Fig. 1. The campsite, September 1952.

PRELIMINARY REPORT ON SCIENTIFIC WORK ON "FLETCHER'S ICE ISLAND", T3

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During March 1952, landings were made on T3, one of the large ice islands in the Arctic Ocean,[1] by a ski-equipped C 47 aircraft from Flight D of the 10th Air Rescue Service, Alaskan Air Command. Lt. Col. J. O. Fletcher, Dr. K. Rodahl, and Capt. M. Brinegar, from this command, remained on the island to reconnoitre and to construct a temporary campsite. During April, A. P. Crary and R. D. Cotell, civilian scientists from the U.S.A.F. Cambridge Research Center, and Capt. Paul Green, communications expert from the Alaskan Air Command, were landed on the island with their equipment, and Dr. Rodahl and Capt. Brinegar were taken off. By early May the permanent campsite, consisting of three Jamesway portable huts for living and working quarters, and snow or tarpaulin shelters for supplies, had been completed (Fig. 1).

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[1]Koenig, L. S., K. R. Greenaway, M. Dunbar, and G. Hattersley-Smith. "Arctic ice islands", *Arctic*, Vol. 5 (1952) pp. 67–103.

One of the main purposes of occupying the island was to install a meteorological station from which weather data could be sent out regularly for use in the synoptic weather maps throughout the arctic areas. These operations were under the command of Col. R. M. Gill, Commanding Officer of the 7th Weather Group at Elmendorf Air Force Base, Alaska. Although six-hourly surface weather observations were started on April 1, detailed weather studies were not begun until late June when a complete rawinsonde station and personnel of the 7th Weather Group were landed. Since that time upper air data have been taken twice daily, and surface weather observations hourly. In October regular snow observations and radiation studies were begun. At present there are nine men at the camp: six concerned with the operation of the weather station and three civilian scientists. The camp operations from late June until October were under 1st Lt. Robert Derrickson, who was replaced in October by Major H. G. Dorsey Jr.

The purpose of this report is to outline the scientific operations other than the meteorological work, which were in progress at "Fletcher's Ice Island" from April 1 to October 1 under the direction of the Geophysics Directorate of the Cambridge Research Center, and which, with minor modifications, are continuing. The program was generally directed along the following lines: study of the physical structure of the ice island, study of the movements of the ice island and of the ice pack, seismic profiling, and the collection of miscellaneous data.

Structure of the ice island

The island measures roughly 31 miles in circumference and is 5 miles across at its narrowest part, with most of the corners well rounded. The campsite is located about ½ mile from shore and 1½ miles from one of the corners. The most distant part of the island is about 7½ miles from camp.

Approximately 7 miles of transit survey have been made across the ice island, and elevations of the snow and ice surfaces were measured about every 350 feet. The ridge elevations are in general 20 to 25 feet above sea level, with the height of the ridges above the troughs varying from about 15 feet in a few places near the shore to an average of only 2 to 5 feet near the centre of the island. A section across the narrowest part of the island is shown in Fig. 2. Approximately 5 miles of coastline have been surveyed and a chain survey from the camp to the far end of the island was made in September.

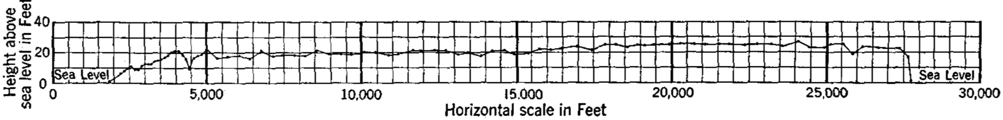

Fig. 2. Cross section of ice island above sea level.

Core holes and test pits

A 52-foot hole was dug near the campsite using a four-inch corer and pipe extensions. In this hole 58 separate and distinct dirt layers were found.

Weights of the dirt were obtained for about half of these layers. The top, heavy layer, from two independent measurements, contained about 120 grams of dirt per square metre. Lower dirt layers at depths of 17.5 and 51.8 feet showed 18 and 15 grams per square metre, respectively, extrapolated from the area of the corer. These two layers were the largest of the lower ones. Many of the others contained less than one gram per square metre. These

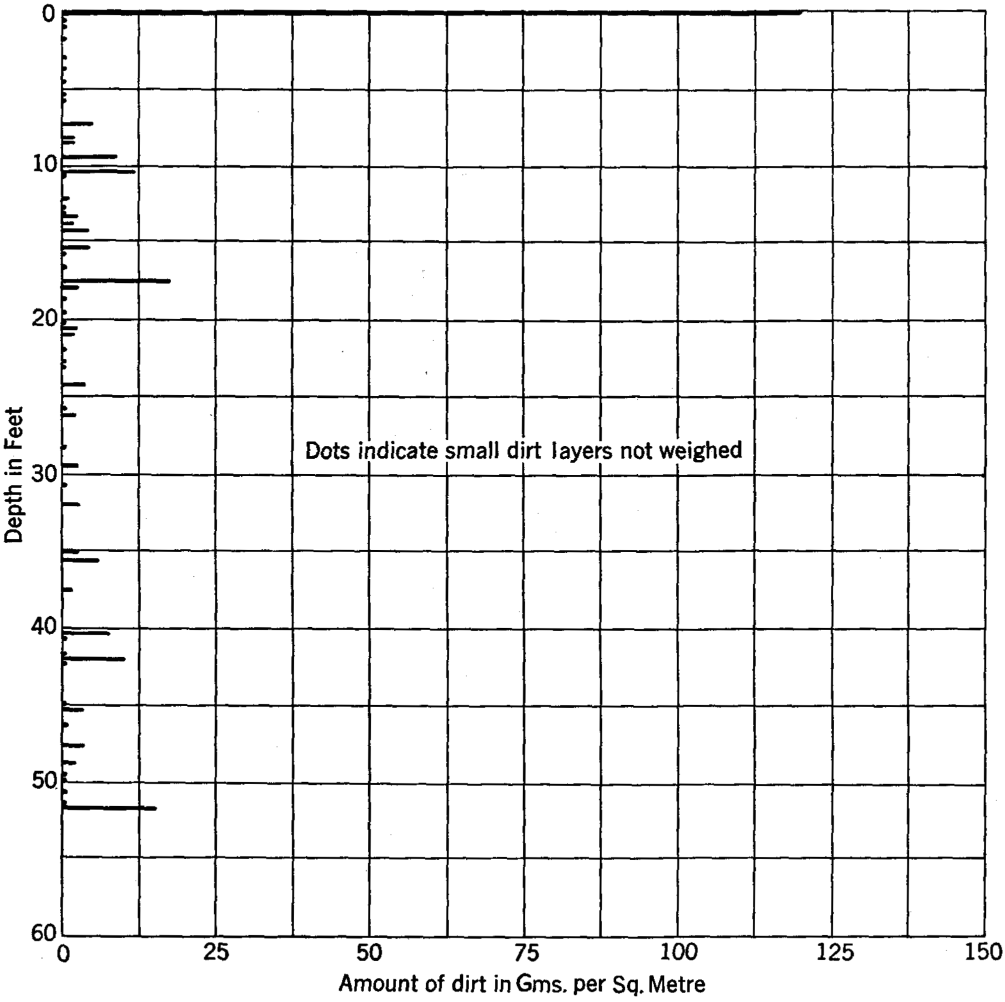

Fig. 3. Depths and weights of the dirt layers in a 52-foot hole.

weights are shown in Fig. 3. It is interesting to speculate that if the smallest dirt layer were considered to be representative of a single year's accumulation, it would appear that the present warm cycle has progressed for at least one hundred years to give the large surface layer. The larger of the lower dirt layers may also represent shorter warm cycles. A total of 29 samples in this hole were used for density determinations employing the immersion method;

the density values varied from 0.87 to 0.93 gram per cc. It is planned to use this hole for temperature measurements and to extend the borings as deep as practicable.

Seven sections between 50 and 300 feet in length, with core holes about 10 feet apart and to an average depth of about 3½ feet, were made across the top of ridges at right angles to the ridge trends. Nearly all sections showed a definite unconformity between the upper heavy dirt layer near the surface and the lower layers, with the upper layer parallel to the present ice level and

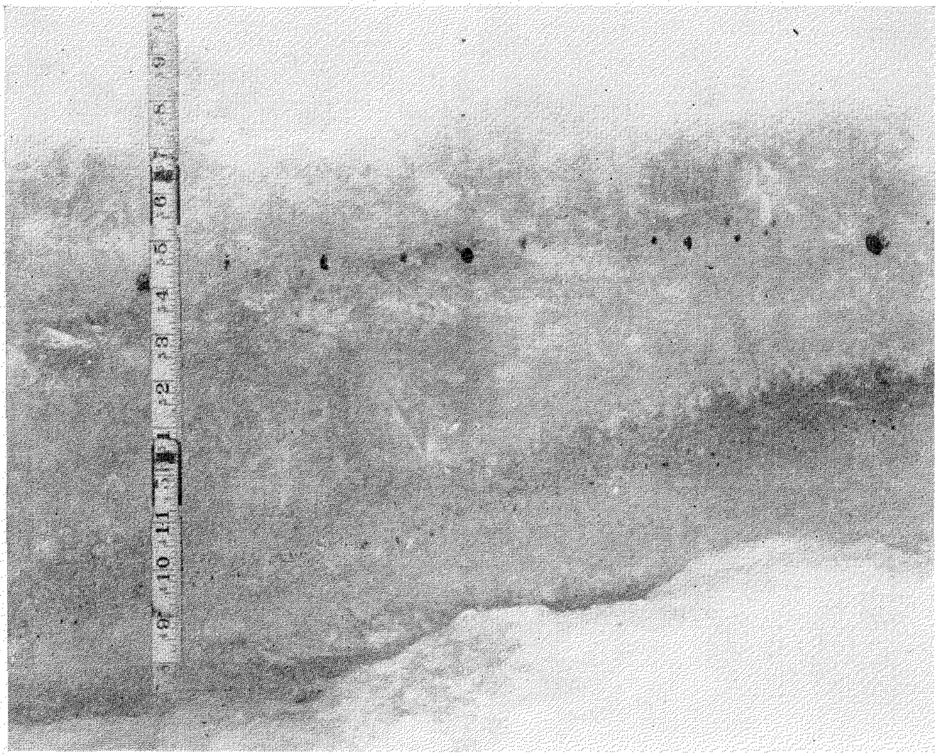

Fig. 4. Section showing dirt layers in the surface ice.

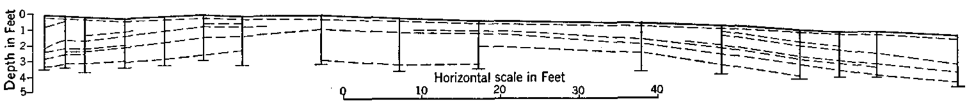

Fig. 5. Typical section across a ridge showing position of the shallow dirt layers.

considerably flatter than the lower layers (see Figs. 4 and 5). This could have resulted from differential thawing over many years.

Microscopic examination showed that the dirt from the upper layer consisted of small grains of quartz, mica, and feldspar. These were the size of fine silt, but were quite angular and fresh. The material appeared to be derived from a metamorphic granite-like land area. Sufficient amounts of dirt from this top layer and from one of the lower layers have been obtained for age determinations of the organic matter present by Carbon 14 analysis.

Fresh water pockets

In two of the core holes made in the valley troughs before the thawing season, fresh water was found. In one there was 8 feet of ice over approximately 8 feet of water, and in the other about 3 feet of ice over 4 feet of water. This water proved very useful for camp purposes. At the first site, there were two distinct dirt layers in the 8 feet of ice. This may perhaps indicate that the water pocket formed three years ago, presumably when the island was at the southern end of its track.

Many large ice bumps or knobs occur on top of the ridges near the shores, and may have been caused by internal pressures associated with pockets of fresh water. These features are usually 2 to 3 feet high and some 5 to 10 feet in diameter.

Surface thawing

Range poles were frozen in the ice surface early in the season, but the extent of the thaw had been underestimated and the first reliable observations of surface thawing did not begin until the first week of July (Fig. 6). These

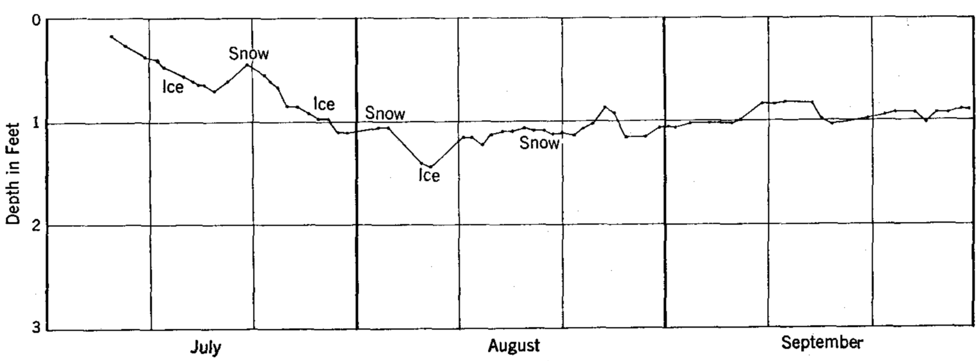

Fig. 6. Variation of the surface level during the summer months in the general campsite area.

indicate about one foot of melting on the ridges, a figure which was supported by visual observations around the campsite, though the latter may well be too large because of inevitable contamination of the surface by soot and other debris.

In general, the thaw period lasts from late June to mid August. Lakes appeared in all the troughs or hollows of the island, starting the first week in July (Fig. 7). From each lake channels led to other lakes (Fig. 8) and, eventually, to the sea. These narrow channels were filled with snow and were late in melting. Once they had melted through, the excess water from the lakes drained off quite rapidly. Following that, the runoff remained about the same, carrying off the excess meltwater as it formed. Later, in early August, the floor of the lakes melted down noticeably. Freezing started in late August,

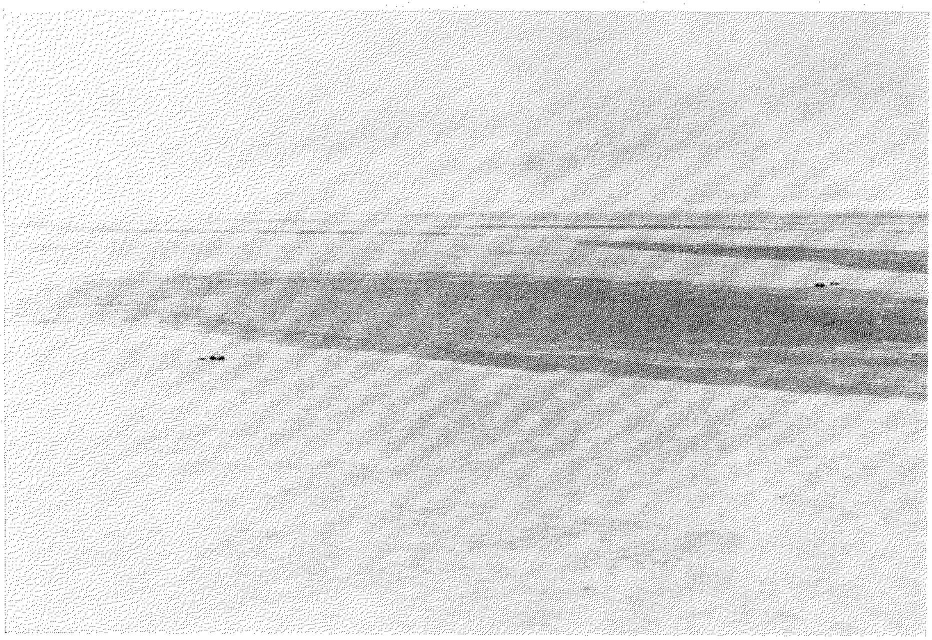

Fig. 7. The ice island in early July showing the beginnings of lake formation.

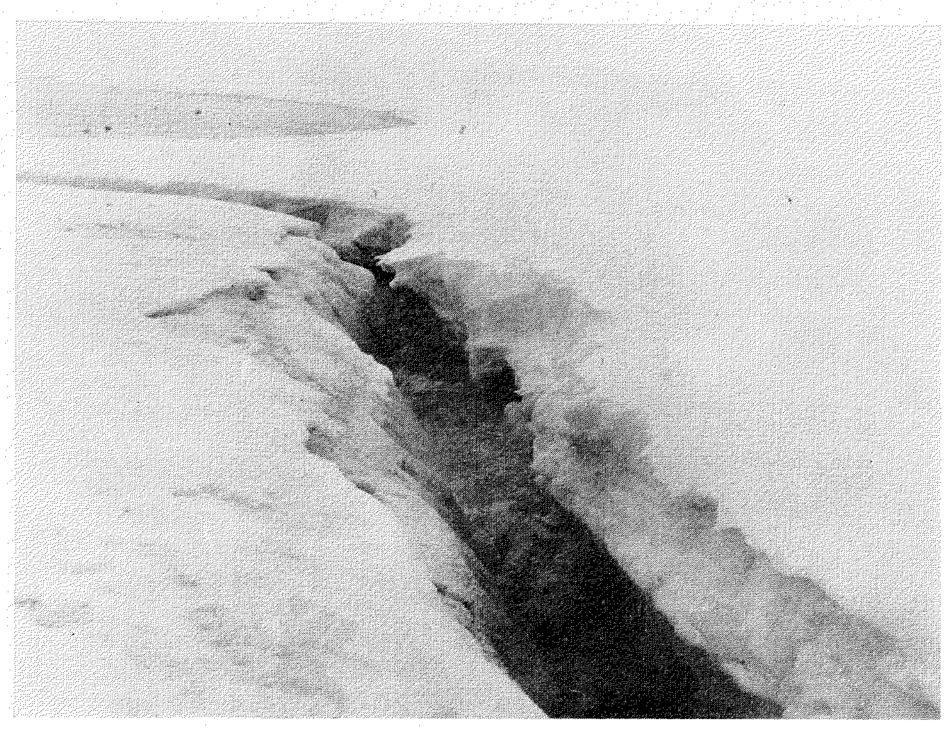

Fig. 8. Narrow water channel typical of the many connecting the lake systems on the island.

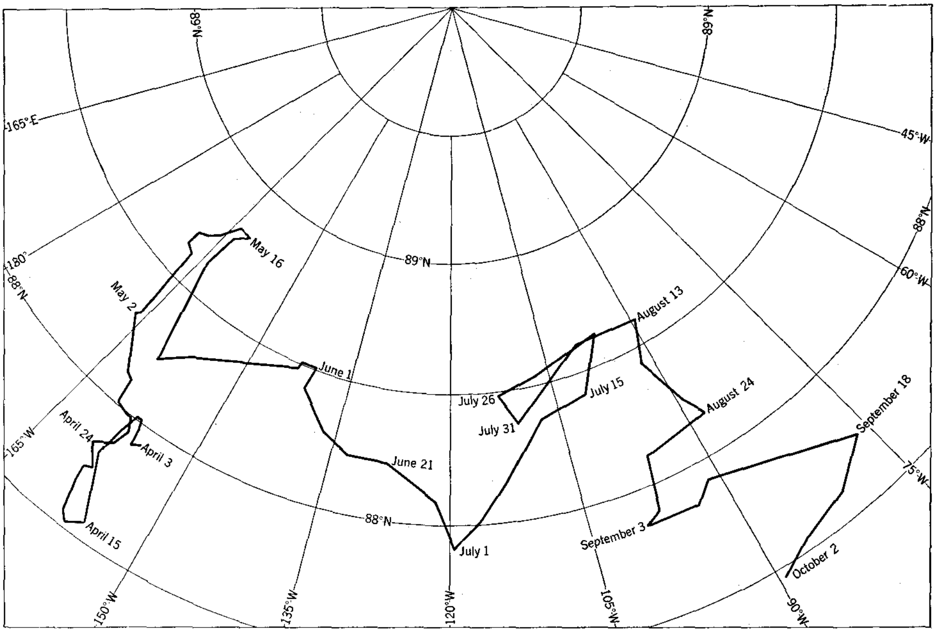

Fig. 9. Track of T3, April to October, 1952.

though the lake ice was not safe to walk on until the middle of September, and it was late October before it would support a C 47 ski-aircraft. Subsidence in the troughs where the lakes formed will be measured by drilling to known dirt layers after freezing of the lakes is complete.

Movements of the ice island and of the ice pack

Solar and lunar observations were made at frequent intervals with an engineering transit, and tentative locations (Fig. 9) were calculated approximately twice a week in order to provide a basis for the use of weather data. It now seems unlikely that the ice island will move out through the Greenland Sea along the route taken by the Russian North Pole Expedition of 1937–8. Movement is more likely toward the northern shore of Ellesmere Island, or toward the southwest to start another circuit through the Arctic Ocean.

At each of the solar observations, azimuths were obtained and the headings of the island were calculated on an approximate weekly basis for the orientation of the station anemometer and directional radio antennas. The island appeared to rotate very little on a grid basis, except for two periods during the summer—July 15 to August 1 and August 15 to September 10—when clockwise rotations of about 50 and 80 degrees respectively occurred. Figure 10 shows the changes of island azimuth to true and magnetic north, and the geographical longitudes.

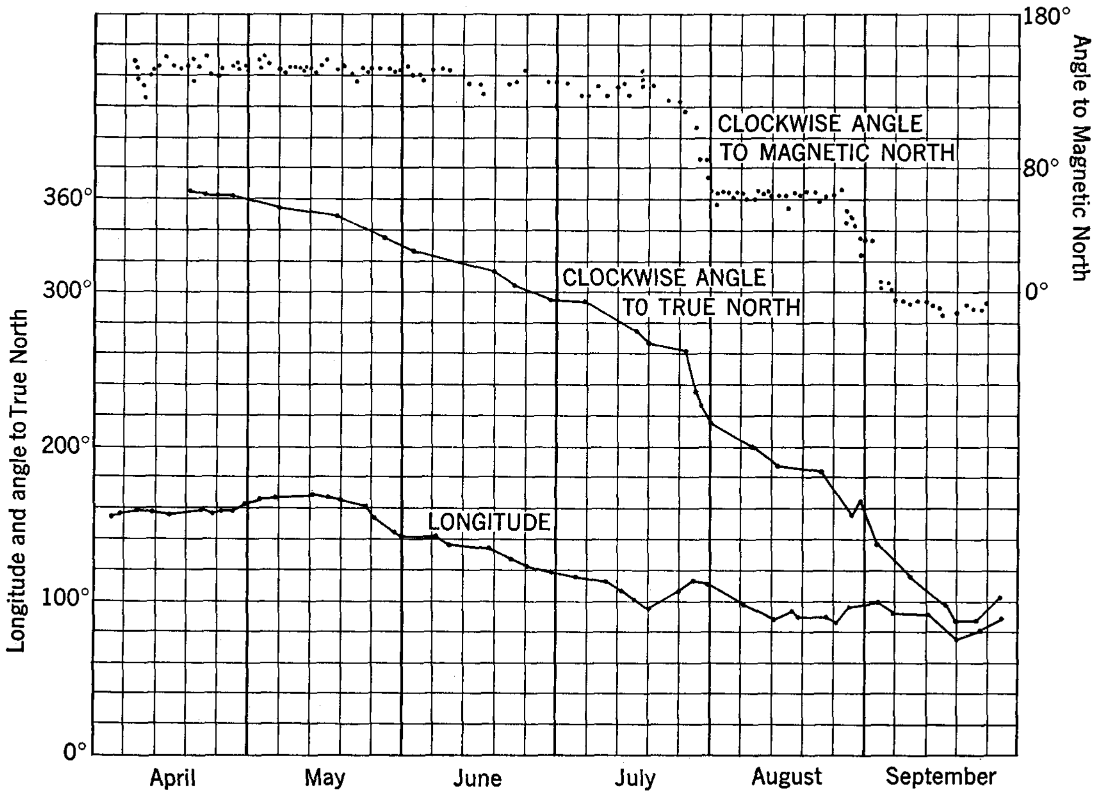

Fig. 10. Changes in orientation of the island in relation to a fixed reference.

Observations of the azimuth to magnetic north were made with a magnetic compass located about 300 yards from camp. These observations were made at 24-hour or, at times, at 12-hour intervals.

Several prominent ice hummocks 2 or 3 miles from the island edge were followed daily from two theodolites set up approximately ½ mile apart on the island. The most prominent hummock, about 25 feet high and 3 miles from the island, was followed from April to August when it toppled over during a heavy melting period. It is believed that the ice island movement does not vary much from that of the surrounding ice pack. The relative movements of these hummocks should also give important data on the stresses acting between the island and the ice pack.

Strain gauges, capable of measuring distance changes to 0.0001 inch, were set up between the ice pack and the ice island, on the island itself, and in cracks in the ice pack near the island. These observations indicate the nature of the internal stresses and will be used in the general study of the ice movements.

A sensitive bubble level, reading to 0.1 second of arc, was set up on a ridge near the campsite and read daily. An over-all tilt of about 2 minutes of arc was observed, which was noted to be dependent to a large extent on the wind speed and direction.

Measurements of the wind gradient over the ice island and over the ice pack have been made with three anemometers placed approximately at 5, 10, and 20 feet above the surface. Limited measurements have also been made of the positions of the weather station pibal balloons during the first minute of flight. From these, it is hoped to get indirect evidence of the wind stresses acting on the various ice surfaces.

A drag-type current meter was suspended through a hole in the sea ice, and readings were obtained of the relative motions of the ice and water at various depths to 1,500 feet. Regular measurements were also made at depths of 500 to 750 feet.

From all these observations it appears that the movements of the island are due mainly to the wind stresses at the surface, and that the magnitudes of any permanent ocean currents are small in this part of the Polar Basin.

Seismic and gravitational studies

A seismic profile near the centre of the ice island was completed to a distance of 15,000 feet with three-directional recordings, using high explosives as the source of seismic energy. A shear or transverse profile was also made in which the waves were generated by swinging a 150-pound rock against the face of an ice pit by means of a 25-foot A-frame. Good shear-wave arrival times were obtained to a distance of 1,500 feet at right angles to the ice pit. In addition to information on the character and thickness of the ice of the ice island, these tests yielded valuable data on propagation of seismic waves. Good high-velocity flexural waves[1] were obtained which should give an accurate depth measurement. A longitudinal wave of constant frequency was very prominent at long distances, and is as yet unidentified.

A single shot of 100 pounds of T.N.T. was fired on the ice surface of the island about 5½ miles from a vertical seismograph operating in the range of periods 1 to 5 seconds. An air–space coupled wave[2] was obtained which indicated a tentative thickness of about 160 feet.

An independent check on the thickness of the ice island was made by shooting ocean depths shots with the receiving instruments at various locations on the island and at sea level on the salt ice. Differences in times of arrival of the reflected wave from the ocean bottom allowed the ice thickness to be measured to the nearest 10 feet, as the vertical travel through ice is about 0.001 second faster per 10 feet than through salt water.

The relative acceleration of gravity was obtained twice daily, using a portable gravity meter. The differences were based on observations at the Thule, Greenland, and Fairbanks, Alaska, gravity stations. The gravity values increased along approaches to two sea mounts and also changed by about 50 milligals in passing over a large fault which was discovered on the ocean floor.

[1]Ewing, M. and A. P. Crary. "Propagation of elastic waves in ice, II" *Physics*, Vol. 5 (1934) pp. 181–4.

[2]Press, F. *et al.* "Air-coupled flexural waves in floating ice". *Trans. Amer. Geophys. Union.* Vol. 32 (1951) pp. 166–72.

In addition to the gravity values, this meter was used as a long-period vertical seismograph, with daily readings taken visually every 5 seconds over a 6-minute period, in order to establish the seismic motions of the island in the periods 10 to 50 seconds.

A short period vertical seismograph, operating in the range 1 to 5 seconds, was monitored for about 2 hours daily, starting in August. Although the noise level was too high to permit the reception of earthquake signals, the observations obtained will be correlated with the weather conditions. The noise level was large compared with land readings.

Oceanographic work

Approximately twice a week soundings were obtained of the ocean depth with a directional array of seismograph detectors, from which strike and dip of the ocean bottom and of the lower sub-bottom layers could be obtained. These soundings showed that the ocean floor in the area of the Polar Basin across which T3 drifted was very different from the deep regular basin previously suggested. Depths were greatest in the west, but a figure of as little as 5,000 feet was found in the east.

Two sea mounts were discovered in the western part of the drift area, where the general level of the ocean floor was 12,300 to 12,800 feet deep. Although the island did not drift directly over these mounts, depths of only 9,500 feet were obtained, with dips of 15 to 20 degrees. In the eastern part of the area of the drift, the dip was in general toward the southwest, averaging up to 5 or 6 degrees. A fault or escarpment is the main feature here, with about 3,000 to 5,000 feet downthrow to the northeast. Depths varied from 5,000 feet to 12,000 feet in this general area.

Two refraction shots, of 100 pounds of T.N.T. exploded at 100-foot depths in the water, were recorded approximately 8 miles away. These were made to determine the velocity, hence composition of the submarine rock deposits and their depths.

Detailed observations of salinity of the salt ice with depth were made monthly from cores taken on an 8- to 13-foot thick floe, immediately off the ice island. These observations will be continued for the complete annual cycle.

Twelve lowerings of a temperature-recording bathythermograph have been made from the ice island. These lowerings varied in depth from 1,500 to 3,500 feet, in each case being sufficient to reach the warm Atlantic waters at about 1,000 feet. A smaller temperature inversion of about ½ degree Fahrenheit has been noted on all thermographs at a depth of about 400 feet.

Miscellaneous collections

Most of the various samples of surface dirt, flora, and fauna were obtained during the melting season along the stream beds near the shore. The most interesting collections are as follows:

Large boulders of coarse gray and black granitic rock showing some evidence of metamorphism were found in an area extending about 3 miles along

Fig. 11. Rocks and gravel near a stream bed close to the shore of the island.

the far shore from the campsite (Fig. 11). Many smaller rocks were found in gravel piles and stream beds in this vicinity.

Wood particles, such as stems, twigs, plant blossoms, and root fibres, amounting to about 300 grams, with the largest piece about 15 grams, were found in a fairly limited area along the shore. Four small leaves approximately one cm. in length were found in one of the lower dirt layers.

Small mollusc shells about one cm. in diameter and slender hollow calcareous tubes, serpulas, about one cm. by one mm. were found in some quantity in the same general area as the wood particles.

Various bones from fish that must have been at least 30 cm. in length; a complete small fish, about 10 cm. long; two different specimens of animal remains, one apparently from a lemming; and a few larger bones, approximately 20 cm. by 2 cm. were found along the shore at various points on the island.

A complete set of caribou antlers (Fig. 12) was found about 3 miles from the camp. Although they were in an upright position, no skull was found, but pieces of skin, fur, and what appeared to be flesh were frozen in the ice nearby. A more complete excavation is planned for the next thaw season.

The above specimens are at present being studied. Many of them will be sent to the Lamont Geological Observatory, Columbia University, for age determinations by the Carbon 14 method.

Fig. 12. Sgt. J. Jones, U.S.A.F. radio operator, holding the caribou antlers found on the island.

Fauna

During the entire stay on T3, the only wildlife seen consisted of eight birds: two in June, four in July, and two in August. One of these was identified as a jaeger, another as either a Sabine's Gull or a Kittiwake.

Recent tracks of polar bear and arctic fox were noted on the island in April. However, the only large open leads were over 2 miles from the camp and were seldom visited by the scientific staff so our observations do not necessarily indicate any scarcity of animal life.

Surface sea life, consisting of gammerid amphipods (shrimp) and ctenophores (jellyfish), was observed in the open holes through the sea ice in early June.

In addition to the regular program of observations on the ice island, similar observations were made at three other points during brief visits in the early part of May. At a landing at the north pole scientific studies included ocean soundings (14,150 feet) and gravity observations, and sample bottles were left for long range ocean current observations. At a landing on the ice island T1, near the Ellesmere Island coast, corings were made at two places which showed dirt layers similar to those on T3, and about ½ mile of transit survey was run inland from the sea ice. Near Ward Hunt Island a landing was made on the north Ellesmere Ice Shelf, and corings were made and transit surveys were taken across the large ice drifts west of the island.

The ice island has proved to be a good site for arctic research projects. Especially favourable is the period April to July when temperatures range from $-35°$ F to $+32°$ F, and days are generally fair with average winds of 5 to 10 mph. During the summer months, with the temperature varying only slightly from $+32°$ F, low clouds and fog were quite general and the lakes hindered easy access to all parts of the island. Most of the collections on the island were made in the period July 15 to August 15, particularly during the heaviest thawing period in the first week of August.

In October A. P. Crary and T. F. Sexton (who had replaced R. D. Cotell in June) returned to the Geophysical Research Directorate and their place on the island was taken by 2nd Lt. R. R. Shorey. Charles Horvath, marine biologist, from the University of Southern California, and Valentine Worthington, oceanographer, from Woods Hole Oceanographic Institution, were flown in to carry out special studies during the period October 1952 to January 1953. During 1953 it is planned to provide facilities for glaciologists in order to make a more thorough study of the ice structure of the island.