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13. It is apparent that I here (as also elsewhere in this paper) distinguish between *fact* and *value* and, at least by inference, reject the view, appearing in current discussions of theory of knowledge, that facts are in themselves value judgments. Actually, I do *not* accept the view that *existential* and *normative* propositions are equivalent—that *scientific* and *ethical* statements are basically similar [G. Lundberg, "Semantics and the value problem," *Social Forces* 27, 114 (1948)]. By contrast, I am inclined to accept the view, as expressed by C. Kluckhohn, that although existence and value are intimately related and interdependent, they are—"at least at the analytical level — conceptually distinct." However, a detailed discussion of this controversy is not appropriate in this paper. The reader interested in a detailed discussion of theoretical considerations in this area is referred to publications cited here, particularly reference 26, and, in addition, to a chapter on "Values and value orientations in the theory of action: an exploration in definition and classification," by C. Kluckhohn *et al.*, in *Toward a General Theory of Action*, T. Parsons and E. A. Shils, Eds. (Harvard Univ. Press, Cambridge, Mass., 1951), pp. 399–433.
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Evidences of Climatic Change from Ice Island Studies

A. P. Crary, J. Laurence Kulp, E. W. Marshall

Arctic Ocean ice islands were located by the 58th Reconnaissance Squadron of the U.S. Air Force in 1946 during routine weather flights (*1*). One of these islands, T-3, was occupied by the Air Force for the collection of meteorological, oceanographic, and geophysical data (*2*) from March 1952 until May 1954. The size of T-3 is about 11 by 5 miles, its thickness is about 170 feet and, except for the annual snow layer, it consists of ice of density 0.89 to 0.92 grams per cubic centimeter.

Surface dirt, various plant and animal samples, and the presence of morainal material give evidence that this island was at one time near land. It was probably part of the ice shelf, the remnants of which are still present along the shores of northern Ellesmere Island. During 1952 and 1953, cores were obtained through the upper part of the island; numerous horizontal dirt layers containing widely differing amounts of dirt were found. The dirt in the layers was collected from one of the deep holes, and weights were obtained for all except the smallest layers. The weights are shown in Fig. 1. From this figure, it can be seen that a large surface dirt layer is present, and below this, in the first 90 feet of ice, there are about 85 layers containing widely varying amounts of dirt, but all containing considerably less than the layer at the surface. Near 90 feet, a very heavy layer is found that contains an approximate weight of 5 to 6 times that of the surface layer. The ice was cored for 20 feet below this layer and found to be free of dirt.

Preliminary petrologic studies of the ice character have established that the top part of the island is iced firn formed from snow, and that the lower part below the dirt layers is partly ice firn and partly sea ice. Although ice with glacial textures, associated with much morainal material, was found in one area on the island, the main parts of the island and of the shelf are not believed to be of glacial origin.

In two areas on opposite ends of the island, very heavy dirt layers were exposed at the surface of the ice. Studies of the ice character showed that these exposures resulted from the outcropping of the dirt layer found at 90 feet in the cored hole located between these areas. The weight of this heavy dirt layer was determined from the deposit on the 4.4-square-meter surface of a pit near the outcrop. The weight of the sample of dirt found at 90 feet in the cored hole was extrapolated for comparison with the larger sample and the two weights agreed within the limits of accuracy of extrapolation. The weight of the top dirt layer was also obtained from surface pits. Values for all intermediate dirt layer weights are extrapolated from the weights found in the 3-inch diameter core.

The dirt of the surface layer occurred in globules up to a few inches in diameter located in holes generally 2 to 3 inches below the ice surface. During surface-ice ablation, such as was noted during the two summers at the island, the dirt in the holes melts the ice under it and keeps an approximately constant distance below the ice surface. Thus it is protected from drainage runoff. Some in-

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dividual grains remain on the ice surface, giving it a distinct coloration during the melting season. The larger of the dirt layers found below the surface, with the exception of the largest bottom one, also occur in this manner on a smaller scale, with the dirt particles collecting in small balls. These are located as much as 1 inch below a thin zone containing individual dust particles; the zone is noticeable as a discoloration. The dirt in the lower 25 feet of the 90 feet of ice that formed the upper part of the island, although it appeared in patches, did not occur in distinct horizontal layers. This is probably due to the presence of lake ice with elongated vertical crystals, the dirt having settled between the crystal boundaries to various depths. The heavy dirt layer at the bottom was scattered quite unevenly in a zone 2 or 3 inches deep.

Dirt from the various layers is under examination at Dartmouth College (*3*). The preliminary investigations indicate that all layers contain materials of the same types, detritus from metamorphics and fragments of altered volcanics, with the particle size about that of fine silt. The percentage of heavy minerals was so low that these must have been wind-deposited. Their origin is presumably the low coastal hills of northern Ellesmere Island, which, at the present, are free of snow from about mid-June to late August.

In one area on the island, about 3 miles from the core holes and apart from the areas of heavy dirt and morainal material that we have mentioned, there are deposits of plant material. These have been examined by Polunin (*4*) who believes that they have for the most part been washed down upon the island from shore areas. His examination of the growth rings in the arctic willow and study of a tuft of moss that was brought back to life have led him to the tentative conclusion that the island broke away

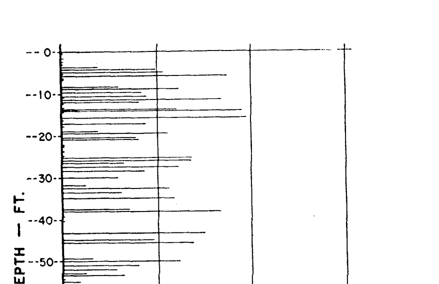

Fig. 1. Depths and weights of dirt layers in a 92-foot hole on T-3.

from the shelf sometime after the summer of 1935.

The present interpretation of the dirt layers is that they were formed from annual deposition over the ice surface in approximately equal increments during the entire period of island build-up. During warm cycles of many years duration, these dirt layers accumulate and, by ablation of the ice surface, they also merge with layers that have been deposited in previous colder periods. It seems apparent from Fig. 1 that there have been many such warm cycles since the island was formed. A major period is represented in the lower heavy dirt layer, and another by the top dirt layer; the latter period is still in progress. All through the time represented in the intermediate layers, evidence is present for smaller periods of net ablation. If we assume that the small dirt layers, those weighing less than 0.5 grams per square meter, represent average annual accumulation, there would be at least a few thousand years of accumulation present.

In an attempt to construct a history of island build-up from the individual dirt weights, the carbon-14 dating technique has been utilized. This method, which is well suited to dating over the period of a few thousand years, deals with the carbon material present in the dirt layers, which is found in the form of microscopic spores, fragments of woody tissues, and pollen grains (*5*). Unfortunately, it has not been possible to collect sufficiently large amounts of the dirt for a good analysis except from locations where it occurs in considerable quantities. However, the method of handling the carbon material in the dating process is undergoing rapid advancements that are making it possible to deal with smaller and smaller samples. The available results of the carbon-14 studies of materials from the ice island are given in Table 1.

There are many difficulties in the interpretation of these dates. Sample 192A, which came from an intermediate dirt layer in the vicinity of the cored holes but which is not included in the table, was the only one in which the material was deposited over a limited number of years and which can be assigned to a definite place in the shelf-building period. Unfortunately, this sample, containing only approximately 1 gram of carbon, was too small to give a reliable age determination. Preliminary results, however, suggest that the layer from which it came might be several thousand rather than several hundred years old. Samples 192B and 213D were the largest and hence most reliable from the standpoint of carbon-14 dating, but both represent an accumulation of many years. Although the accumulation per year may have been fairly uniform, a great deal of the material may have been lost through drainage

Table 1. Results of carbon-14 analysis

Sample No.	Description	Age (yr)
192B	Surface dirt in bottom of drainage lake. Represents a combination of all dirt layers with possibility that much of the top material had been washed away.	5730 ± 300
192E	Surface grass and debris. Represents top layer in area of much floral material but may not be representative of general top dirt layer.	450 ± 200
213D	Bottom layer dirt near outcrop. Uncontaminated by surface layer and not subject to drainage loss as sample 192B was.	3050 ± 200

or other processes, and this loss may have occurred to any part of the accumulation. In addition, the heavy dirt layer may have ablated well into the ice upon which it is resting and in which some salt was present, and it may have picked up marine material of undetermined age. If we assume uniform representation of all years in these samples, the dates given in Table 1 would need to be increased somewhat to be the arithmetical average, for the counting rate varies exponentially with time. There is also the possibility that the soil blown onto the shelf ice carried some "fossil" carbon with it. This could give, at least in the case of sample 192B, an age greater than the time of formation of the dirt layer.

Despite the difficulties in the carbon-14 dating, there is a general agreement in the order of age as determined by this method with that deduced from the total weights of dirt and possible annual accretion, both of which indicate a beginning following the Climatic Optimum or Thermal Maximum, which, according to Ahlmann (*6*), reached its height about 4000 years ago. Numerous carbon-14 measurements made at the Lamont Geological Observatory on samples from Alaska suggest a major warm period 3500 to 5500 years ago. Whatever amount of ice may have accreted after this warm period, it appears that it was subsequently ablated to the original level, taking with it the dirt layers. The end of this ablation period and start of the accretion represented by the ice still present on the island occurred at a time, indicated by dirt weights alone, about two-thirds to three-quarters of the total island age. Although there is no direct information about this date, it can reasonably be assumed to have occurred 500 to 1000 years ago following the warm period that the Norse settlements in Greenland evidence. Then, in the last 200 years or so, there has been another warming-up period that we are still experiencing. Throughout the island history, there must also have been periods of melting and accretion of salty or brackish ice taking place at the lower boundary. These periods may or may not have been parallel with the upper ice history, although the upward heat flow would, of course, increase with decreasing total thickness. Figure 2 shows the change of thickness of the iced firn with accumulated dirt weights, the latter being essentially a time scale. Dotted lines show possible accumulations that have since been ablated.

The significance of this historical record lies in its future climatic implications. During the period in which the 90 feet of ice accumulated on the island, the ice of the entire Arctic basin, including shore areas along the high-altitude land mass, must also have attained considerable thickness. The snow cover noted on T-3 in 1952, 1953, and 1954 amounted to from 1.5 to 1.7 feet. This amount is also typical of northern Ellesmere. As the ice pack became thicker, it was able to withstand the pressures of the wind that tended to hummock it to great heights. In time, the surface must have leveled off considerably. The reduction in surface roughness decreased the wind drag and lessened the ice movements caused by winds and permanent currents. The result of this process was a smaller loss of ice to the Greenland Sea each year. Even today, the ice that flows through this entrance to the Atlantic Ocean is mostly derived from the eastern hemisphere part of the basin. A few hundred years ago the general accretion

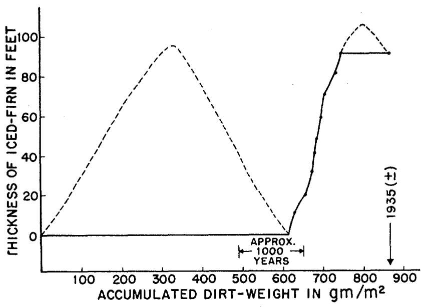

Fig. 2. History of iced-firn accumulation.

period stopped and the present period of ablation began. Little by little, the percentage of heavy ice in the Arctic basin decreased.

The earlier Arctic explorers often wrote of the thick "paleocrystic" ice that is rarely seen today in an ocean where the ice is 6 to 12 feet thick and probably less than 20 years old. Storkerson spent the summer of 1918 on an ice flow in the Beaufort Sea that he estimated to be 50 feet thick (*7*). This, probably, was sea ice rather than shelf ice or a surface dirt layer would have been noticed. At present, there is probably little left of older ice except that along the shore, which is itself breaking up under the forces of a faster-moving ice pack and the increased tides and storm effects that accompany the thinner ice pack.

Although it would appear from Fig. 2 that 90 feet must be ablated from the island before we can approach the conditions prevailing a thousand years ago, it must be pointed out that however mild the temperatures may have been at that time, the ice shelf survived and is not surviving the present period. We can only infer that either the ice shelf is thinner now or that the disrupting forces are greater, or both. These disrupting forces are excessive vertical movements of tidal or storm origin, which would increase in frequency with decreasing pack ice thickness. The implications in either case are that the ice is thinner at the present than ever before in historical times.

The ice along the shores of the high-latitude land masses such as Ellesmere Island and Greenland should be the first to form in a cold period following an open polar sea and should be the last to melt as we approach the conditions of the open polar sea. The evidence given here would indicate that we are approaching such a period again. The far-reaching effects of such a possibility warrant further efforts for the collection of more evidence in the other floating islands and in the shelf and high-latitude glaciers of Ellesmere Island and Greenland (*8*).

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Traveling High-School Science Libraries

Hilary J. Deason

The AAAS Traveling High School Science Library Program, made possible by a grant from the National Science Foundation, began operation in October, when the first unit of the libraries arrived at each of the 66 high schools selected for the experiment. Announcements of the program and its objectives were made in *Science* [**122**, 190 (29 July 1955)] and in *The Scientific Monthly* [**81**, 159 (Sept. 1955)]. The program was organized with assistance from the U.S. Office of Education and the National Education Association and its affiliated organizations.

The general purposes of the project are to stimulate interest in reading science books, to broaden the science background of high-school students, and to assist students with scientific interests in choosing a career.

The books, which number 150, are divided into six units of 25, each fitted into an attractive case that serves both for display in the school libraries and for shipping the books from school to school. The cases, bearing a display poster on the inside of the raised front cover, are shown in Fig. 1. Each school retains a unit for 4 to 5 weeks while classes are in session; thus, by 15 May 1956, all six units will have been used by the students and teachers at the 66 schools.

The 150 books were selected with the assistance of more than 250 scientists, science teachers, and librarians from a long preliminary list that was compiled from various sources. The 150 volumes are included in each of the 12 libraries;

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