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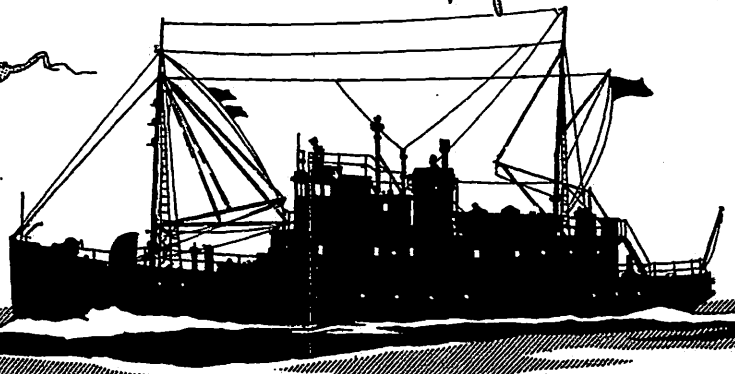

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Technical Report No. 142

BIO-LITHOLOGY OF NORTHEAST PACIFIC SURFACE SEDIMENTS, by Y. R. Nayudu and B. J. Enbysk. Marine Geology, 2(4):310-342. 1964. (AEC: RLO-1725-42)

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THE TINTINNID PARAFAVELLA GIGANTEA (BRANDT), KOFOID & CAMPBELL, 1929, IN THE NORTH PACIFIC OCEAN, by Hsin-Yi Ling. Journal of Paleontology, 39(4): 721-723. 1965. (AEC: RLO-1725-43)

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THE CARBONATE CONTENT OF SURFACE SEDIMENTS FROM THE NORTHEAST PACIFIC OCEAN, by M. Grant Gross. Northwest Science, 39(3):85-92. 1965. (AEC: RLO-1725-44)

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The Carbonate Content of Surface Sediments from the Northeast Pacific Ocean[1]

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THE DEEP ocean sediments of the North Pacific Ocean differ in many respects from those of the South Pacific Ocean (Sverdrup and others, 1942; Bramlette, 1961); variations in the carbonate contents are especially pronounced. For example, calcareous oozes are common in the South Pacific but rare in the North Pacific. Revelle and others (1955) suggested that variations between the deep ocean sediments of the Atlantic and Pacific Oceans were caused by regional differences in river runoff and sediment discharge in the ocean.

Such effects on a smaller scale are evident near the North American coast between Cape Flattery, Washington, and Cape Mendocino, California (Nayudu, 1959), an area where the Columbia River as well as numerous smaller coastal rivers discharge into the North Pacific Ocean (Figure 1). The carbonate content of 95 modern marine sediments from this area was determined as part of a study of the relative rate of deposition of calcareous biogenous constituents (foraminifera, coccolithophores, etc.) as compared with the deposition rate of noncalcareous or low-carbonate sediment, largely derived from the land.

Nayudu (1959), Enbysk (1960), and Nayudu and Enbysk (in press) studied the relative abundances of calcareous and siliceous biogenous constituents as well as the lithogenous constituents in the coarse fraction (>62 microns) of the sediment from the Northeast Pacific Ocean. They described seven "bio-lithologic areas" in the Northeastern Pacific Ocean and discussed the influence of the ocean circulation and bottom topography on the accumulation of marine sediments in the region.

McManus (1964) reviewed the literature, discussed nomenclature of the physiographic features of the same area and concluded that at least three physiographic provinces can be distinguished: (1) the continental terrace, (Continental Shelf and Continental Slope), (2) Cascadia Basin, and (3) "a province of irregular topography on the western flank of the basin." For

[1] Contribution No. 343 of the Department of Oceanography, University of Washington.

this study, I have further divided Cascadia Basin into Eastern Cascadia Basin and Western Cascadia Basin, with Vancouver Valley and the southern portion of Cascadia Seachannel as the dividing line (Figure 1). Tufts Plain and the Seamount Provinces are delineated approximately as shown by Hurley (1964). More detailed analysis of the bottom topography in this region may require significant changes in the preliminary delineations of the physiographic provinces used here.

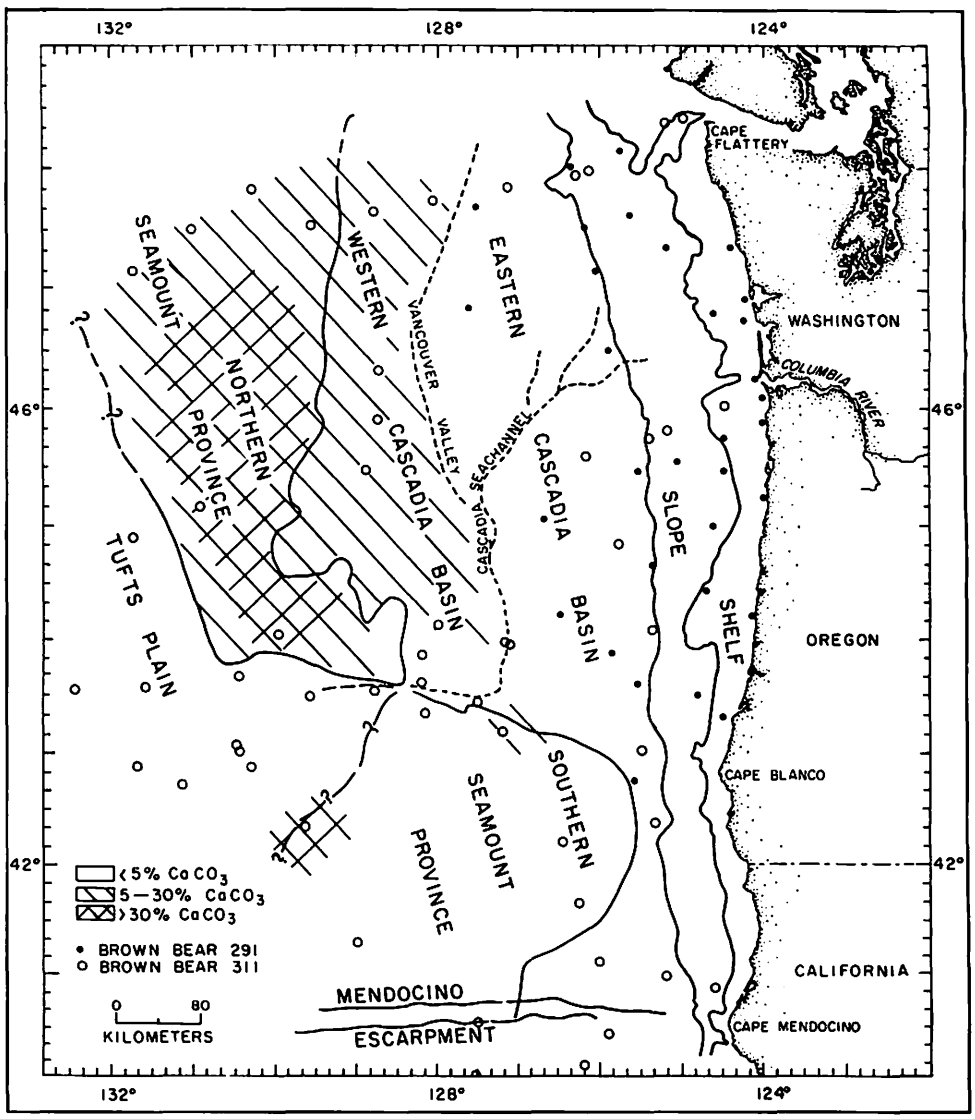

Figure 1. Distribution of $CaCO_3$ in surface sediment in part of the Northeast Pacific Ocean. Approximate boundaries of the major physiographic provinces are shown (McManus, 1964; Hurley, 1964).

Analytical Techniques

Samples (Figure 1) were collected from the R/V BROWN BEAR in August 1961 (Cruise 291) and August 1962 (Cruise 311). In order to limit the study to modern sediment, only the top one to three centimeters was taken from the gravity cores and only the top layer of the sediment was taken when a grab sampler was used. Because of the varying rates of deposition, these samples doubtlessly represent different intervals of time; in areas with low rates of deposition the intervals sampled may include some pre-Holocene sediment.

Weighed samples of finely ground, unwashed, dried sediment were mixed with 10 per cent H_3PO_4 in a closed flask which was heated to remove CO_2 and then flushed with CO_2-free air. The gases were collected, and their CO_2 content was determined by taking the difference between the initial and final volumes of the gas after passing it through KOH. The results, corrected for variations in temperature and barometric pressure and calculated as $CaCO_3$, are reproducible to within 2 per cent of the value reported.

The data are plotted in Figures 2 and 3; the median values for each physiographic province are given in Figure 2.

Discussion

The sediments from the various physiographic provinces (Figure 2) may be grouped according to $CaCO_3$ content as follows: (1) low-carbonate sediment from the Beaches and Columbia River estuary (median value 0.4% $CaCO_3$) and Continental Shelf (median value 1.4% $CaCO_3$); (2) the sediments of the Continental Slope (median value 2.2% $CaCO_3$), Eastern Cascadia Basin (median value 2.2% $CaCO_3$), Tufts Plain (median value 2.4% $CaCO_3$), and the area near the Mendocino Escarpment (median value 2.3% $CaCO_3$); and (3) the high-carbonate sediments from Western Cascadia Basin (median value 5.7% $CaCO_3$) and the Seamount Provinces (Northern Seamount Province—10.5% $CaCO_3$, Southern Seamount Province—4.5% $CaCO_3$). This last group of high-carbonate sediments includes some which Nayudu and Enbysk (in press) classified as oozes because of their abundant Foraminifera.

The complex history and diverse origins of the sediments in the Columbia River Estuary, on the beaches, and on the Continental Shelf are reflected in the variability of their $CaCO_3$ content. Local sources of carbonate appear to be especially important in this area. Unfortunately there are too few samples to warrant a discussion of the factors controlling the carbonate content of these sediments.

Sediments from the Continental Slope, Eastern Cascadia Basin, Tufts Plain, and from near the Mendocino Escarpment have a similar $CaCO_3$ content (Figure 2), with median values between 2.2 and 2.4 per cent $CaCO_3$. Deposition of lithogenous sediment is probably the dominant factor controlling the carbonate content of the sediments in these areas. As previously mentioned, the Northeast Pacific Ocean receives the runoff of the Columbia River as well as numerous, coastal rivers; thus there appears to be a plentiful supply of lithogenous sediment. The uniform carbonate content of these sediments can be explained as the result of a high rate of deposition of lithogenous sediment, containing 2 to 2.5 per cent $CaCO_3$, which is much greater than the rate of deposition of calcareous biogenous constituents. Consequently local variations in the carbonate content of the sediments are obscured.

The variability of $CaCO_3$ content of the Northeast Pacific sediments is probably caused, at least in part, by local topography which can have a profound influence on the type of sediment deposited at a given spot on a hilly or mountainous sea floor (Menard, 1964). Topographically low areas may be affected by turbidity flows whereas nearby slightly higher areas probably receive only the sediment settling down through the overlying water.

For example, the $CaCO_3$ content of the sediments from the Seamount Provinces and Western Cascadia Basin is clearly outside the range of $CaCO_3$ content of sediment in adjacent areas (Figures 2 and 3). In these areas the ocean floor is somewhat protected from the deposition of lithogenous materials transported along the bottom (Menard, 1955). Vancouver Valley and Cascadia Seachannel tend to channel turbidity currents away from Western Cascadia Basin and onto Tufts Plain.

Topographic effects are most evident in the Seamount Provinces where much of the sediment accumulates by particle-by-particle settling through the overlying water column or from the downslope movement of sediment from the seamounts. Where the supply of lithogenous sediment is limited to the material carried in suspension, the calcareous tests of foraminifera locally constitute more than 50 per cent of the sediment (Nayudu and Enbysk, in press).

The marked decrease in the $CaCO_3$ content of the sediments from the Seamount Provinces at depths between 3,100 and 3,300 meters (Figure 3) is probably also caused by dilution of the calcareous constituents with low-carbonate lithogenous sediment. Those sediments with the greatest carbonate content occur on topographic highs where the calcareous biogenous constituents

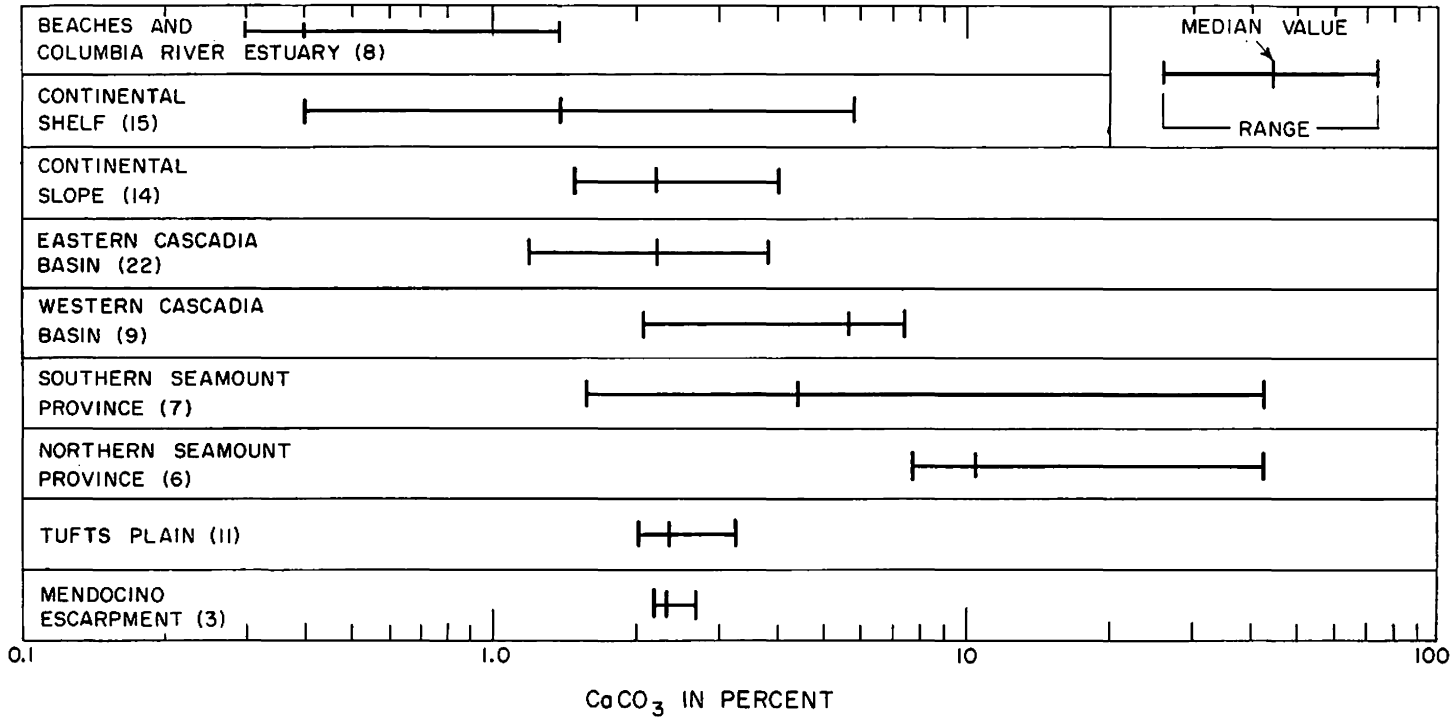

Figure 2. Range and median value of the $CaCO_3$ content of surface sediment from each of the major physiographic provinces in part of the Northeast Pacific Ocean. The number of analyses for each province is given after the name of the province.

are little diluted by lithogenous sediment, whereas sediments deposited on the plains include large amounts of low-carbonate sediment.

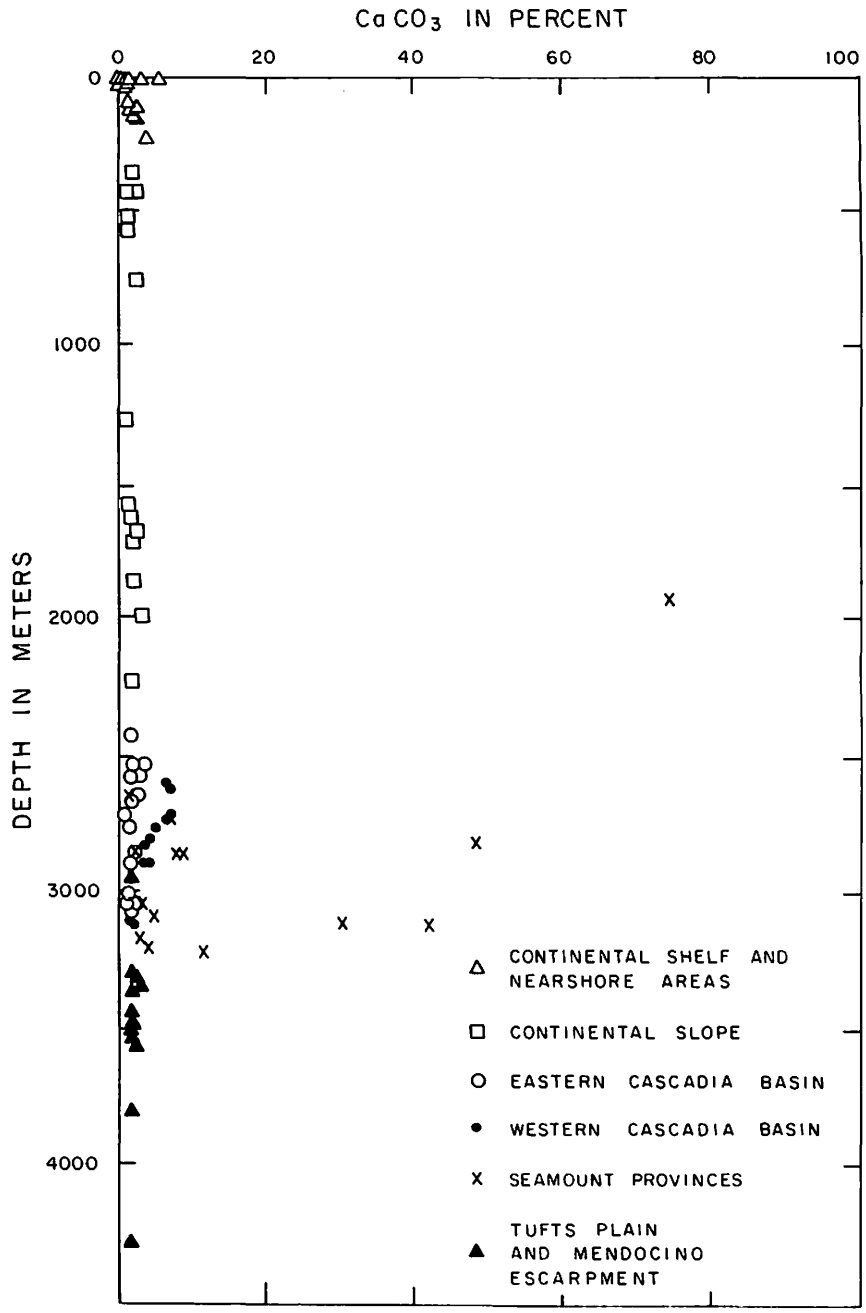

Figure 3. Distribution with depth of the $CaCO_3$ content of surface sediments in part of the Northeast Pacific Ocean.

There is no evidence indicating removal by solution of $CaCO_3$ from the sediments to a depth of 3,600 meters. Nayudu and Enbysk (in press) observed no globigerinids in the surface sediment at depths greater than 4,000 meters and concluded that removal by solution of foraminiferal tests is a significant factor at depths greater than approximately 4,500 meters. The observed marked decrease in the $CaCO_3$ content of the sediments at approximately 3,200 meters (Figure 3) occurs almost 1,000 meters above these depths where Nayudu and Enbysk observed pronounced solution effects and is probably caused by the greater rate of deposition of low-carbonate sediment in the deeper portions of the Seamount Provinces.

Thus, bottom topography appears to be a major factor controlling the rates of deposition and the $CaCO_3$ content of the sediments deposited in much of the area studied. That this is not the complete answer is obvious from the marked differences in the carbonate content (Figures 1 and 2) of the sediments of the Northern and Southern Seamount Provinces. Among other factors, it will be profitable to consider the deposition rates of siliceous marine organisms in future studies of the chemistry of Northeast Pacific sediments.

Summary and Conclusions

1. Modern marine sediments near the coast of Washington and Oregon generally contain less than 3 per cent $CaCO_3$. Sediment containing more than 5 per cent $CaCO_3$ is found only in the Northern Seamount Province and the western part of Cascadia Basin. It is inferred that the $CaCO_3$ content is low and rather uniform over most of the area because lithogenous sediment, containing little carbonate, is deposited much more rapidly than the calcareous remains of marine organisms.

2. There is no evidence to indicate that solution of carbonate controls the amount of $CaCO_3$ in the sediments deposited at depths less than 3,600 meters.

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