Semi-annual Technical Summary Report
July 1 - Dec. 31, 1966

ARPA Order No. 218-61
Project Code No. 8100
Contractor: Columbia University
Contract Date: 1 April 1961
Contract Amount: $360,178
Contract Number: Nonr 266(82)
Contract Expiration Date: Mar. 31, 1967
Project Scientist: Kenneth Hunkins
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Studies in marine geophysics and underwater sound from drifting ice stations.

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

1. NAVIGATION

During the period the island moved west and northwest between 75-46.7N, 150-37W and 78-12.0N, 176-36W, describing an arc approximately 425 miles long. One hundred and nineteen fixes were obtained. In July the movement was in a closed NE-SW oval centered about 75-45N, 151-30W and with a maximum dimension of twenty-five miles. In August the island reversed course and headed northwest, southwest, and then west for a net movement of 83.6 miles. September and October saw net west-northwesterly gains of 108 and 96 miles respectively, with small deviations and course reversals occurring in the vicinity of 75-47N 158-30W, 75-50N 163-00W, and 77-05N 170-00W. In November the island proceeded to its westernmost position of 78-12.0N 176-36W on the 25th, north to a maximum of 78-12.5N, 175-45W on the 29th and then southeast for an overall track distance of 157 miles. In December movement was generally southeast despite two pronounced westerly excursions. The final position was 77-37.8N 173-43W. The overall distance between fixes for the six-month period was 734 miles, the net distance was 322 miles, and the meandering coefficient was 2.3.

During this time the island executed an almost complete rotation. The azimuth increased slightly from 12.2° to 22.0° between the 1st and 14th of July, then fell slightly before increasing to 152.1° on the 28th. August saw large fluctuations. The azimuth dropped to 69.3° on the 1st, rose to 303.4° on the 17th, fell to 234.8° on the 19th, then increased to 327.1° on the 26th. There after a gradual increase occurred until the 30th of December when the azimuth was 356.8°.

2. BATHYMETRY

Continuous echo sounding during the period revealed new information on six major features of the Amerasia Basin.

(1) The Western Half of the Canada Abyssal Plain

1 July - 27 August

In this area, the depth increases toward the Northwind Cap which constitutes the western boundary. In the middle of the plain (75-45N 150-30W) the depth is 3831 m, increasing westward to 3841 m along the edge of the Cap (75-37N 155-40W).

(2) The Northwind Cap

27 August - 14 September

In a profile taken along 75-45N, the Northwind Cap appears as a high plateau, trapezoidal in cross section, whose 52 km wide upper surface dips slightly toward the east. Superposed on this is a high of 594 m in the western third and a trough of 924 m in the eastern third. The eastern flank is 46 km wide and rises from 3841 m to 801 m while the 37 km wide western flank, containing a 500 m high ridge (?), rises from 2100 m to 644 m.

(3) Area between the Northwind Cap and the Chukchi Rise

14 Sept. to 27 Sept.

Between the Northwind Cap and the Chukchi Rise two abyssal plains, separated by a ridge, were observed. The eastern plain is about 50 meters deeper, and appears to warp up slightly, being approximately 2098 m at the center, 2102 m by the Northwind Cap, and 2100 m by the median ridge. Navigational coverage was poor while

crossing this area but the median ridge appears to lie along the 162°W meridian, has a height of more than 800 m, a depth at the crest of 1290 m, and a width of about 8 km.

The western plain contains a disturbed zone paralleling the ridge with a 65 m high saddle separated from the ridge by a trough 20 m below the level of the plain. This plain is downwarped at the center with a depth of 2045 m along the disturbed zone, 2052 m at the center, and approximately 2000 m at the edge of the Rise.

(4) Chukchi Rise

27 September - 14 October

A crossing of the northern part of the Chukchi Rise shows a plateau with minimum depths of approximately 380 m. A depression with a maximum depth of 713 m occurs in the middle of the plateau. This appears to be the southern edge of a larger depression at the northern end of the Rise. A small rounded feature 60 m high at the western edge of this depression appears to be the surficial expression of an eastward dipping compressional fault seen clearly to a depth of 600 m on the seismic profiler.

Information regarding the last two major features crossed is sketchy at this time as the data are still on the ice station.

(5) Chukchi Abyssal Plain and the Charlie Gap

14 October - 14 November

Depths remained constant at about 2200 meters except for the crossing of a trough or channel 100 meters deep on 8 November.

(6) The Alpha Cordillera

14 November - 31 December

Rough topography with depths between 900 m and 2056 m.

3. GRAVITY

Seven hundred and two gravity readings were taken during the period, and a calibration tie was made with Barrow in late September. Anomalies have not yet been computed, but preliminary analysis reveals anomalies over the eastern half of the Northwind Cap and in the depressed region of the north central Chukchi Rise where profiler data show an increase in the depth to basement. Large edge-effect anomalies are also noted on the eastern margins of the Cap and Rise.

4. MAGNETICS

Continuous total intensity field measurements were made throughout the period. Numerous magnetic events were recorded, but the largest, with 1000 γ amplitude, occurred 3 September. Field changes during this event sometimes exceeded 150 γ per minute, and perturbations of as much as 550 γ were observed for the following four days. Preliminary analysis indicates anomalies to be associated with the Chukchi Rise and the Alpha Cordillera but not the Northwind Cap.

5. SEISMOLOGY

A long period ($\sim$20 sec) vertical seismometer was installed during July and run intermittently for eleven weeks. A low frequency band bass filter allowed observation of long-period ocean waves. Vertical ice movements on the order of 1-2 mm were recorded during August and September.

6. SEISMIC PROFILER

A seismic profiler, using a single omnidirection hydrophone and a capacitor-discharge sound source with spark-type transducer, became operational at the beginning of the period. More than 1700 hours of record was obtained with source energies of 5000-9000 joules and a 36-120 second repetition rate.

Records now available for analysis show no basement for the plains to the east of the Chukchi Rise, although numerous strong reflectors are seen with penetration often exceeding 1 km. The Northwind Cap shows approximately 300 m of sediment over a strong basement reflector and up to 900 meters are seen on the western flank apparently trapped by the outlying marginal ridge. Between the Cap and the Rise, 800 meters of sediment are seen in the eastern plain, and perhaps as much as 1400 meters in the western plain. The median ridge is thinly draped with sediment and there is a hint of rough basement under the deformed zone along the ridge's western flank. The eastern half of the Rise shows basement overlain by sediments which thin from 400 m along the flank to 100 m next to the depression. Over the depression up to 600 meters of deformed sediments are observed, along with the aforementioned fault and several zones of deformation. Penetration of 500-600 meters was observed with no apparent basement in the Chukchi Abyssal Plain.

7. GEOCHEMISTRY PROGRAM

The geochemistry program included, this last summer:

(1) An attempt at establishing a chronology of young sea ice by using 2 bomb-produced radionuclides, Cesium 137 and Strontium 90. Samples are being processed at present.

(2) A determination of the Cs^{137} and Sr^{90} fallout at high latitudes by extracting these 2 nuclides from freshly fallen snow.

(3) A sampling of atmospheric carbon dioxide for its Carbon 14 content.

(4) Stable Cesium content in sea water:

The samples were collected for and analyzed by Ted R. Folsom (Scripps Inst. for Oceanography). The results show a small increase of Cs^{133} with depth: 20 m: .30 μg Cs^{133}/liter

65 m: .31

500 m: .33

2000 m: .35

(5) Radioactive Cesium and Strontium in sea water:

The $Cesium^{137}$ was sampled by 2 different techniques, in situ sampling with KCFC and on-deck adsorption of the Cesium on AMP in order to compare the 2 methods. Results for 3 samples are at hand, 22 more samples are actually being processed (11 for Cs^{137} and 11 for Sr^{90}). The 65 m sample contains .27 $\pm$ .04 pc/l which is lower by a factor of 2 compared to samples of the same depth in the N-E Pacific in 1965.

The 500 and 2000 m samples contain each .03 pc/l which is probably of the same order of magnitude as the background, hence, the bomb-produced Cesium 137 most likely has not yet reached the the Atlantic water and the Arctic Deep Water at the northern limit of the Chukchi Sea.

(6) Radiocarbon concentration in sea water:

The CO_2 of 14 large volume water samples from various depths was extracted on T-3 for ulterior determination of Carbon 14 concentration. Three samples have been counted to date. The Pacific maximum and minimum temperature layers show exactly the same C^{14}/C^{12} ratio and hence are of the same age. Their ΔC^{14} is higher than the 1963 and 1965 values, which might indicate that the bomb-produced C^{14} has reached the Pacific water on the western side of the Canadian basin. The same conclusion does not hold true for the one surface sample which has been counted and whose ΔC^{14} is

of the same order of magnitude as that from 1963 and 1965.

(7) Total CO_2 and partial pressure of CO_2 in sea water: 23 water samples were brought back to Lamont for an analysis of total CO_2 in sea water. The results will be included, with partial pressure of CO_2 data, in Yuan Hui Li's Ph.D. thesis.

(8) Sedimentation rates:
44 short gravity cores were taken on the Chukchi Cap with a barrel corer for a Carbon 14 determination of sedimentation rates on the foraminifera fraction of the top 10 cm of the cores, cm by cm.

Preliminary studies of sieving and leaching processes on dredged sediments from T-3 are being done actually before treatmeant of the cores.

8. BOTTOM SAMPLING

In early July, one nine-foot core was obtained in the Canada Abyssal Plain with the USGS winch, the only winch on the island large enough for sustained coring operations. The breakdown of this winch seemed to preclude coring for the rest of the summer. On August 27, the island approached the Northwind Cap, and it was decided to attempt coring with a small American Hoist winch used for hydrographic work. Using a Ewing piston corer, thirty-two attempts were made, and twenty-four cores obtained before the winch drum cracked on Sept.[22] The cores were taken from the two slopes and across the top of the Northwind Cap, from a ridge to the west of the Cap, and from the two plains on either side of the ridge. During this time the island moved in a meandering line from 75°39'N, 155°44'W to 75°50'N, 162°59'W.

Although core lengths ranged up to 16 feet, much of this was flow-in due to scope problems encountered because of the excessive rebound of the 5/32" wire being used. Usable core lengths ranged from 15 cm to 288 cm, with most of the cores being around 150 cm. The cores were opened and described at Lamont. They are currently being examined for paleomagnetic direction, micro fossil content, and physical properties of the sediments. A larger winch and ¼" wire have been purchased to extend the coring program, and future cores will hopefully range up to 30 or 40 feet in length.

A short multi-barreled gravity corer was used to obtain large volume core samples of about 1½ foot depth for geochemical analysis.

Three dredge samples were obtained in the Canada Abyssal Plain at depths greater than 3800 m, five samples on the Northwind Cap at depths of 650 m to 2000 m, and one sample in December at 77°56'N, 174° 30'W at a depth of 2700 m. Four of the samples were obtained with the USC Menzies Trawl and the rest with a 2 gallon bucket dredge. A rock dredge was used several times with no success.

9. CAMERA/NEPHELOMETER

Bottom photographs were taken during the summer months of August and September. Pictures were obtained from the Canada Abyssal Plain, the Northwind Cap, and the abyssal plain to the west of the Cap. Nephelometer lowerings were made during July, August and September. No nepheloid layer was seen - even on the slopes of the Northwind Cap - but during halts, traces were made by some swimming organism. These were captured in a Ewing large volume water sampler and identified as Parathemisto abyssorum.

Additional camera and nephelometer stations were made during November and December.

10. PHYSICAL OCEANOGRAPHY

Twelve hydro stations were taken during the months of June to October. Although in all stations, samples were taken from the surface to depths just above the sea floor, special attention was given to the top 300 m, with BT lowerings supplementing the hydro casts. This part of the program was a continuation of the extensive, long-range study of the Pacific Layer begun on T-3 in 1963. The accumulating evidence tends to point to a seasonal, rather than geographical fluctuation in Pacific Layer temperatures, with the highest temperatures coming this year in mid-August. For the purposes of this study, a BT with an expanded temperature range capable of giving temperatures to an accuracy of $\pm$ .02°C was put into operation in October. The Pacific Layer was observed to have considerable fine structure and to fluctuate greatly in periods of time as short as a day. Four more hydro stations to 300 m were taken in the months of November and December.

11. BIOLOGY

Vertical net hauls were made monthly with depths selected to corespond to the major water masses. Also, horizontal net tows were made in connection with studies of shallow sound scattering layers.

12. HIGH FREQUENCY ECHO SOUNDING

A 50 kc RCA fish finder was operated throughout the summer, and scattering layers observed at 17 m and 22 m. These tended to have a diurnal nature, appearing during hours of low light intensity and disappearing during high intensity, but the correlation is not complete. Also, there was practically no vertical movement of the layers, only a sudden appearance and disappearance. They seem to occur only under the sea ice, as when the fish finder was operated in an open lead, the layer disappeared at 15 to 20 m from the pack ice.

13. LIGHT MEASUREMENTS

A continuous record was kept of the light level at 20 m. In addition, a profile was made in the Lamont Hydro Hole. From the bottom of the hole to a depth of 17 m, the light level increased, due to the shadow effect of the hydro hut. From 17 m to 48 m the extinction coefficient was .0073. At 48 m, it changed to .0227 and remained at that value to 94 m, at which the light level was ¼ candle power, the limit measurable with the Weston photo voltaic cell being used. At this level it was about 1/10,000 of surface illumination (about 2500 cp). There was about 1 m of snow and 3 m of ice cover. The surface temperature minimum was at 48 m, and this roughly corresponds to the beginning of the boundary layer between the Surface and Pacific water layers.

II. Meetings Attended and Papers Published

K. Hunkins attended a meeting in December at the Naval Electronics Laboratory in San Diego on the subject of the future of Arctic research.

Henry Kutschale and Dave Prentiss attended the 72nd meeting of the Acoustical Society of America in Los Angeles during November 1966. They delivered a paper on "Spectral character of ice vibrations in the central Arctic Ocean from 0.1 to 100 cps".

Two articles by K. Hunkins were published in the "Encyclopedia of Oceanography" edited by Rhodes Fairbridge and published by Reinhold. The

subjects of the articles are "Chukchi Sea" and "Drifting Ice Stations".

Papers and reports published during this period:

Hunkins, K., "Ekman drift currents in the Arctic Ocean", Deep-Sea Research 13, 607-620, 1966.

Kutschale, H., "Arctic Ocean Geophysical Studies: The Southern Half of the Siberia Basin", Geophysics XXXI, 683-710, 1966.

Yearsley, John, "Internal Waves in the Arctic Ocean", Tech. Rept. No. 5, CU-5-66-Nonr 266(82), Sept. 1966.

Beal, M.A., F. Edvalson, K. Hunkins, A. Molloy and N. Ostenso, "The Floor of the Arctic Ocean: Geographic Names", Arctic 19, 215-219, 1966.