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# MARINE-SEDIMENT THICKNESS IN THE EASTERN ROSS SEA AREA, ANTARCTICA

**Abstract:** Thickness of ocean sediments was obtained at two locations in the eastern Ross Sea area, Antarctica, during the International Geophysical Year. Sediment thickness in the vicinity of the Little America Station is about 1325 m. Cores from the upper meter of these sediments are composed mainly of a mixture of coarse and fine glacial till.

During the International Geophysical Year operations in Antarctica, the thickness of ocean sediments was obtained at the Little America Station (lat. 78°10′ S., long. 162°13′W.) by seismic-refraction and reflection methods. Figure 1 shows the Ross Sea and floating Ross Ice Shelf areas; bottom contours are taken from Crary and van der Hoeven (In press). Bentley *et al.* (1960) published the first outline of the configuration of West Antarctica under its ice layers. A large channel with rock surface well below sea level was found between the

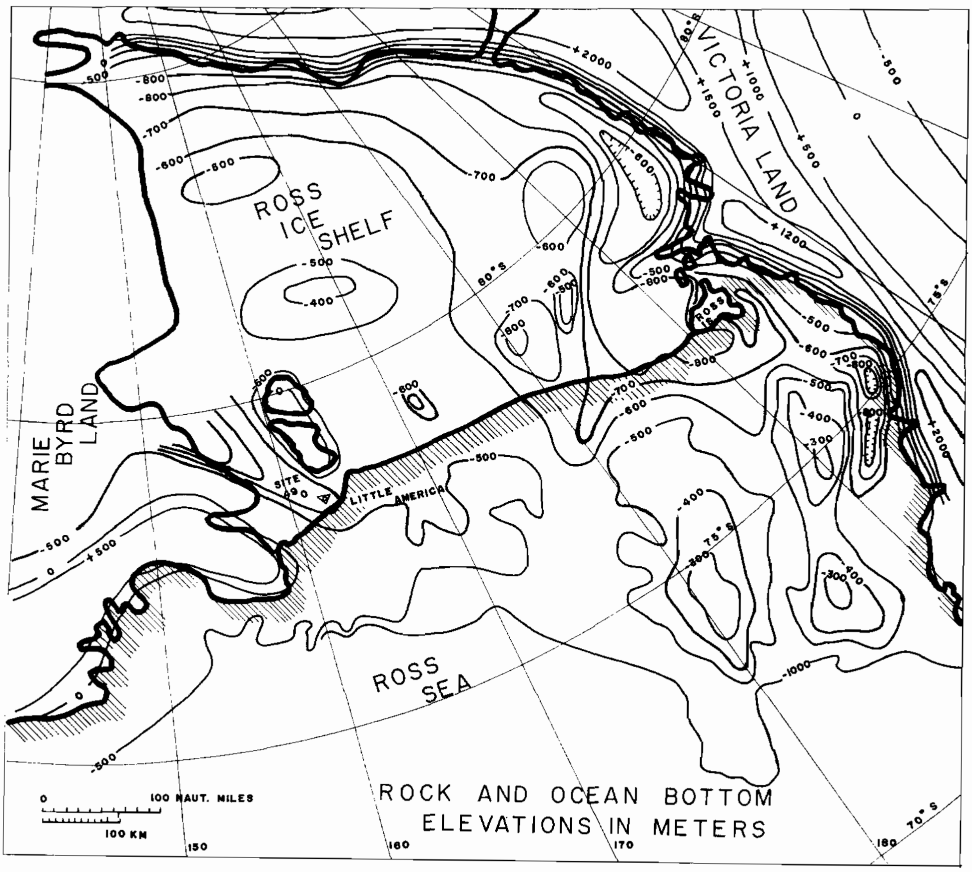


Figure 1. Ross Sea and Ross Ice Shelf area, Antarctica

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Ross Sea and the Bellingshausen Sea. Depths to rock surfaces in most areas of the channel are considerably below the floor depths found under the Ross Ice Shelf (Fig. 1).

Information on the seismic velocities in the sediments was obtained by taking a profile on the thin ice of Kainan Bay near the Little America Station. The distances involved were limited to the confines of the bay, about 3 km. Though this profile was not reversed, nor instant of firing obtained at the longer distance shots, the reflections from the ocean floor were good, and the multiple reflections received made possible the determination of firing times and the amount of slope of the bottom under the line of profile. The water in Kainan Bay was 606 m deep at the recording site in the inner part of the bay, and the ocean floor sloped upward toward the northwest by about half a degree. Refraction signals were obtained only on the record from the shot 3 km from the detectors. Over the instrument separation of 300 m, a slight increase in velocity was obtained, with values of 2400 and 2444 m/sec for the two sides of the spread. After correction for an assumed dip equal to that of the ocean floor, these values become 2428 and 2473 m/sec; the depth to these velocities was 109 and 205 m below the ocean floor, using a velocity of 2000 m/sec for the top sediments.

Further information on the sediment velocity is obtained from the sub-bottom seismic reflections received on the records with shorter distances from shot to recorder. Sub-bottom reflections that could be identified were limited to those arriving before the second ocean-floor reflection, after which they were masked. From the variation of the reflection times with distances over the 300-meter geophone spread, the average velocity for the entire path can be obtained. These values of average velocity were then corrected for the known travel time and distance in the water to obtain sediment velocity. The errors involved in the assumption of a straight-line path were estimated from theoretical calculations by using the known depth and velocity of water with various sediment depths and velocities. The results of this reflection study are listed in Table 1.

These velocity values and the refraction values obtained are plotted in Figure 2. The results fall between Nafe and Drake's (1957) values for shallow- and deep-water marine sediments. The discrepancy between refraction and reflection velocities may be due to anisotropic conditions in the upper sediments.

TABLE 1. CALCULATION OF SEDIMENT DEPTHS

| Distance | Time X=O (sec) | Average velocity (km/sec) | Sediment velocity uncorrected (km/sec) | Correction (km/sec) | Sediment velocity (km/sec) | Sediment depth (meters) |
|---|---|---|---|---|---|---|
| 0 –350 m | .934 | 1.53 | 2.33 | −.26 | 2.07 | 98 |
| 0 –350 | 1.255 | 1.69 | 2.20 | −.13 | 2.07 | 430 |
| 500–800 | 1.170 | 1.66 | 2.20 | −.17 | 2.03 | 335 |
| 500–800 | 1.237 | 1.72 | 2.32 | −.19 | 2.13 | 423 |
| 500–800 | 1.347 | 1.90 | 2.65 | −.25 | 2.40 | 609 |
| 500–800 | 1.504 | 2.05 | 2.83 | −.20 | 2.63 | 873 |
| 500–800 | 1.545 | 2.05 | 2.77 | −.18 | 2.59 | 913 |
| 500–800 | 1.666 | 1.93 | 2.42 | −.12 | 2.30 | 950 |

The main seismic reversed profile was made on the floating shelf ice in the vicinity of Little America Station, with surface elevations above sea level about 39 m and average ice thickness 238 m (Crary, in press). The seismic line was laid out with a deep crevassed valley in the center, which successfully eliminated the direct ice waves except on a few of the shorter recording distances. This seismic work on the shelf ice was limited by the high-velocity ice layer to seismic waves with velocities greater than 3.80 km/sec. The time-distance graph is shown in Figure 3. Two high-speed signals from below the sediments were received: one with velocities 4.21 and 4.27 km/sec from the southeast and northwest respectively; and a deeper one with velocities 6.08 and 6.74 km/sec, also from the southeast and northwest respectively. The returns received on the northwest side of the line were not so clear as on the other side, because they were masked somewhat by the direct ice waves with 3.75 to 3.80 km/sec

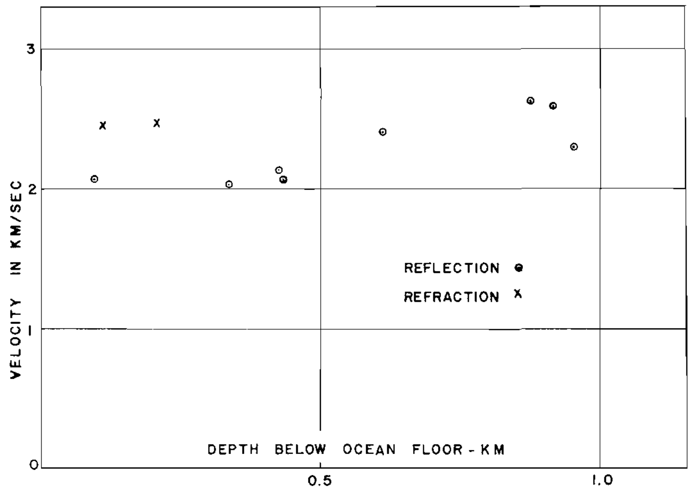

Figure 2. Seismic velocity of sediments, Kainan Bay, Antarctica

velocities. Interpolation was made by conventional seismic computing methods, using an ice thickness of 238 m with an average velocity of 3.45 km/sec, a water layer 409 m thick with a velocity of 1.44 km/sec, and sediments below this with an average velocity of 2.40 km/sec. The results (Fig. 3) show a sediment thickness of 1325 m, which thins at a low rate, about 1 m in 200 m distance, toward the southeast. The thickness of the 4.24 km/sec layer is not so well defined but is about 645 m in the center of the profile. It is underlain by a layer with an average velocity of 6.38 km/sec and a slope of 2.6° down toward the northwest.

At site 49 of the inland traverse, about 35 km southeast of the Little America Station, at lat. 78°25′ S. and long. 161°20′ W., a single unreversed refraction shot was fired, with pertinent data as follows: distance: 9.87 km; travel time: 2.630 sec; refraction velocity: 4.51 km/sec. The reflection survey indicated 363 m ice, 293 m water, and negligible slope

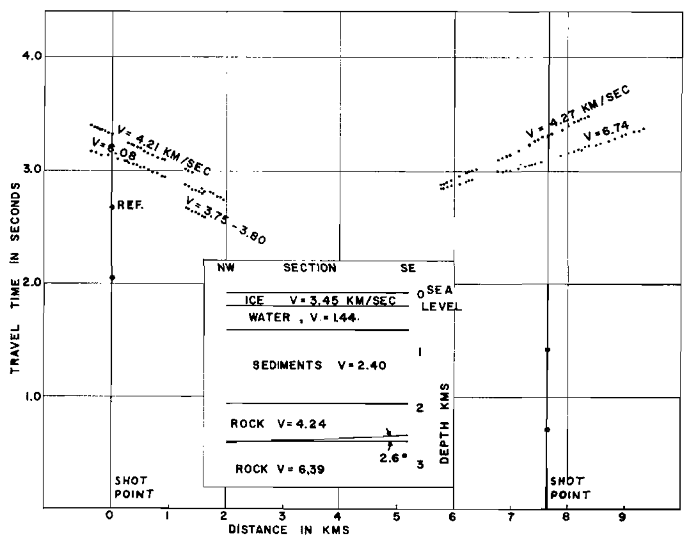

Figure 3. Time-distance curve of seismic-refraction profile, Little America Station, Antarctica

of the ocean floor at this site. If sediment velocity of 2.40 km/sec is used, the thickness of the sediments here would be 754 m.

Preliminary refraction velocities of 4.30, 5.43, and 6.54 km/sec have been obtained by the Little America Station traverse party in the upper Skelton Glacier area south of McMurdo Sound on the western side of the Ross Ice Shelf (Crary, 1959). From the known geological section in the McMurdo Sound area these values are tentatively associated with the Beacon sandstone, granitic or gneissic rock, and gabbro, respectively. Though no intermediate velocity was obtained on the profile at Little America, the same general type of Beacon series rocks appears to underlie the marine sediments. The Beacon series thickness obtained at the top of the Skelton Glacier by the seismic refraction was about 870 m, comparable to the 645 m deduced from the Little America Station study. At the Byrd Station, Bentley *et al.* (1960) report a similar velocity immediately under the ice.

It would be logical to expect similar thick sediments in most of the Ross Sea and Ross Ice Shelf areas. If depths to bed rock are compared with those in the Ross Sea—Bellingshausen Sea channel (Bentley *et al.*, 1960), the depths below sea level at the Little America Station and site 49 are 1933 and 1354 m respectively.

Cores from the upper meter of these sediments are composed mainly of a mixture of coarse and fine glacial till and have been examined by various investigators, including Stetson and Upson (1937), Thomas (1960), and personnel of the U. S. Navy Hydrographic Office (1956, p. E1–E23). Though there is no reason to believe that the total sediment column was deposited by ice, most of it may have been. Many factors will complicate sedimentation by rafting from shelf ice. Eventually, sediments will build up to ground the ice which will then redeposit them farther north. This continuing process will be aided by lowered sea level and land uplift. Rafted material brought down from glaciers of the Amundsen and Bellingshausen seas will also be carried west to the Ross Sea by prevailing surface currents. Sediment thicknesses in other parts of the Ross Sea should be determined and long piston cores obtained.

### *Acknowledgments*

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