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[redacted] Kenneth Hunkins.
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(6) Studies in marine geophysics and underwater sound from drifting ice stations.

I. Operations at Fletcher's Ice Island (T-3)

A special summer program in underwater sound and physical oceanography supplemented the normal program in marine geophysics which includes gravity, magnetic, depth, and navigation measurements. Three persons were at T-3 during the summer to run the Lamont program.

Underwater acoustic listening gear was set up at T-3 for monitoring underwater explosions set off by University of Wisconsin personnel aboard the USCG NORTHWIND during its cruise into the Barents and Kara Seas. A number of the shots were successfully recorded at T-3. Since all shots were detonated on the continental shelf and since attenuation is known to be high in shallow-water propagation, the successful recording was not entirely predictable. The recorded signals were generally weak due to the shallow-water losses. Ambient noise was also recorded with geophones and hydrophones. Ice tremors caused by thermal stress in the ice were often recorded. The fact that the distinction between ice tremors and the shot signals is sometimes difficult points to the need for further study of ice tremors and their characteristics.

The physical oceanography program during the summer centered on internal waves. Vertical and horizontal arrays of thermistors were suspended below the ice and their outputs recorded on a 24-hour helical seismograph drum. Portions of the records were reduced to digital form and spectrum analyses are being made. The depth of the thermistor array was monitored with a pressure transducer. Other measurements were taken for background information on the oceanographic situation. These included standard hydrographic stations, bathythermograms, and current observations.

At the end of the summer, 45 gallon water samples were obtained from 5, 75, 500 and 2000 m depths. These depths were chosen to represent the four main water masses of the Arctic Ocean. The samples will be analyzed for C^{14}, Sr^{90} and C_s. This is part of a continuing program for determining Arctic Ocean circulation from the radioactive isotope distribution. The same depths were sampled in 1963 at T-3. A surface sample was taken at Arlis II in 1965. Another complete set of samples will be taken at T-3 in 1966 if conditions permit.

T-3 drifted over the Canada Continental Rise during most of s period. During December it drifted westward over the Canada Aby al Plain. The two provinces grade smoothly into each other in this region. The only distinction is the gradient which is 1/1000 or greater on the rise, while on the abyssal plain it is considerably less than 1/1000. Depths are almost uniformly 3790 in. over the abyssal plain after correction for sound velocity in Arctic Ocean water. T-3 was located at 76°09.5'N 141°42'W on July 1, 1965. By Dec. 31, 1965 it had drifted to 75°15.7'N 146°05'W.

A larger piston corer was operated during the summer in an attempt to obtain longer cores. The USGS winch and tripod were used to raise and lower the corer. Four cores ranging up to 2½ m in length were obtained. The program was not fully successful in raising long cores. This was partly due to limited access to the winch since it was primarily used by the USGS group and partly due to problems with rigging and operating the corer.

2. <u>Data analysis at Lamont</u>

Progress continued on the reduction and analysis of magnetic, gravity and sounding data for a comprehensive study of the Alpha Rise and Canada Abyssal Plain. Most of the data for this study were collected from T-3 but other data collected from earlier ice stations will also be incorporated. Ralph Shaver analyzed gravity data. Jeffrey Friedberg analyzed magnetic data and computed interpretative models of crustal structure. Werner Tiemann and John Berry plotted and checked navigational fixes.

K. Hunkins analyzed current observations taken at T-3 and earlier stations. He spent some time at Woods Hole and was able to apply a technique developed by Ferris Webster to the Arctic data. The results show the inertial motions observed at T-3 to be correlated with the wind amplitude.

3. Meetings attended and papers published during this period

K. Hunkins attended the Seventh International Congress of the International Association for Quaternary Research which was held in Boulder, Colorado from Aug. 30 to Sept. 5, 1965. At the session on the Quaternary History of the Ocean Basins he read a paper on "Quaternary Sedimentation in the Arctic Ocean". This will be published in a proceedings of the Congress.

Hunkins also attended the International Upper Mantle Symposium held in Ottawa, Canada from Sept. 4 to 9, 1965. At the session on Continental Margins and Island Arcs, he read a paper on "The Arctic Continental Shelf north of Alaska". This paper will be included in a proceedings of the symposium.

The following paper was published under support of this contract during this period:

Hunkins, K., "The seasonal variation in the sound-scattering layer observed at Fletcher's Ice Island (T-3) with a 12-kc/s echo sounder", Deep-Sea Research, 12, 879-881, 1965.

4. Abstracts of papers published or read at meetings

The seasonal variation in the sound-scattering layer observed at Fletcher's Ice Island (T-3) with a 12-kc/s echo sounder

Kenneth Hunkins

Abstract

For nearly two years, from June 1963 to the present, an echo sounder has been operated continuously at Fletcher's Ice Island (T-3), a drifting research station in the central Arctic Ocean. Diffuse reverberations are frequently seen on the echograms during the summer months. These reverberations are similiar in general appearance to the deep scattering layers of other oceans.

In non-polar oceans, the deep scattering layer is usually found at depths between 200 and 600 m during the day. At night it rises almost to the surface and weakens or disappears. Two important features distinguish the Arctic Ocean scattering layers from these non-polar scattering layers: (1) the Arctic Ocean scattering layers are relatively shallow, 50-200m, and (2) the Arctic scattering layers have a

pronounced annual, rather than diurnal, cycle. These effects are probably related to light conditions peculiar to polar oceans. First, the light is relatively weak beneath the permanent ice cover. Second, the "day" becomes effectively one year long at these high latitudes so that the Arctic scattering layers are present at moderate depths during the summer light period and then disappear during the winter dark period.

In addition to the scattering layers, discrete echoes from shallow depths are frequently recorded. These discrete echoes occur throughout the year but are particularly frequent during the winter. These echoes take a hyperbolic shape indicating relative movement between the ice station and the reflector. Presumably they are caused by nekton such as fish or seals.

This is believed to be the first observations of sound scattering layers in the central Arctic Ocean. An examination by DIETZ and SHUMWAY (1961) of echograms taken on the nuclear submarines Nautilus and Skate during their Arctic Ocean cruises revealed no deep scattering layers or discrete echoes. However, the submarines probably cruised within or below the scattering layer. The echo sounder at the ice station was better placed for detecting a shallow scattering layer.

The Arctic Continental Shelf north of Alaska

Kenneth Hunkins

Abstract

North of Alaska, the shelf ranges from a normal type off Point Barrow to a "continental borderland" type north of the Chukchi Sea. Northwest of Barrow, seismic refraction results indicate a layer with a compressional-wave velocity of 7.4 km/sec which rises from a depth of 32 km at Barrow to 20 km near the edge of the shelf. The Cretaceous rocks of the Arctic coastal plain apparently thicken seaward from 1.1 km at Barrow to 6 km near the edge of the shelf.

The Chukchi Cap is evidently a feature of continental origin north of the Chukchi Sea although it is now separated from the shelf by a saddle. The Chukchi Cap is 150 km in diameter at the 500 m contour. The shallowest sounding recorded for the Cap is 246 m. A continuous 1,000 gamma positive magnetic anomaly borders the western and northern margins of the Cap. The anomaly is interpreted as an effect of a buried basement ridge similar to that found along the continental margin of eastern North America.

Quaternary Sedimentation in the Arctic Ocean

Kenneth Hunkins and Henry Kutschale

Abstract

A distinct boundary between sediment types usually occurs at a depth of about 10 centimeters in bottom cores raised from the Alpha Rise in the Arctic Ocean. The sediment between the tops of the cores and the 10 cm boundary is a dark brown, foraminiferal lutite mixed with ice-rafted sand and pebbles. The sediment between the 10 cm boundary and a depth of about 40 cm is a light brown sand with ice-rafted material but few foraminifera. The 10 cm boundary apparently represents the most recent change in pelagic deposition in this region and must be connected with climatic changes. Foraminifera from a zone between 7 and 10 cm have been dated by the C^{14} method as $25,000 \pm 3,000$ and as 30,000 years B.P. in two different samples. The 10 cm boundary itself has been dated as 70,000 years B.P. by a uranium series method. If these dates are accepted, a low sedimentation rate of $1\frac{1}{2}$ to 3 mm/1000 years is indicated for the Alpha Rise and for the Arctic Ocean as a whole if pelagic sedimentation has been uniform over the entire ocean. Cores from the Canada Abyssal Plain differ in character from the Alpha Rise cores consisting primarily of olive-gray lutite without foraminifera or ice-rafted material. This sediment was probably deposited by turbidity currents. A 3mm layer of dark brown, foraminiferal lutite occurs at the top of the Canada Abyssal Plain cores. This layer is similar to the upper layer in Alpha Rise cores and apparently represents continued pelagic deposition since the last turbidity current. Foraminifera from this upper 3 mm layer have been dated as 700 ± 100 years B.P. by the C^{14} method. The conclusion is that pelagic sedimentation has continued unchanged in the Arctic Ocean from about 70,000 years ago to the present. This implies that the present ice cover has existed for that length of time.