30. REDEPOSITED SEDIMENTS ALONG THE LINE ISLANDS, EQUATORIAL PACIFIC[1]

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The purpose of this paper is to document the occurrence and main types of redeposited sediments in the Line Islands region by a brief discussion of their descriptive and interpretive elements followed by a series of annotated photographs. Various aspects of these deposits are currently under study and will be published at a later time; thus a rigorous analysis of these sediments is not included in this volume.

Hole 315A and Site 316 of JOIDES Leg 33 were drilled along the eastern side of the Line Islands (Figure 1). Sediments at these sites are divisible into six mappable lithologic units that are described in the site reports of this volume. Within these units we encountered a wide variety of Cretaceous to Quaternary redeposited archipelagic sediments which at certain stratigraphic intervals comprise up to 50% or more of the section. Texturally, these deposits range from beds composed of silt and sand-sized grains to breccias and conglomerates with clasts up to 2 × 5 cm in cross-section. The finer-grained beds exhibit well-defined fabrics and primary sedimentary structures such as normal size grading of particles, parallel and low-angle cross-lamination, and selective sorting of grains with various densities. Commonly, the basal parts of these beds have grain-supported textures which grade upward into mud-supported sediments. In contrast, the coarser grained allochthonous conglomerates and breccias tend to be massively bedded, poorly sorted, and virtually devoid of any well-defined primary sedimentary structures. Where grading or bedding does occur in the coarse debris, it is restricted to the upper few centimeters of an otherwise massive unit. Clasts in these breccias and conglomerates are commonly set in a pervasive mud matrix such that the clasts are mud supported. Some breccias, however, are grain supported with the interclast space filled with sand and clay.

These sediments, believed to be redeposited, probably were derived from three major sources: shallow marine carbonate complexes along the Line Islands, shallow and/or deeper water volcanic terrains, and basinal deep-marine environments. We suspect various mechanisms were involved during their transport. These mechanisms possibly included a spectrum from viscous, turbulent movement for the graded and laminated sandy debris to plastico-viscous motion of a debris flow type for the massively bedded, mud-rich breccias and conglomerates. Gradual deposition from a turbulent suspension is a reasonable interpretation for the silts and sands that display normal grading, cross-lamination, and parallel lamination (Kuenen, 1964; Harms and Fahnestock, 1965; Walker, 1965). In contrast, deposition of the mud-supported breccias possibly took place as a mixed mass, rather than as a gradual vertical accumulation of particles. This process is suggested by their massive, poorly sorted heterogeneous textures and virtual lack of grading, parallel lamination, or cross-lamination. The uppermost few centimeters of some breccias form the only part that appears to have been deposited gradually from a turbulent suspension. Such breccias have many textural features similar to those of allochthonous carbonates interpreted by Cook et al. (1972) to have formed from submarine debris flows.

Although we recognize various types of redeposited beds, we distinguish only the following main divisions:

1) **Pelagic constituents only**: Graded units comprised of pelagic foraminifers and nannofossils are not uncommon; however, they are difficult to recognize. These graded layers are generally very thick (60-250 cm) and are characterized by a slight color change from clear white at their bases to faint yellowish-brown at their tops. This color change is presumably linked to increased clay content in the higher levels of the redeposited unit. Foraminifer tests are concentrated in the basal levels. Internal structures are not recognizable; burrow mottling may occur toward the tops. Good photographs of this type could not be made as these beds occur high in the stratigraphic section in unconsolidated sediments.

2) **Mixed pelagic and reef and/or bank associated constituents plus minor to moderate volcanogenic constituents**: Grading is obvious in most of these units with green volcanogenic grains and large foraminifers concentrated in basal layers. Scour structures are common. Cross-lamination, parallel lamination, and grading are all well displayed. Lutite fractions are rare in the upper levels, but burrowing is widespread (Figures 2-8).

3) **Volcanogenic constituents only**: Resedimented layers comprised entirely of volcanogenic constituents are of two types: breccias (up to 3 m thick), and graded, cross-, and parallel-laminated sand-sized units. Colors generally are light to dark greenish-black. Burrowed tops are conspicuous with "exponentially" downward decreasing abundance of burrows (Figures 9-12).

4) **Slumped beds**: Slumped folds and parallel-laminated zones produced by sediment slippage are rare. They appear to be most prevalent in conjunction with beds containing abundant volcanogenic material and therefore are correspondingly more common in the

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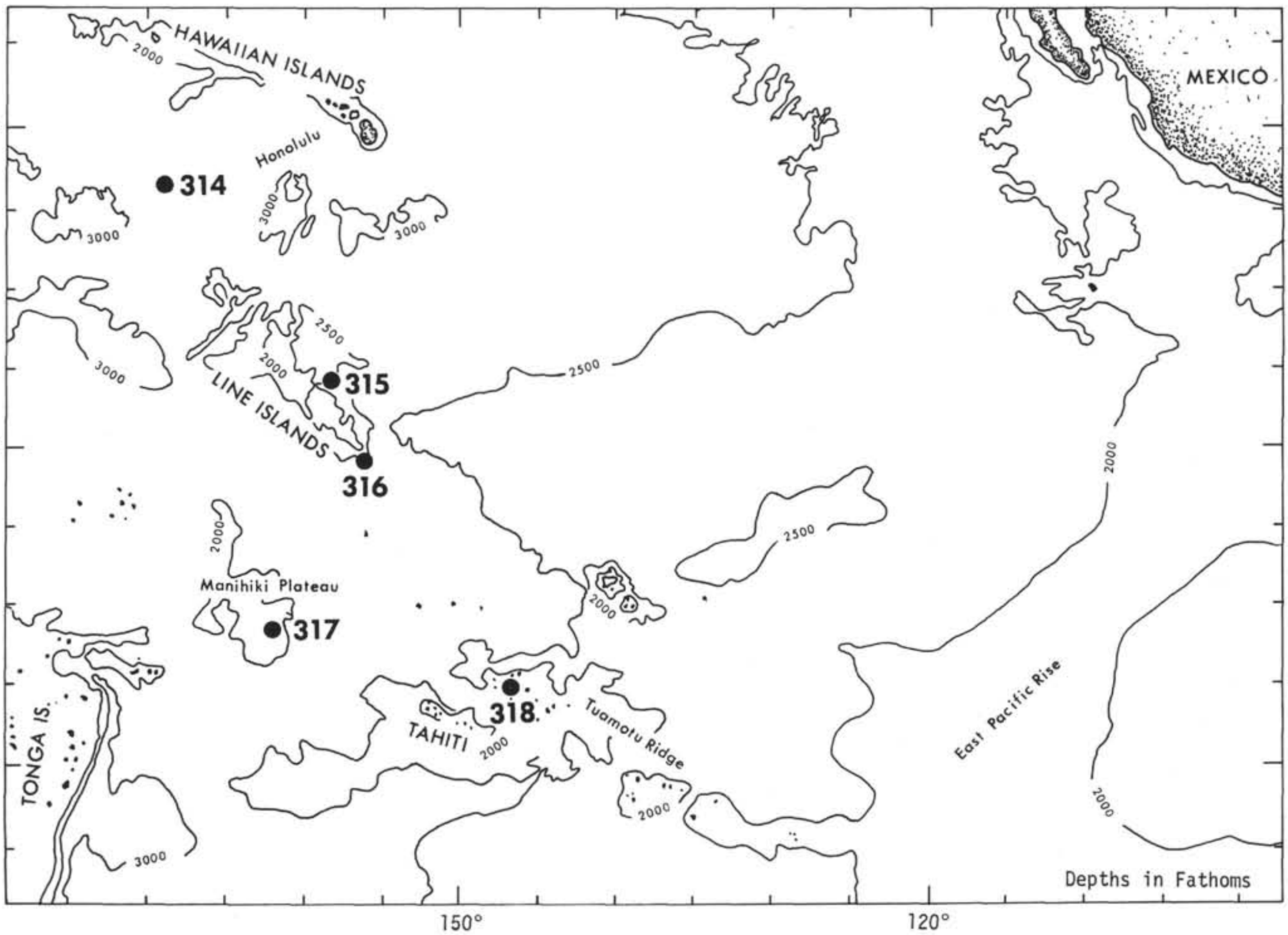

Figure 1. *Location of sites drilled during Leg 33.*

basal sections. Cores contain slump beds frozen in various stages of development. These include incipient bed failure, phacoid-type soft-sediment slippage, convolute folds, and mud-flow textures (Figures 13-18).

ACKNOWLEDGMENT

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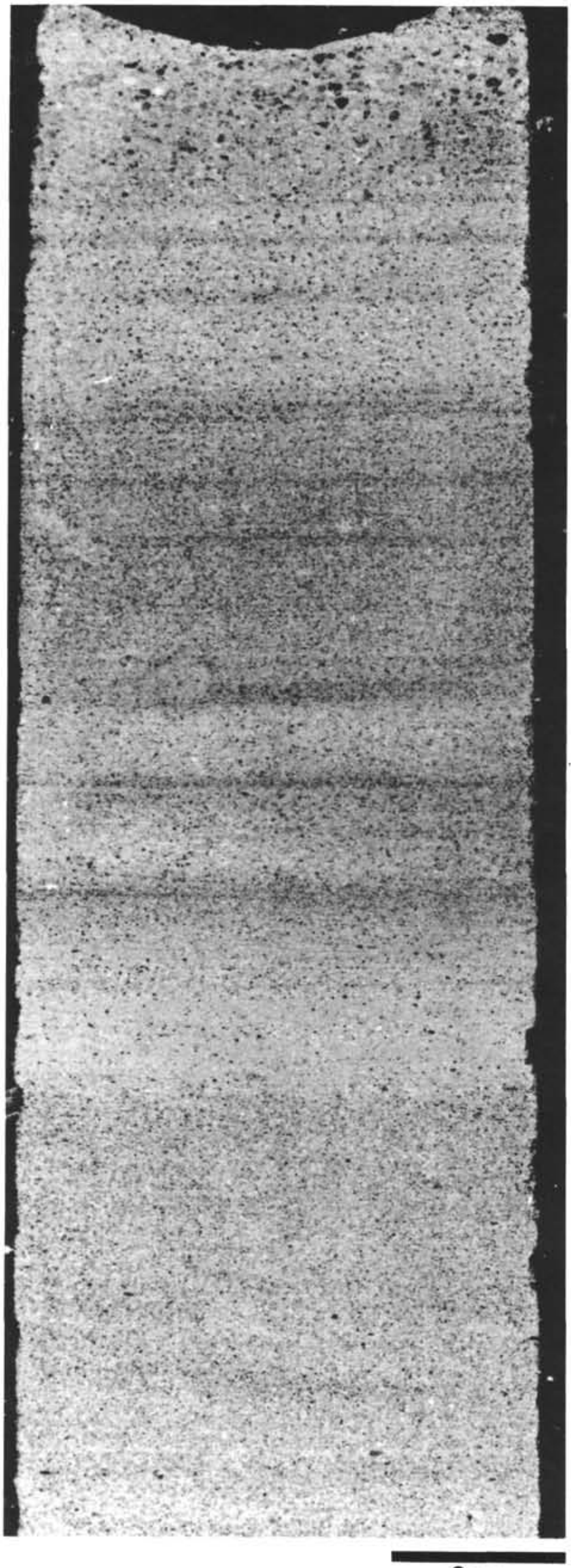


Figure 2. *Sample 33-316-23-4, 130-150 cm.*

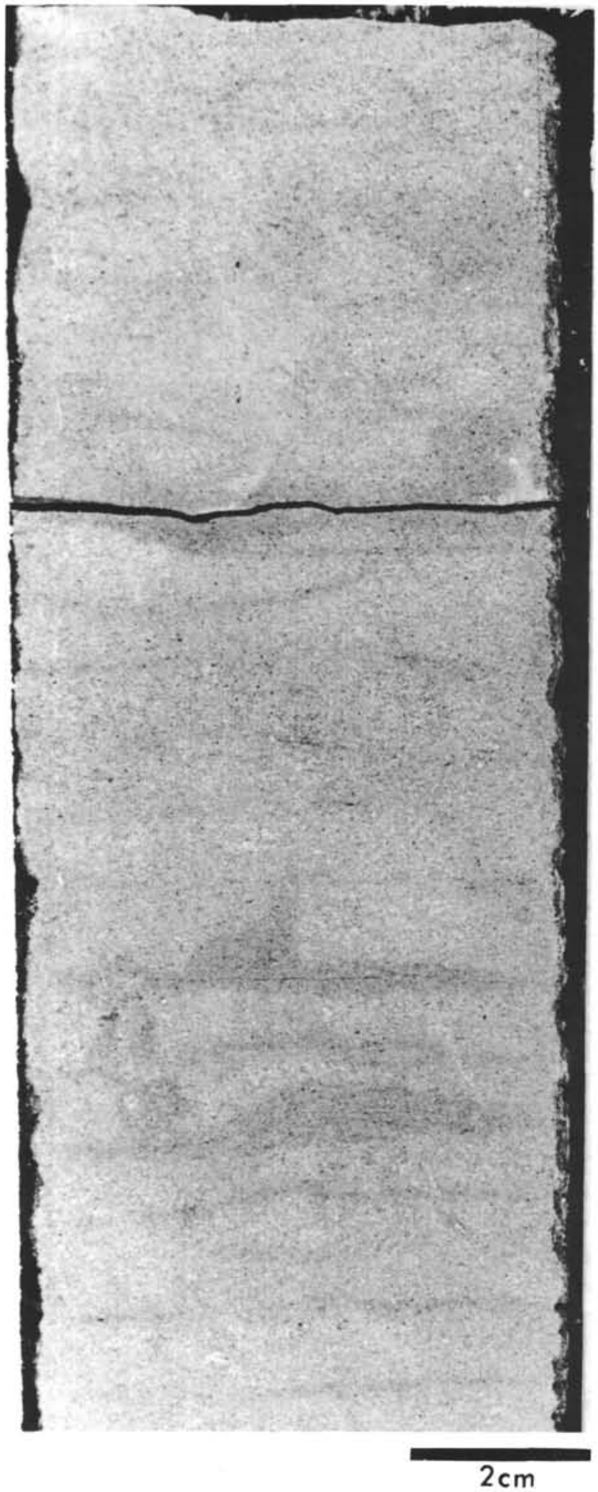


Figure 3. *Sample 33-316-23-4, 80-90 cm.*

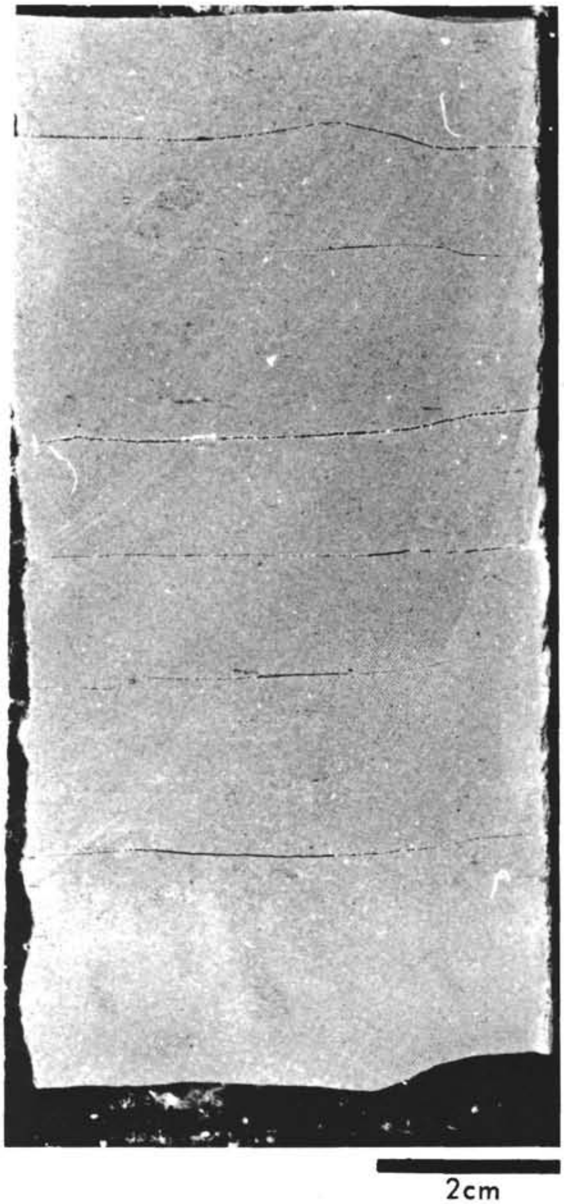


Figure 4. *Sample 33-316-23-4, 10-20 cm. (671 m), Unit 4–upper Campanian. Figures 2, 3, and 4 are part of a single allochthonous bed about 3 meters thick. Figure 2 is the lowermost 18 cm of this bed. Here the basal 2 cm at 148-150 cm consists of massive to faintly laminated granules of palagonite and large planktonic forams with a grainstone to packstone fabric. This grades upward into finer grained parallel laminated palagonitic and foram-rich sands that are also grain supported. Figure 3 at 80-90 cm is distinctly finer grained, has only faint laminations, and starts to show evidence of slight burrowing. Figure 4, higher in the same bed, appears massive with only faint traces of laminations and questionable burrowing. In this upper interval mud-supported wackestone textures are dominant.*

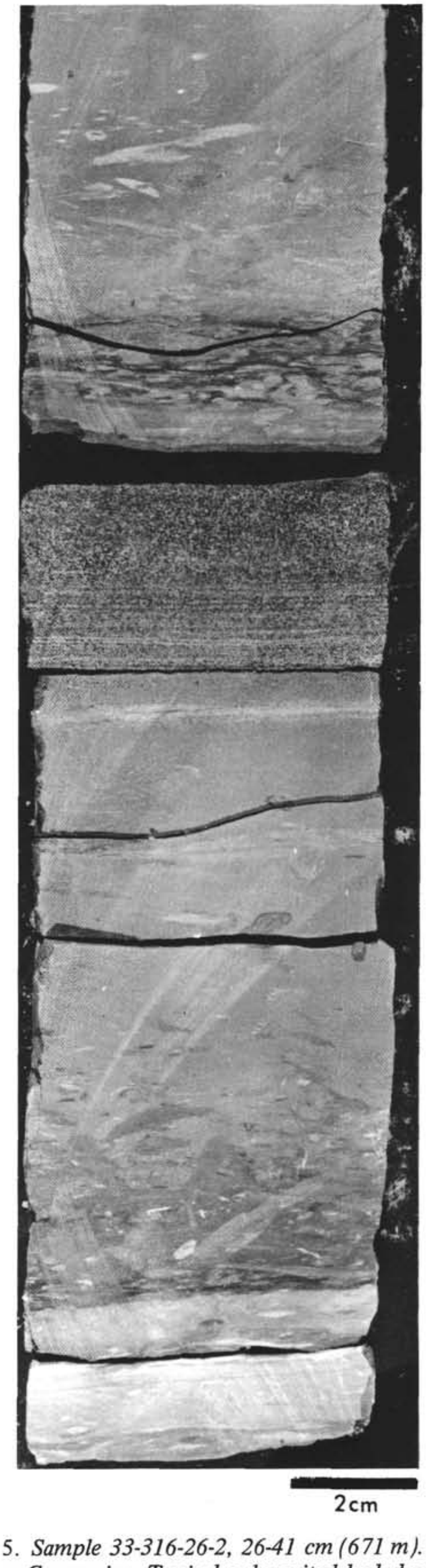


Figure 5. *Sample 33-316-26-2, 26-41 cm (671 m). Unit 4–upper Campanian. Typical redeposited bed about 15 cm thick. This type of allochthonous deposit is very common*

throughout the upper part of Unit 4. These beds range from 5 to 80 cm thick. This bed exhibits a basal 2 cm of massive to poorly laminated grain supported sands. The sand is composed of dark colored palagonite grains admixed with light colored forams. This grades upward into a 1-cm-thick finely laminated, grain-supported palagonitic-foram sand. The uppermost 10-12 cm are typically mud-supported nanno-rich wackestones with abundant burrows.

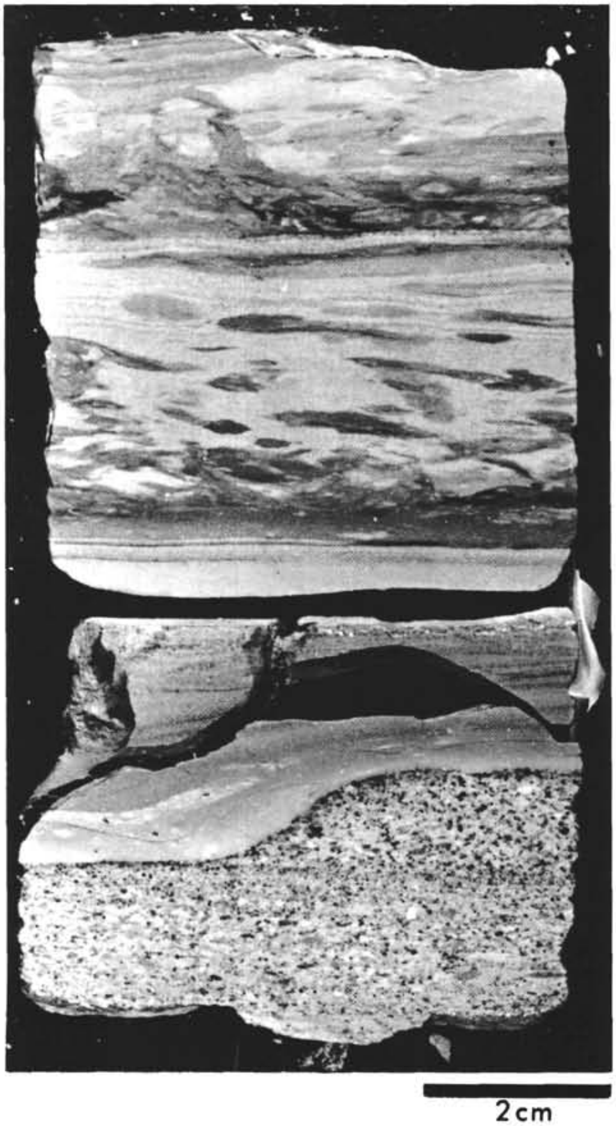


Figure 6. *Sample 33-315A-20-1, 128-134 cm (826 m), Unit 3–lower Maestrichtian. Basal portion of a graded foraminiferal grainstone with common rounded palagonite grains and shallow water carbonates. Examples of erosional scour and basal current laminations.*

Figure 7. *Sample 33-315A-19-2, 52-60 cm (819 m). Unit 3–middle Maestrichtian. Graded foraminiferal grainstone with shallow water carbonate debris, forams, and rounded palagonite clasts. The basal contact with reddish-orange burrowed limestone is sharp, but the upper part of the graded layer is diffusely burrowed beyond recognition. Burrows show signs of compaction and perhaps some incipient slippage. Faint subparallel, light and dark, laminations are visible.*

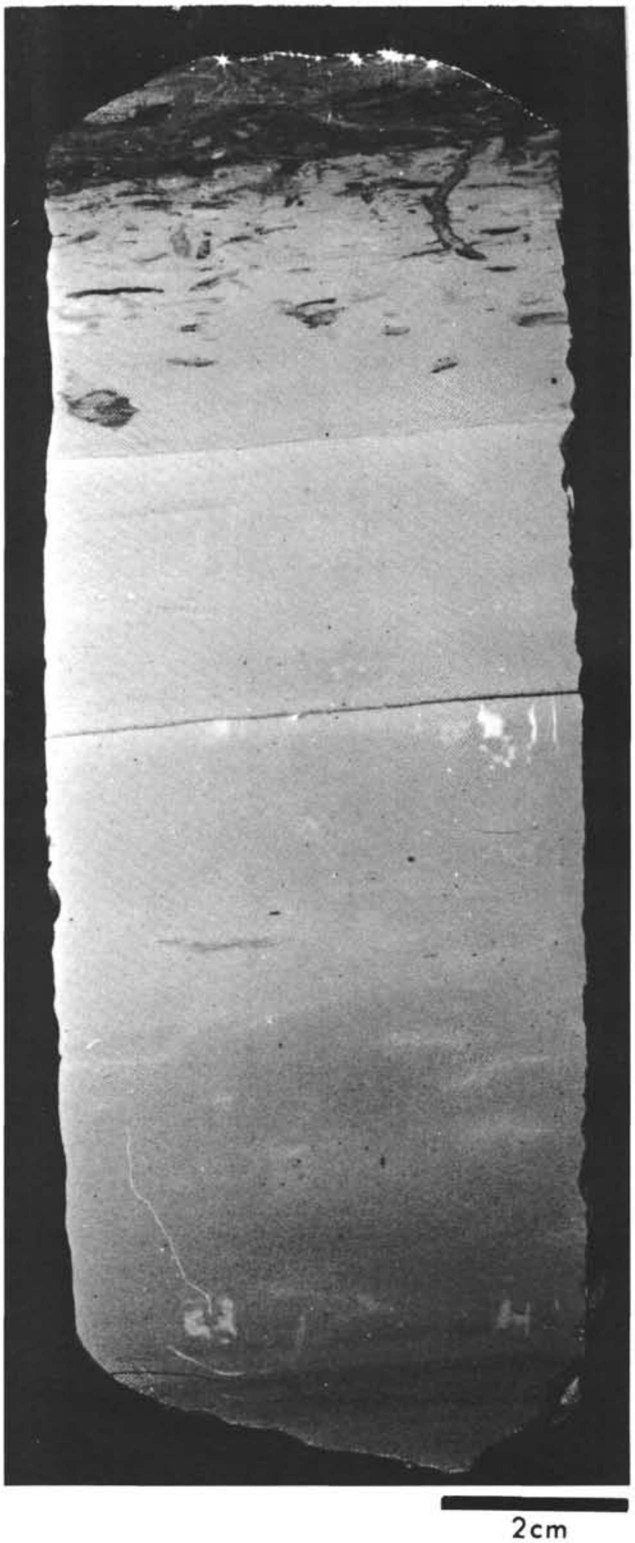
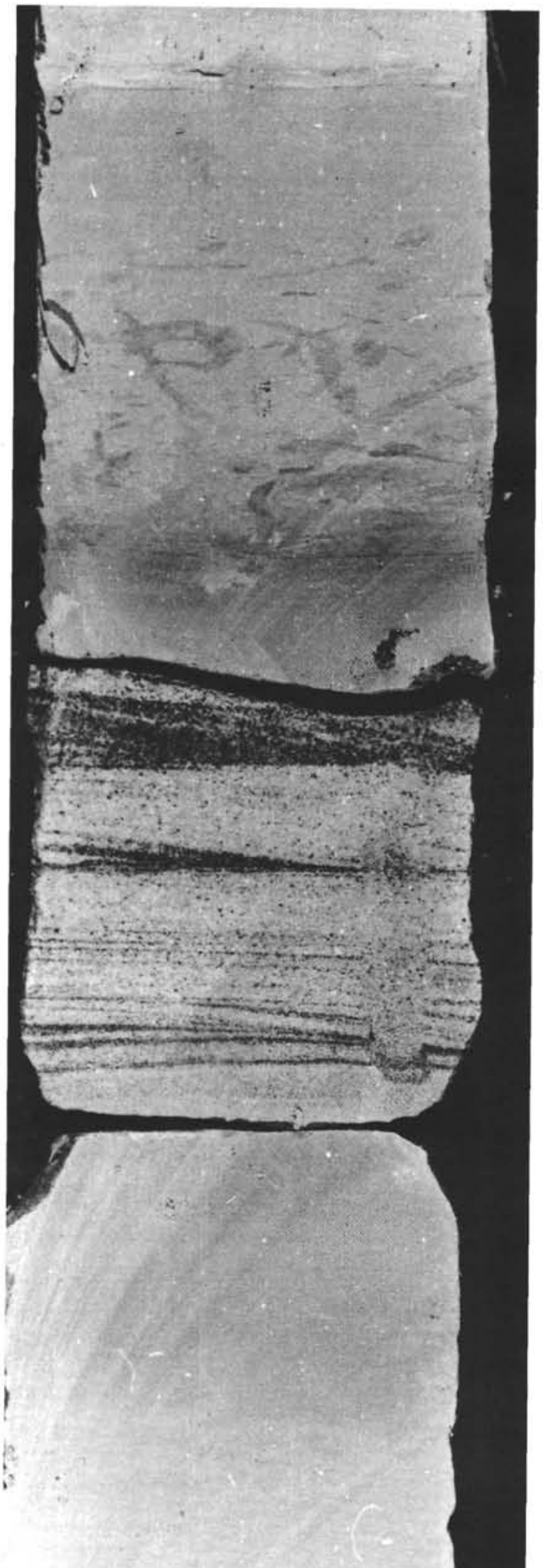


Figure 8. *Sample 33-315A-24-6, 30-45 cm (880 m). Unit 3–middle Maestrichtian. Example of a typical hemipelagic, fine-grained graded bed. Consists mostly of fine-grained carbonate with some clay and admixtures of volcanic grains. The base is distinguished by finely laminated concentrations of dark volcanic grains, mostly palagonite. Note the undisturbed homogeneous mid-section and the upward increase of burrowing near the top.*

Figure 9. *Sample 33-315A-23-4, 125-150 cm (860 m). Unit 3–middle Campanian. Light to dark greenish-gray, graded volcanogenic sand layer. Calcareous components speckled in the base. Note the uneven basal contact, parallel laminations above and below a zone of subparallel and cross-bedded laminations.*



2cm

Figure 10. *Sample 33-316-24-3, 32-38 cm (689 m). Unit 4–upper Maestrichtian. 6-cm-thick allochthonous bed which exhibits good parallel laminations and low-angle cross-laminations. Note the base of the bed is slightly channelized with up to 0.5 cm of relief. The dark layers are very dusky red-purple volcanic-rich sands with grain-supported textures, whereas, the lighter colored laminations are foram-nanno-rich packstones and grainstones. The zone from 32.5 to 37 cm exhibits a large vertical burrow.*

2cm

Figure 11. *Sample 33-315A-20-5, 111-123 cm (833 m). Unit 3–lower Maestrichtian. Three cycles of dark to light greenish-gray, graded volcaniclastic graded beds. Typically carbonate poor base with subparallel laminations comprising volcanic grains. Upwards increasingly calcareous. Tops show characteristic burrowing. Note how burrowing organisms have mixed basal volcanic sand into the lutite portion of the lowest bed.*

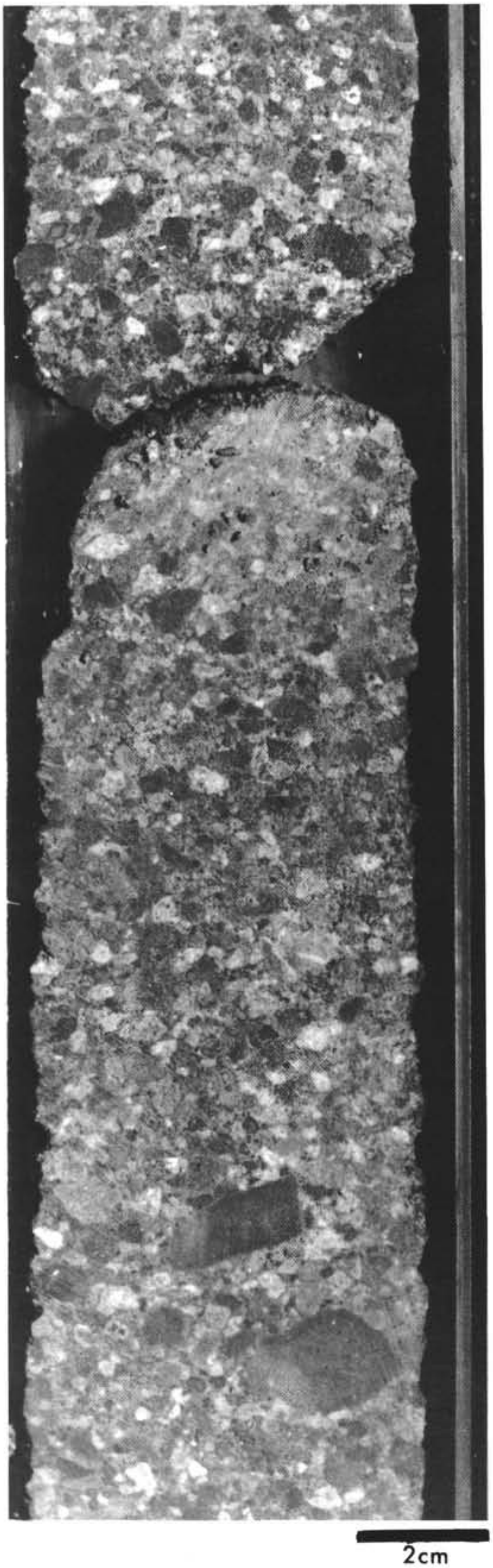


Figure 12. *Sample 33-316-28-1, 102-125 cm (772 m). Unit 4–middle Campanian. Middle part of an allochthonous basaltic scoria-rich conglomerate and breccia which is at least 2.5 meters thick. It is greenish-black, with no internal lamination or bedding. Many tabular clasts are oriented in subhorizontal attitudes. Clasts are poorly sorted and range from sand sizes to 1.5 × 5.5 cm in cross-section with the dominant size being about 0.5 to 1.0 cm across. It is crudely normally graded, with the largest clasts and greatest proportion of large clasts near the base. In order of decreasing abundance, clast types include greenish-black altered basaltic scoria, white foram limestones with packstone to grainstone textures, dark green volcanic sandstones, and rare fresh-appearing basaltic scoria. The entire bed is grain supported with the interclast space filled with poorly sorted clay to sand-sized material.*

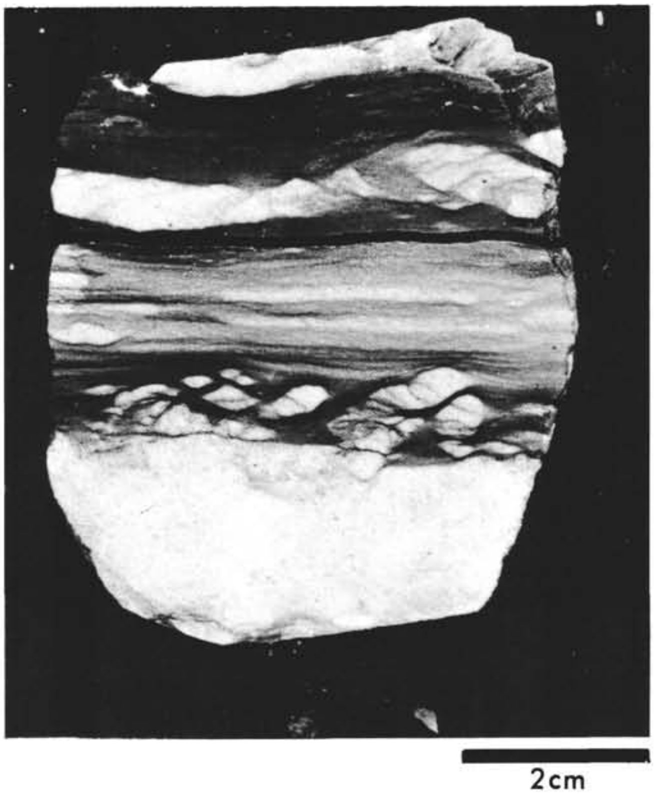


Figure 13. *Sample 33-315A-19-2, 68-74 cm (818 m). Unit 3–middle Maestrichtian. Heavily burrowed remnant former lutite portion of a graded and laminated green volcaniclastic siltstone. Note the evidence of soft sediment slippage with enechelon shearing of burrows.*

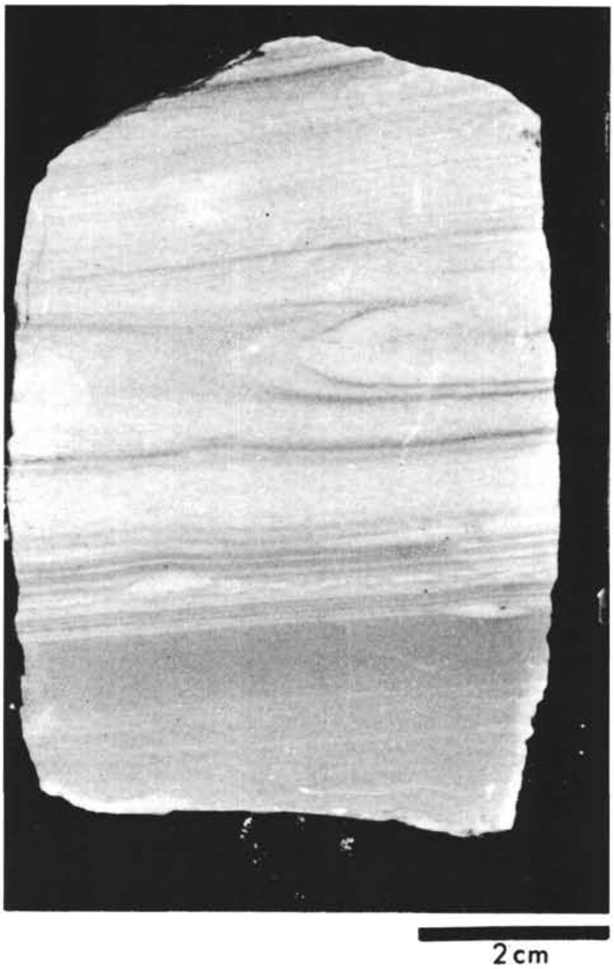


Figure 14. *Sample 33-316-18-1, 141-150 cm (591 m). Unit 4–(?) Maestrichtian. White to grayish-green laminated nanno-foram limestone with slump fold at 146 cm. Slump fold has a nearly horizontal fold axis. In third-dimension this slump appears to have quite a complex geometry.*

Figure 15. *Sample 33-316-7-2, 70-85 cm (468 m). Unit 3–Eocene. Slumping in dark brown dolomitized nanno chalk. Slump angles are up to 70°. Bedding above and below slumping is nearly horizontal.*

Figure 16. *Sample 33-315A-24-3, 120-130 cm (899 m). Unit 4–lower Campanian. Soft sediment deformation mobilized layer containing palagonite and other volcanic grains in a clay and micrite matrix. Light color is mostly a greenish montmorillonite. High water contents in a redeposited layer may have caused instability and failure. Dark layers at the top of the photograph are due to streaking elongation of burrows in the top of the graded bed.*

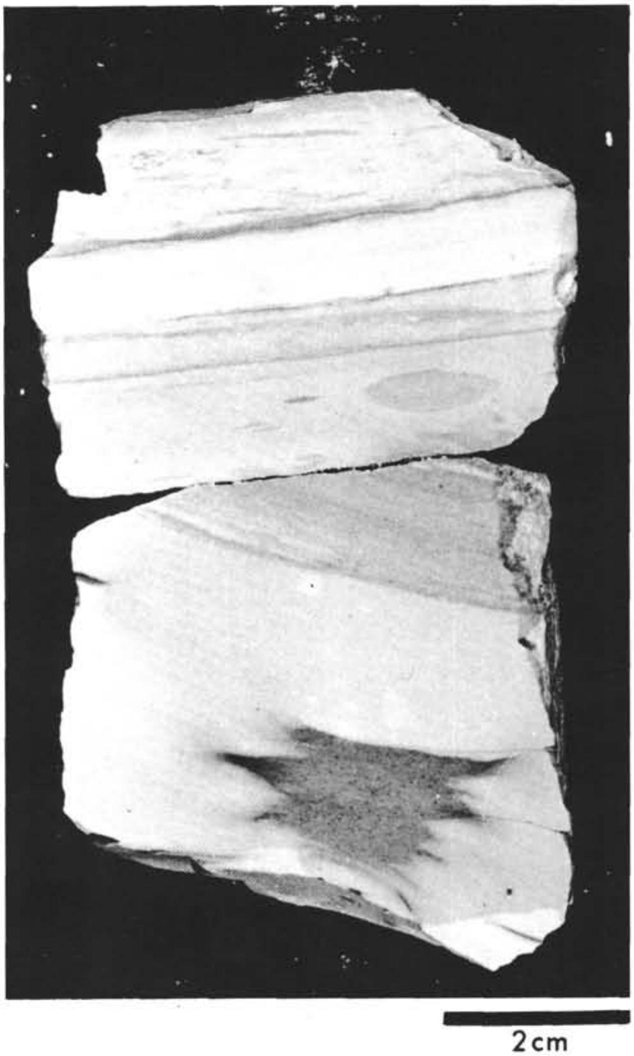


Figure 17. *Sample 33-315A-19-4, 60-66 cm (821 m). Unit 3–upper Campanian. Remnant evidence of soft sediment deformation in a light green micritic limestone. Pocket of green volcanogenic grains is sheared off by differential movements.*

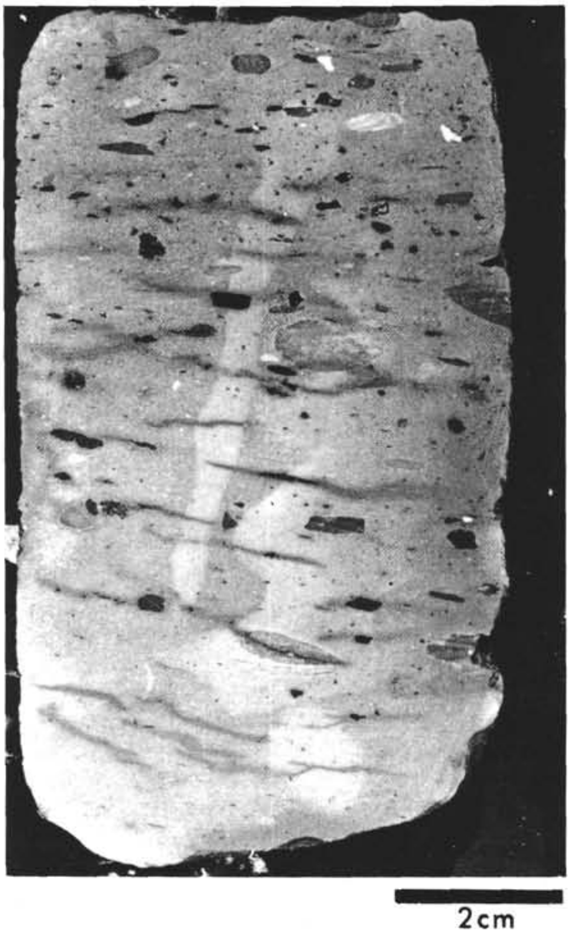


Figure 18. *Sample 33-315A-25-3, 105-117 cm (859 m). Unit 4–middle Campanian. Brownish-green "wackestone" with large angular to rounded palagonite grains and clay pellets in a mud-supported matrix. Some calcite is present as clasts of soft chalk as well as in the matrix. Note the fabric with faint flow-banding.*