LIGHT OILY</td>
<td>NANNO-RICH</td>
<td>DIATOMITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 cm thick, much bioturbated.</td>
<td>Above this level, color is light olive; below is pale olive</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trace it. ash in lower part of core</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20 cm bed with paler color; No detectable lithology change.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Smear Slide (Sect. 3, 100 cm)
- Diatoms: 50%
- Nannos: 15%
- Clay: 10%
- Silt: 4%
- Radiolaria: 5%

Explanatory notes in chapter 1

## Site 173
### Hole Core 20 Cored Interval: 176.5-186.0

<table>
<thead>
<tr>
<th>AGE</th>
<th>ZONE</th>
<th>FOSSIL CHARACTER</th>
<th>LITHOLOGY</th>
<th>DEPOSITIONAL ENVIRONMENT</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>LIGHT OILY</td>
<td>NANNO-RICH</td>
<td>DIATOMITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thin bed of sandy ash</td>
<td>Above this level, color is lt. olive; below, pale olive, and nanno-rich</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thin ash bed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Smear Slide (Sect. 3, 100 cm)
- Diatoms: 80%
- Nannos: 10%
- Clay: 7%
- Silt: 3%

Explanatory notes in chapter 1
Site 173 Core 21 Cored Interval: 186.0-195.5

Pale olive DIATOMITE

Smear Slide (Sec. 1, 100 cm)
Diatoms 80X
Nannos 10%
Clay 7%
Silt 3%

Middle part of core grayish olive color, with only a trace of nannos.

Lt. ash, 0.5 cm thick bed, v. fn. sand size.

Ash bed 1 cm thick

Pale olive nanno-rich diatomite

Site 173 Core 22 Cored Interval: 195.5-206.0

Light olive NANNO-RICHT garnet

Smear Slide (Sec. 4, 100 cm)
Diatomite 70%
Calc. nannos 10%
Clay 10%
Silt 2%
Forams 1%
Radiolaria 1%

Explanatory notes in chapter 1
Site 173 Hole 23 Cored Interval: 205.0-214.5

LITHOLOGIC DESCRIPTION
Pale olive NANNO-DEAEMITE
Lt. ash, 1.5 cm thick bed, bioturbated
Lt. olive color
Smear Slide Diatoms 65%
Calc. nanos 20%
Radiolaria 5%

Lt. olive color, fewer nanos

Explanatory notes in chapter 1

Site 173 Hole 24 Cored Interval: 214.5-224.0

LITHOLOGIC DESCRIPTION
Pale olive NANNO-DEAEMITE

Smear Slide (Sect. 1,130 cm)
Nannos 60%
Clay 30%
Silt 10%
Radiolaria 5%

Thin ash bed

Passes gradually into light olive color

Explanatory notes in chapter 1
<table>
<thead>
<tr>
<th>Site 173</th>
<th>Hole</th>
<th>Core 25 Cored Interval: 224-233.5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LITHOLOGIC DESCRIPTION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light olive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interbedded pale olive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NANNO-DIATOMITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and light olive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NANNO-RICH DIATOMITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smear Slide (Sect. 1, 100 cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light olive lithology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diatoms 85%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nannos 15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light olive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Color pale olive where</td>
</tr>
<tr>
<td></td>
<td></td>
<td>not otherwise shown.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smear Slide of pale olive lithology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diatoms 70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nannos 30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silt and clay 5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand and ash 3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>? mixing with ash bed</td>
</tr>
</tbody>
</table>

Explanatory notes in chapter 1
### Site 173 Hole Core 30 Cored Interval: 271.5-281.0

<table>
<thead>
<tr>
<th>AGE ZONE</th>
<th>FOSSIL CHARACTER</th>
<th>LITHOLOGY</th>
<th>DEFORMATION</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grayish olive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CLAY-RICH DIATOMITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Discoaster deflandrei</em></td>
<td>smear slide</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>M. mediterraneus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Site 173 Hole Core 31 Cored Interval: 281.0-285.5

<table>
<thead>
<tr>
<th>AGE ZONE</th>
<th>FOSSIL CHARACTER</th>
<th>LITHOLOGY</th>
<th>DEFORMATION</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Greenish gray</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NANNODIATOMITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Site 173 Hole Core 32 Cored Interval: 285.5-295.0

<table>
<thead>
<tr>
<th>AGE ZONE</th>
<th>FOSSIL CHARACTER</th>
<th>LITHOLOGY</th>
<th>DEFORMATION</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pieces of 1. altered basic volcanic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. chert</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. lithified calcareous clay-sand-diatomite</td>
</tr>
</tbody>
</table>

Explanatory notes in chapter 1

*Discoaster deflandrei*

**NOTE:** Core 33, no recovery. Cored interval: 295.5-304.5 m.
SITE 173

WET-BULK DENSITY, gm/cc

POROSITY, %

SOUND VELOCITY, km/sec

SOUND VELOCITY, km/sec

SECTION

CM

Grain Density

SITE 173

WET-BULK DENSITY, gm/cc

POROSITY, %

SOUND VELOCITY, km/sec

Grain Density, gm/cc

SECTION

CM

0 25

173-3-1 173-3-2 173-3-3 173-3-4 173-3-5 173-3-6

photograph not available
SITE 173

Grain Density, gm/cc

Porosity, %

Sound Velocity, km/sec

Wet-Bulk Density, gm/cc

SECTION

173-8-1  173-8-2  173-8-3  173-8-4  173-8-5  173-8-6
WET-BULK DENSITY, gm/cc

POROSITY, %

SOUND VELOCITY, km/sec

Grain Density, gm/cc

SECTION

173-11-1 173-11-2 173-11-3 173-11-4
SITE 173

WET-BULK DENSITY, gm/cc

POROSITY, %  SOUND VELOCITY, km/sec

SECTION

CM

173-14-1 173-14-2 173-14-3
WET-BULK DENSITY, gm/cc

POROSITY, %  SOUND VELOCITY, km/sec

Grain Density gm/cc

SECTION

CM

0 25 50 75 100 125 150

173-23-1 173-23-2 173-23-3

SITE 173