Oversnow Traverse from McMurdo to the South Pole

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Oversnow Traverse from McMurdo to the South Pole

Elevations and ice thicknesses are reported by the first U.S. scientific oversnow party to reach the South Pole.

A. P. Crary and Edwin S. Robinson

The fourth major U.S. antarctic traverse based in the Ross Ice Shelf area departed from McMurdo station 10 December 1960 after a long delay in preparation and outfitting of new oversnow vehicles. The individual participants were A. P. Crary, leader and seismologist; Edwin S. Robinson (University of Wisconsin), geophysicist; Mario Giovinetto and Jack Zahn (Ohio State University), glaciologists; Ardo Meyer (U.S. Coast and Geodetic Survey), geomagnetician; Jack Long and Ralph Ash (University of Wisconsin), traverse engineers; and Sven Evteev, exchange glaciologist from the U.S.S.R. (*1*).

The route of the traverse is shown in Fig. 1. The first part of the trip from McMurdo Sound was along existing trails running southeast and south around the Minna Bluff–Mount Discovery Peninsula, thence west to the Skelton Glacier. From the top of the glacier the route lay due west for 60 miles to station 84 of the 1958–59 traverse at 78°02′S, 154°20′E. The remaining 1000 miles of the operation, where the scientific work was done, was on the high plateau. The route was generally parallel to the route of the British Trans-Antarctic Expedition of 1957–58 and crossed it near 85°S. The traverse group departed from station 84 on 30 December and arrived at the Pole station on 12 February 1961. The group traveled from station 84 to the Pole in two parties, an hour's travel time apart. The parties stopped every hour for scientific studies; the back vehicle or vehicles stopped at the station at which the front vehicles had stopped an hour earlier. These en route stations are called minor stations; 14 major stations were established for making more detailed studies. The studies made in the course of the traverse were as follows.

1) Determination of en route surface elevations from simultaneous altimeter readings made at adjacent minor stations 3 nautical miles apart.

2) Determination of detailed surface elevations from altimeter readings made every 0.4 nautical mile while the vehicles were in motion.

3) Determination of surface slope at the major stations.

4) Study of seismic reflection by conventional means at 14 stations.

5) Study of seismic reflection with tape recorders at 11 stations.

6) Study of seismic refraction to determine ice velocities at six sites, over distances ranging from 0 to 12 kilometers.

7) Studies of density, temperature, and hardness of near-surface snow from shallow (50 cm) snow pits at minor stations (studies made by the Soviet exchange scientist).

8) Detailed studies of density, temperature, and grain size of snow from deep (2 m) snow pits and studies of general stratigraphy for determining annual accumulation, at 12 stations.

9) Remeasurement of accumulation stakes located in 1958–59 at the Upper Skelton cache and at station 84.

10) Collection of samples for radioisotope measurement in near-surface layers at two stations.

11) Coring and studies of densities, stratigraphy, and temperatures at 5- and 10-meter levels in 10-meter hand-drilled holes at 12 sites (studies made by the Soviet exchange scientist).

12) Studies of temperature at 34 meters (the limit of the Thermohm cable) in seismic shot holes, which were generally 35 to 41 meters deep.

13) Studies of general sastrugi patterns and amplitudes at all minor stations.

14) Gravity observations at all minor stations.

15) Magnetic observations (declination, H and V) at all major stations and at several overnight stopping points.

16) Studies of differences in vertical magnetic intensity determined from simultaneous readings at adjacent minor stations.

17) Proton magnetometer readings of the total magnetic field, made every 0.5 nautical mile while the vehicles were in motion (the instrument was towed behind the vehicle in a small sled).

18) Surface meteorological observations (including observation of air temperature, wind speed and direction, pressure, sky cover, and so on) three times a day, at 1900, 0000, and 0600 Greenwich Mean Time.

19) Hourly determination of temperature and winds during traveling periods.

The traverse units and equipment, now located at the South Pole station, will be used on future operations exclusively in the high polar area south of 80°S, particularly in the sectors toward the South Atlantic and Indian oceans between 50° west and 90° east longitudes.

Though detailed analysis of the scientific work—particularly of studies of snow accumulation, surface parameters, gravity, magnetics, and seismic findings—will be slow and laborious, some of the more obvious information, though still preliminary, is available at this time and can be briefly outlined. It includes preliminary data on elevations and seismic soundings and some figures on snow accumulation.

Elevations

The multiple-altimeter method used, though subject to errors of reading, instrument errors, and errors arising from differential pressures, is more accurate by an order of magnitude than single altimetry, in which meteorological changes are an almost invariable source of error. Data obtained simultaneously from two or more stations require correction for various factors of

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instrumentation and temperature, but the differences between them are not distorted by large variations in absolute pressure. With a starting value of 2282 meters at station 84, the elevation obtained during the 1958–59 traverse, the elevation at the South Pole was found to be 2810 meters. The elevation at the Pole station, as determined from meteorological soundings of the upper atmosphere, is 2800 meters. In either case, whether determination is by meteorological studies or by surface altimetry, the probable error is not expected to be less than 20 meters. From station 84 to the easternmost point reached, the elevation increases more or less uniformly, to about 2900 meters. From here to the southeast the surface shows little change to about 84°S, where it begins to rise rather sharply to about 3100 meters near 86°S, 170°E, the highest point of the traverse. Toward the south for the last 80 miles to the Pole the elevation drops 300 meters. Evidence for this surface high separating the Pole and the Ross Ice Shelf appears in the data of Amundsen and of Scott and in the preliminary data of the British Trans-Antarctic Expedition, and with the newly obtained information it will be possible to outline this anomalous surface high to a much greater extent. Details of the elevation show that the plateau is by no means monotonous. The elevations of the last 80 miles to the South Pole (Fig. 2) show many wavelike crests and troughs.

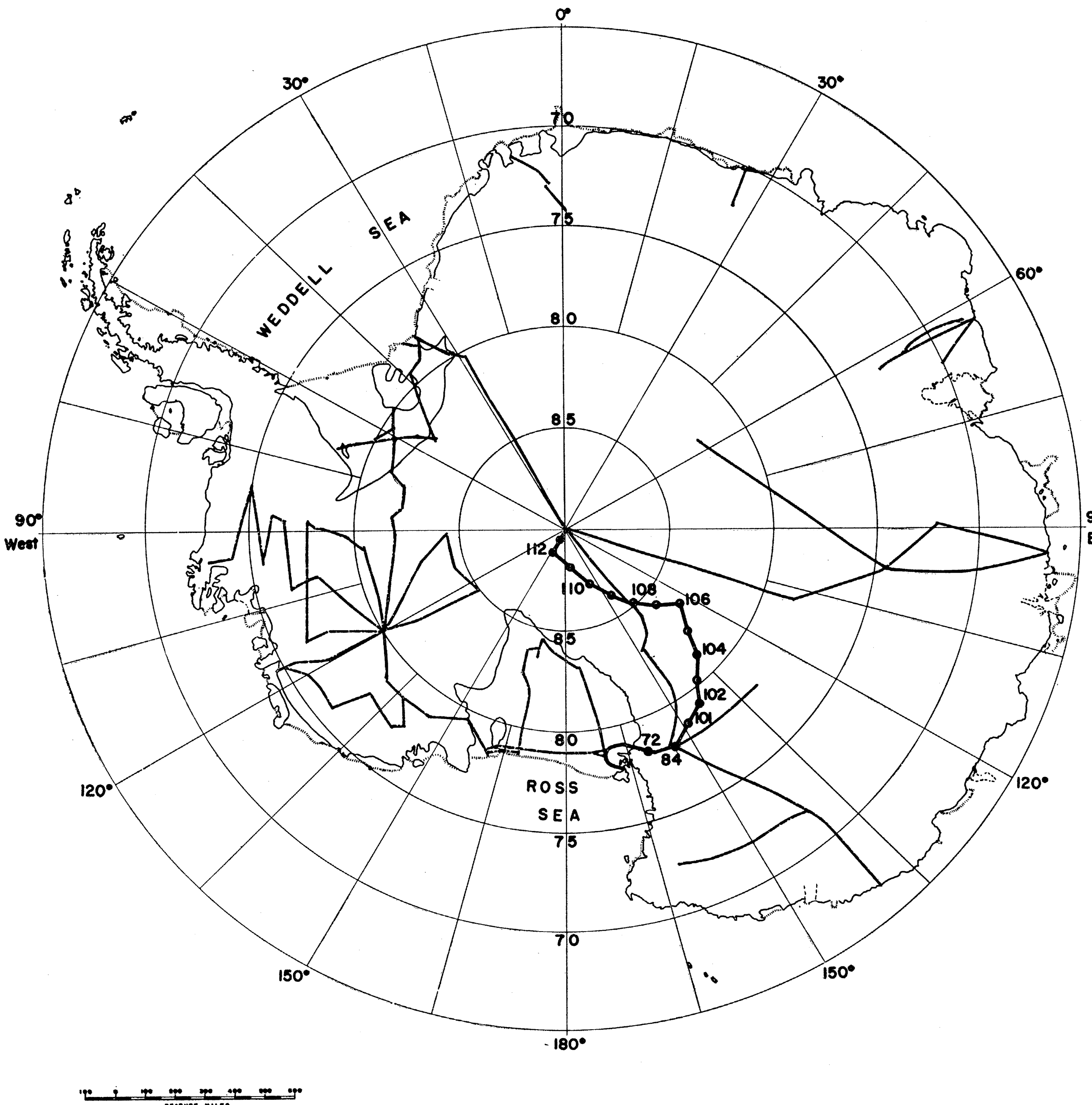

Fig. 1. Oversnow traverse routes in Antarctica. Along the McMurdo-Pole route, stations 72 (Upper Skelton cache) and 84 were occupied by the 1958–59 Victoria Land traverse.

Ice Thickness

Of major interest is the ice thickness in this part of the plateau. Previous work on the plateau showed that the seismic surface noise from the explosive shot is abnormally high and that the reflection strength is low, resulting in a very low signal-to-noise ratio; as this ratio approaches 1, the reflection identity becomes quite doubtful and is a matter of personal interpretation. On this traverse a mechanical drill (*2*) was available. However, not all the ice chips were brought to the surface, and consequently the final hole was only about 70 percent as deep as the depth drilled; thus, 40 meters was the maximum depth of hole for 55 meters of drill. Reflections at 11 of the 14 major stations where reflection soundings were attempted ranged from poor to good, but all had signal-to-noise ratios greater than 1. At the remaining three stations, which included the station at the South Pole, no signals were received above the general noise level, and any reflection identification will be subject to question. Samples of the seismic reflections are given in Fig. 3, and a tentative section along the profile is shown in Fig. 4, with the Pole-station data of Kapitza (*3*) from the U.S.S.R. traverse of 1959–60. It is evident from these and previous results (*4*) that the great transantarctic mountain system is tremendous, dropping below sea level on either side.

Though details of the gravity read-

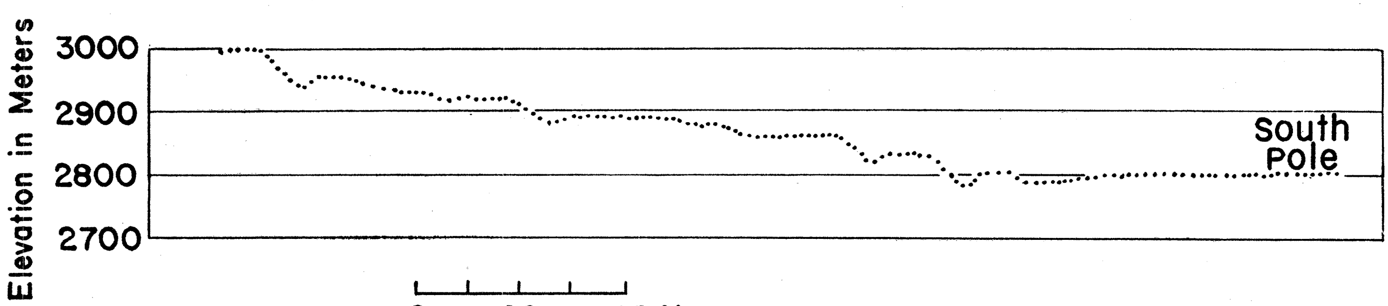

Fig. 2. Detailed surface elevations of the approach to the South Pole along meridian 157°W.

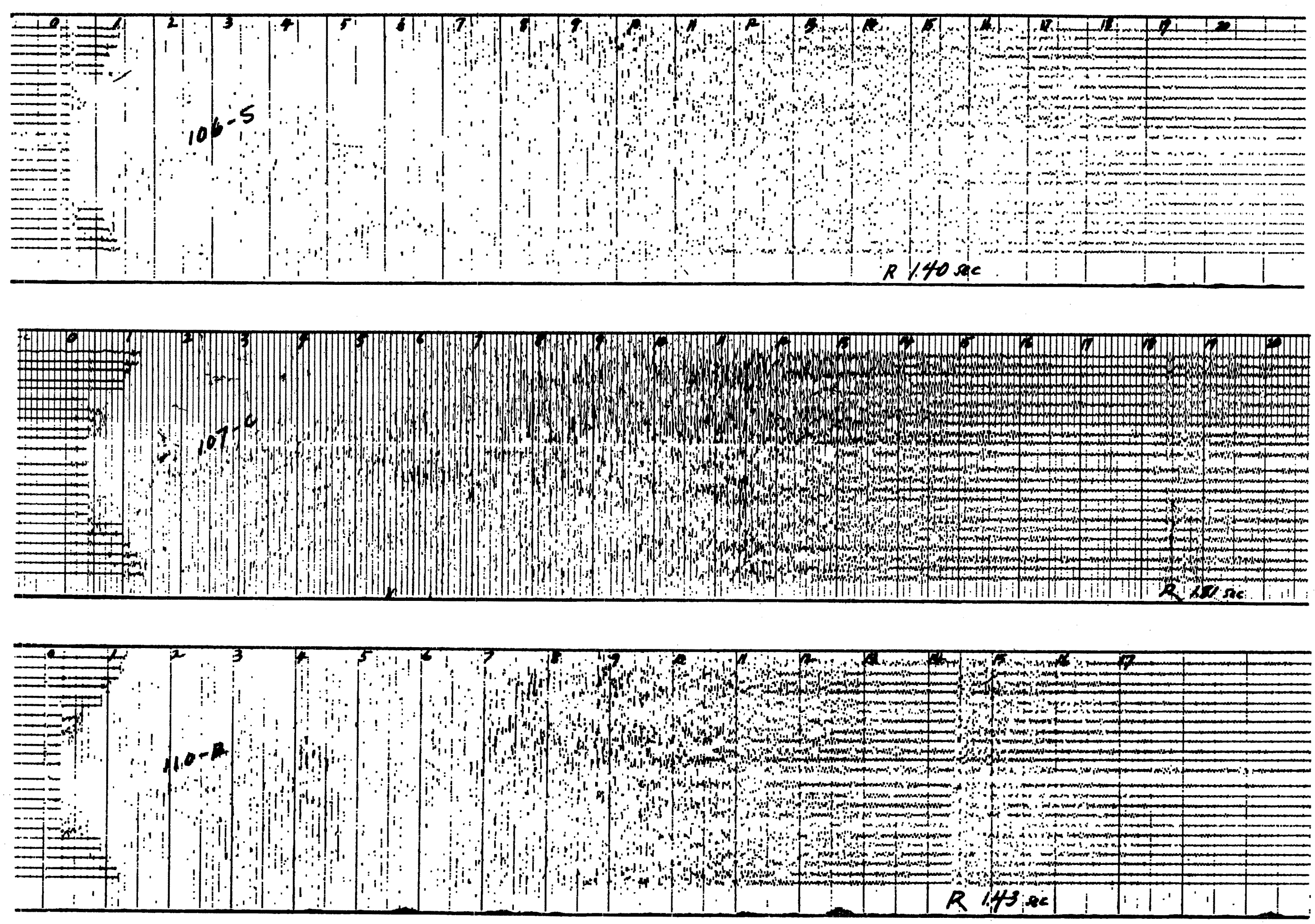

Fig. 3. Samples of seismic reflection recordings.

Table 1. Data for wind speed, wind direction, and temperature on the plateau for three 15-day periods during 1961.

Period	Average elevation (m)*	Average wind speed (knots)	Average wind direction (deg)	Average temperature (°C)†
1–15 Jan.	2466 (8090)	12	200	−19.5 (− 3.1)
15–31 Jan.	2838 (9311)	11	175	−27.1 (−16.8)
1–15 Feb.	2940 (9646)	7	225	−36.5 (−33.7)

* Feet in parentheses. † Degrees Fahrenheit in parentheses.

ings must await further confirmation of elevations and locations, it appears from preliminary reduction that the readings will confirm the change in ice thickness between station 84 and the Pole. Near 85°S, 140°E, where the traverse route crossed the British Trans-Antarctic Expedition trail, the seismic sounding results are in wide disagreement with values given by Pratt (*5*), who found ice thickness here of only about 1000 meters. Resolution of these differences should be possible when all the recordings are available for study. General agreement with results given by Kapitza (*3*) for stations immediately to the west has been obtained.

The reflection-sounding charges were generally small, limited to 1 to 5 pounds of explosives. One of the most disappointing aspects of the traverse was the failure of special bulk explosives to detonate reliably. As a result, it was impossible to make long refraction shots, which would have supplemented the poor reflection results and, at the same time, have given some information on the character of the rock below the ice mass. It is believed that some explosives that are stored for long periods in the extreme cold of the plateau may be subject to chemical change.

Snow Accumulation

The character of near-surface snow is at present under study. Whether or not complications introduced in many areas of low accumulation and large sastrugi will make it impossible to deduce annual accumulation with any degree of accuracy is not yet clear. However, good progress has been made with this method in Lesser (West) Antarctica and at the South Pole station, and the outlook is promising. Some help will come from the analysis of radioisotopes in the sample collections made at two of the stations. An illustration of the variation of accumulation is available from the results of remeasurement of accumulation stakes located during the 1958–59 Victoria Land traverse. One location was immediately west of station 72; this was the Upper Skelton cache, where 22 stakes were set out about one-fifth of a mile apart along the trail to the west. The second location was at station 84, where a group of 32 stakes was installed. A histogram of the 2.1-year accumulation (December 1958 to January 1961) is shown in Fig. 5. The average net annual snow accumulation was 35 centimeters at station 72 and 4 centimeters at station 84.

Meteorological records taken by Giovinetto define the weather conditions of the ice plateau, which are very similar to conditions at the South Pole. The approximate averages for wind speed, wind direction, and temperature on the plateau for three 15-day periods are given in Table 1.

On the traverse, only 2 days of 64 were lost because of bad weather. On the first of these, in the Skelton Glacier crevassed area, poor visibility made it inadvisable to travel; on the second (30 January) travel was impossible because of storm and blowing snow.

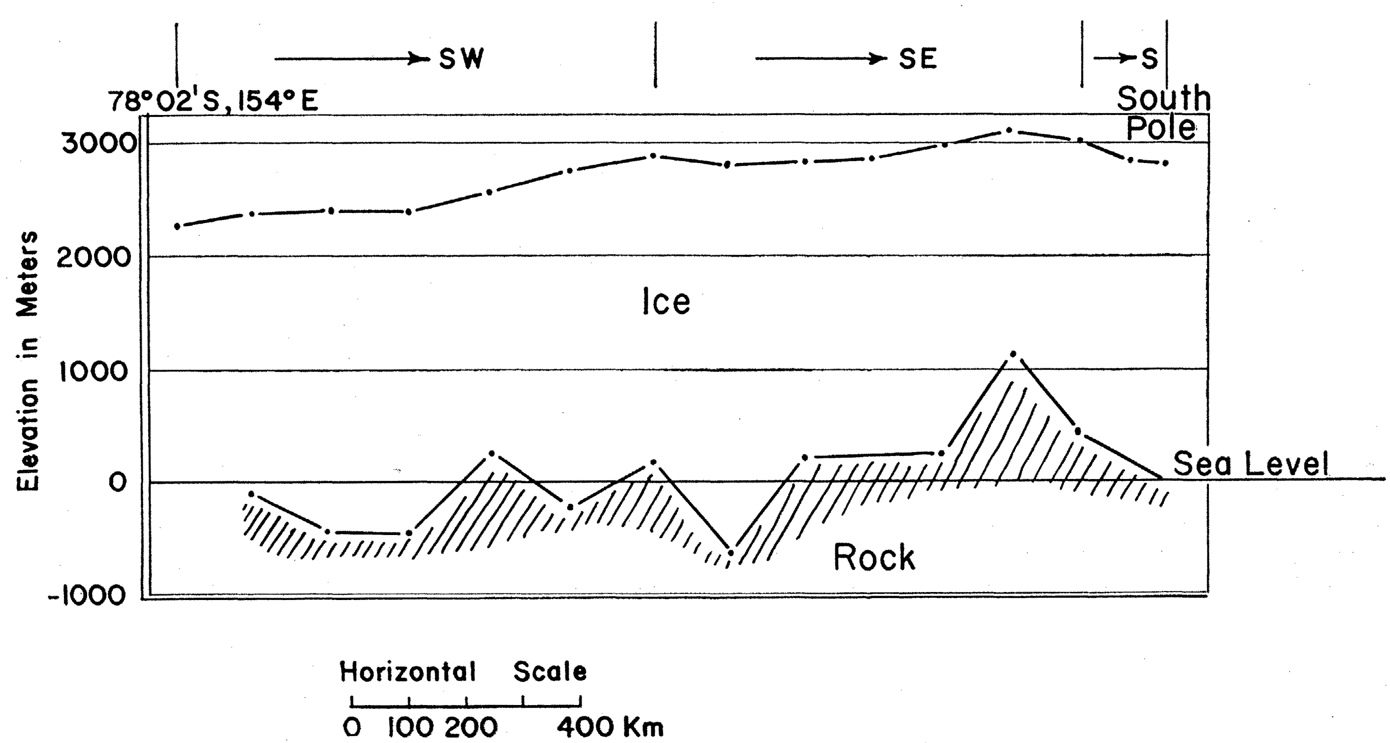

Fig. 4. Preliminary section along the traverse route.

Vehicles

One of the achievements of the traverse party was the successful testing of the new large diesel-driven vehicles. Previously, all U.S. traverses had relied on the Tucker Sno-Cat model 743, a four-pontoon vehicle powered by a Chrysler industrial engine. Because of the generally rough sastrugi and the high altitudes on the plateau, it was found desirable to procure heavier vehicles with longer range, and therefore model 843 was developed, similar to model 743 but almost twice as large, with a total weight of about 11 tons. With the larger vehicles, more extensive use was made of the cab, for scientific installations as well as for living facilities. Two of these large vehicles were used on the traverse; the third vehicle was a model 742 Sno-Cat, which is similar to the 743 except that it is powered by a diesel unit. This vehicle has a mounted mechanical drill behind the smaller cab. Also used on the traverse were rollitrailer units with large rubber tires; 500 gallons of fuel could be carried in each of these, making the total fuel capacity 4000 gallons. The trailer cargo capacity for these units is approximately 2 tons. In addition, four 1-ton sleds were used for cargo of various kinds, one having a wanigan outfitted for glaciological studies. One wanigan sled had to be abandoned midway to the Pole after serious breakage due to rough surface conditions. Although there was considerable delay in getting started, the delays due to mechanical troubles in the field were minimum and all equipment is now at the Pole, ready for future traverse work in that area.

Two major caches were located for use of the traverse. One, the Upper Skelton cache or Plateau depot, at station 72, was stocked by repeated flights of the U.S. Navy R4D planes. The other was a fuel cache at 81°S 123°E, stocked by paradrop by U.S. Air Force C-124 planes. In addition to these flights, a flight by Navy helicopter was made when the traverse was two days' journey from McMurdo station to bring repair parts for the Sno-Cat, and three additional flights by Navy R4D planes were made to the Upper Skelton cache in late December. During the traverse party's 1000-mile trip from the Skelton cache to the Pole station, no further flights were required. With the operational season on the high plateau limited to about 75 days, representing about 1000 miles of traverse, and with an over-all fuel consumption of about 4 gallons per nautical mile, any further traverses planned for this polar plateau unit will be nearly self-supporting.

Though the route from McMurdo to station 84 on the plateau had been traversed previously, it had not been traversed with the heavier vehicles. The party came upon potentially dangerous crevasse areas. One was along the line joining the eastern end of Minna Bluff with Cape Crozier on Ross Island, which represents a shear zone between the faster flowing Ross Shelf ice area to the east and the more stagnant ice south of Ross Island. The lead vehicle (the lighter model 742) passed this area without incident, but the heavier vehicles broke open several small crevasses, the largest being perhaps 2 feet wide. On the Skelton Glacier in the vicinity of Twin Rocks, traverses of the two previous years had come upon dangerous areas. On this trip the party attempted to follow a new route, on the opposite side of the glacier, but the attempt was abandoned after several very large crevasses were found. The old trail near Twin Rocks was used again, though the route followed was somewhat to the west of the traveled route. The party passed without undue difficulty but not without opening many crevasses and doing some heavy bridging. Unfortunately, no safe route for heavy vehicles from McMurdo up the Skelton Glacier to the plateau has yet been located.

The surface conditions on the high plateau are quite variable, and no single definition of traveling problems is adequate. The area near the Upper Skelton cache and the area near the South Pole are characterized by soft surfaces. The vehicles, particularly with full fuel loads in the tires, were kept in second gear and traveled at 3 to 4 miles per hour. In the region between 80° and 85°S many sastrugi of various heights were found, some with

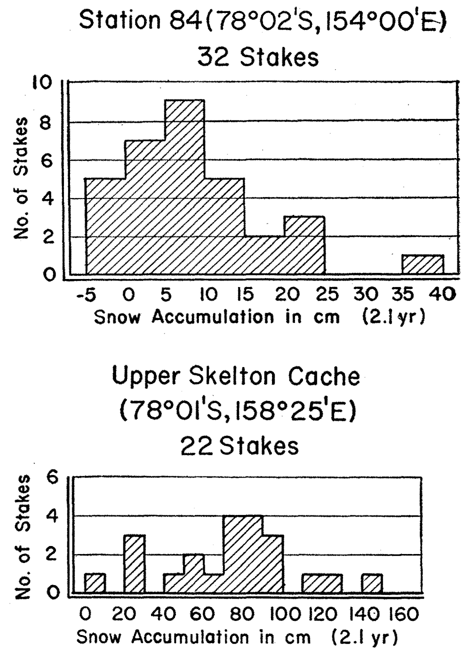

Fig. 5. Histogram of snow-accumulation data at two plateau stations that were revisited.

measured heights of almost 2 meters, and because of these and of poor visibility it was at times necessary to send someone ahead of the leading vehicle to feel out paths so the vehicles could pass through the sastrugi without danger of tipping over. At times, even in regions of large sastrugi, there were small areas where vehicles could travel in fourth gear as fast as 8 to 9 miles per hour. Generally, however, they traveled in third gear, and at about 5 to 6 miles per hour, and in an 11-hour travel day, with about one-third of the time spent for scientific studies en route and with the usual stops for minor repairs, they covered 25 to 35 miles.

References and Notes

1. The traverse was made possible through a grant from the National Science Foundation to the University of Wisconsin, and the scientific work was divided among the University of Wisconsin, Ohio State University, and the U.S. Coast and Geodetic Survey.
2. The mechanical drill used was a product of the Mobile Drilling Company.
3. A. P. Kapitza, "New data on the ice cover thickness of the central region of Antarctica," *Information Bulletin of the Soviet Antarctic Expedition No. 19* (1960).
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