38. PHYSICAL PROPERTIES SUMMARY

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DENSITY-POROSITY

In general, Tertiary rock densities (1.4 to 2.0 g/cc) are less than those of typical Cretaceous recrystallized (partially or wholly) rocks which are characteristically 1.8 to 2.2 g/cc (range of 1.6 to 2.6 g/cc). Density-porosity variations are related to consolidation, grain-size distribution, and composition. For example, the Pleistocene-Miocene sediments tend to be more clayey than the older sediments and tend to have higher porosities than coarser grained sediments.

As a broad generalization, the superficial sediments (0 to 100 or 200 m), which consist of Pleistocene-Miocene chalk ooze, chalk, and marl, have wet bulk densities which tend to increase with increasing depth (1.3 to 1.8 g/cc). This density increase is apparently related to decreasing porosity caused by consolidation in the upper 100 to 200 meters. The greatest increase in density is from the surface to 100 meters and to a lesser extent to 200 meters below the sea floor at Sites 148, 149, and 153. However, it is possible that part of this variation is related to sediment that has been disturbed by coring. At Site 154, for example, the sediment was probably too disturbed to observe an increase in density with increase in depth.

At the sea floor, 100 meters, and about 300 meters below the sea floor, porosities are typically 80, 60, and 50 percent, respectively. Porosity rapidly decreases (exponentially) from the sea floor to 100 meters; below 100 to 200 meters, porosity decreases more slowly; and below 200 to 300 meters, density and porosity no longer have a "blanket" density increase or porosity decrease with increasing depth. Below 300 meters, sediment composition begins to play a more predominant role in determining densities and porosities.

Porosity variations positively correlate with the penetrometer tests in the sediments from 0 to 300 meters below bottom. Needle penetration decreases with increasing depth, but above 100 meters depth is where the greatest decrease in needle penetration occurs, and the depths of 140 and 300 meters correspond to the depths where needle penetration slowly decreases and becomes insignificant with increasing depth.

These depths appear to be unique in respect to porosity. Below 200 or 300 meters, there appears to be enough grain-to-grain contact with sufficient strength to support the overburden pressure (10 to 25 bars), and consolidation is a slow process. Since these sediments are marls, clays, and oozes, or at least typically clayey, these exact sets of parameters may not be observed with other sediment types, as the depths of 100, 200, and 300 meters and the porosities involved will be different for other sediment types and grain-size distributions. Therefore, the above parameters are probably only characteristic of local and similar sedimentary sections.

Below 200 or 300 meters, consolidation plays a less immediate role than it does above, and sediment composition becomes one of the controlling factors of wet bulk density changes. Occurrences of radiolarian layers and sponge spicules are characterized by relatively low densities compared to pure calcareous sections. This is caused by the low density (2.2 g/cc) opaline silica, in addition to the typically higher porosities of radiolarian ooze.

Higher porosities within radiolarian ooze are the result of the very fine netlike structure of the radiolarian tests, and a higher porosity evolves if the calcareous portion of the sediment is dissolved in situ, thus eliminating nannofossils or other small calcareous particles which would be filling the radiolarian structures. For example, a foraminiferal ooze, containing some nannofossil or other small calcareous particles, would have smaller porosities than radiolarian ooze formed as a dissolution residue.

Chert layers and nodules in limestone or chalk also cause low densities for a given porosity relative to a pure limestone. This is again because of the low density of opaline silica and cristobalite (?) compared to calcite.

In general, density does not correlate with sound velocity as well as does porosity; the high sound velocities (4 to 6 km/sec) correspond with a meager 2.2 g/cc density (zero porosity) in opaline silica, but a nannofossil chalk of the same density would have a porosity of about 30 percent, and a much lower sound velocity.

PENETROMETER TESTS

In general, needle penetration values decreased very rapidly and exponentially from the surface to about 70 (?) meters and slowly below 70 meters to values of 1 to 3 mm at subbottom depths of 100 and 200 meters. Below 200 or 300 meters, needle penetrations are insignificant. These tests were in Miocene or younger marls, oozes, and clays. The penetration pattern does not appear to vary systematically with age; however, there is a positive correlation with porosity variations versus depth. See the porosity-density summary for a discussion.

NATURAL GAMMA RADIATION

A characteristic natural gamma radiation signature based on geologic age appears at all sites drilled in the Caribbean Sea, except for Sites 154 and 147, which lack critical data. The pre-Miocene and early Miocene sediments and rocks typically emit little gamma radiation, but in late Miocene sediments the natural gamma radiation increases and remains typically high through the Pleistocene. This high natural gamma radioactivity is apparently related to the clay minerals in the marl and clayey sediments that characterize the late Miocene through Pleistocene. Most pre-Miocene sediments and rocks have a natural gamma radioactivity which is typically lower than the sediments above, except for minor thin clay layers and organic- and phosphate-rich zones. As a generality the following sediments and rocks are listed in order of decreasing natural gamma radioactivity: (a) phosphate and organic material, (b) clay, (c) marl, (d) chalk, (e) radiolarian ooze, and (f) basalt or diabase.

SOUND VELOCITY

Sound velocity within the Caribbean sediments and rocks varied more with age than depth of burial. Low velocities from 1.5 to 2.5 km/sec were characteristic of Pleistocene to Oligocene unlithified sediments. High and low velocities ($1.75 \leqslant 2.50 \leqslant 5.0$ km/sec) occur with some variation in Eocene to Campanian rocks, with the lower velocities characteristic through clay and marly zones, while the higher velocities occur through the chalk and silicified chalk. Chert fragments have the highest velocities (5.67 km/sec). High velocities (2.5 to 4.0 km/sec) were typical through Santonian and Coniacian micritic limestone with siliceous limestones having the higher velocities, and cherts, again, with velocities greater than 5 km/sec.

Sound velocity in basalts ranged from 4.78 to 4.86 km/sec. Slightly lower velocities of 4.52 to 4.66 km/sec were recorded for a vesicular basalt sample. These velocities agree with the refraction and wide-angle reflection data obtained from the Caribbean Sea and summarized in Edgar et al. (1971).

Sound velocity through semi-lithified and lithified samples is predominantly faster parallel to the bedding planes, and, in general, anisotrophy had a tendency to irregularly increase with increasing depth. A few Miocene to Oligocene (younger undisturbed samples did not exist in sufficient quantity to determine anisotrophy) chalk samples from 262 to 350 meters, with velocities of 1.7 to 2.4 km/sec, generally showed higher sound velocities of 1 to 5 percent parallel to the bedding planes, with 2 percent being typical. Deeper samples from 471, 572, and 667 meters had velocities of 1.9, 3.1, and 3.2 km/sec, respectively; and were limestone, chalk, and siliceous limestone with the following respective anisotrophies: 5, 11, and 14 percent faster parallel to the bedding.

REFERENCE

Edgar, N. T., Ewing, J. I. and Hennion, J., 1971, Seismic refraction and reflection in Caribbean Sea. Am. Assoc. Petrol. Geol. Bull. 55, 833.