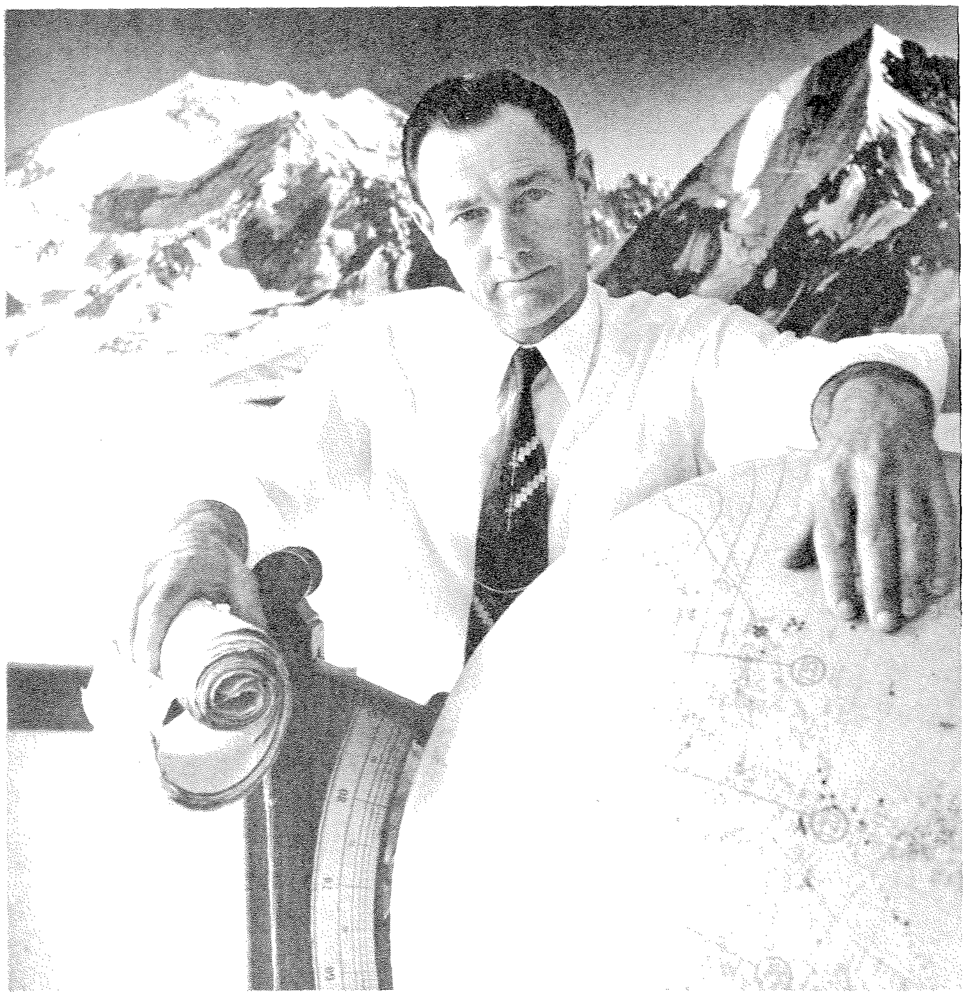

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by ROBERT P. SHARP

CALTECH AND THE IGY

GLACIOLOGICAL RESEARCH

BY CIRCUMSTANCE and tradition, ice occupies a prominent place among subjects to be studied during the forthcoming International Geophysical Year. Twice before, various nations of the earth have joined in similar coordinated scientific efforts known as Polar Years which were devoted to investigations of ice-infested arctic regions. During the first Polar Year, 1881-1882, the U. S. Army sent a detachment of 24 men to northern Ellesmere Island for purposes of exploration and observation. Only 6 returned from this tragic expedition. In the second Polar Year, 1930-31, Alfred Wegener led a German scientific party to Greenland. At the cost of his own life, he established the German station *Eismitte* near the center of Greenland's ice sheet and produced the finest study made on that huge body up to the present decade.

Since much of the field activity of IGY focuses upon the Antarctic, it is natural that ice continues to be a subject of major interest. In truth, it can't be avoided. Fully 99 percent of the Antarctic continent is ice-covered. Some 85 percent by area and 90 percent by volume of the world's landborne ice lies on this south polar continent and contiguous islands. The surrounding seas support floating ice shelves and a heavy ice pack.

Now, a stevedore in Hong Kong, a tycoon on Wall Street, or a bather on the beach at Acapulco may all regard the Antarctic ice mass as too remote to be of much interest. Actually, they, and indeed much of the world's population, can be seriously affected by the behavior of this body. If it were all melted tomorrow, a world-wide sea-level rise conservatively estimated at 200 feet would occur. This would convert Florida to a few small islands and would solve the problems of congested traffic in New York City.

An objective of IGY Antarctic glaciological research is to place this estimate on a firmer basis by determining the volume of the Antarctic inland ice. Its area, already known to be something in excess of 5,000,000 square miles, will be more accurately determined by geographical explorations, air photography, and geodetic measurements. The great unknown is thickness. The Ross Ice Shelf has been sounded in a number of places, but since it is largely afloat, this is no help in the present problem. Measurements of depth have been made near the edge of the inland ice in only two small areas, and, though valuable, these data are wholly inadequate for volume calculations.

Previous estimates of mean and maximum thickness for the Antarctic ice sheet are judged to be much too low. These estimates have been unduly influenced by the predominance of observations in West Antarctica, an area of high rugged terrain and thinner-than-average glaciers. The bulk of Antarctic ice probably lies under the great East Antarctic dome, which is now known to attain an elevation of at least 13,000 feet. Owing to U.S. preoccupation with establishment of a South Pole station, the Russians have inherited the interior of East Antarctica. If they are successful in establishing their bases and in carrying out the proposed scientific programs, East Antarctica may yield some of the most significant results of the IGY operation.

Ice thickness

A guess is ventured that ice under the East Antarctic dome will prove to be in excess of 14,000 or 15,000 feet thick. It is also anticipated that IGY investigations by the 11 nations now proposing to occupy some 37 bases in Antarctica will establish a mean thickness for the entire ice sheet of more than 5,000 feet. This is a considerable boost over the 2,000 feet now commonly cited and used in calculations. Ice thickness will be measured by the usual commercial seismic exploration techniques, which involve the recording of artificially generated waves reflected from the rock floor beneath the ice. Earthquakes are to be recorded at a few Antarctic stations, and, if some of proper size and location occur during IGY, they may afford another means of arriving at a figure for average ice thickness. These methods are more fully explained by Frank Press in a companion article.

Now, the more important question facing our stevedore, tycoon, and bather is the possibility that enough Antarctic ice will melt to cause a significant sea-level rise within the near future. A one-foot rise would be embarrassing and a 10-foot rise catastrophic. Melting of 25 to 35 feet of ice from the entire surface of the Antarctic ice sheet would raise worldwide sea levels by one foot, and this amount of melting currently occurs on glaciers in other parts of the world in a few years. We have little basis for estimating the potential for such an occurrence in the Antarctic, but studies during IGY of accumulation, wastage, the micrometeorological factors affecting these processes, and the past history of fluctuations in ice volume will help immeasurably in evaluating the possibilities.

Wastage of Antarctic ice occurs at present by melting, evaporation, wind erosion, and calving in the form of icebergs. This last may be the most important, but it is not particularly sensitive to climatological change. Wind drifting of snow into the sea is relatively minor. Therefore, it looks as though melting and evaporation are the only wastage processes likely to be much influenced by climatological change. The Antarctic is so cold that a considerable warming of the environment could occur without notably increasing melting and evaporation. In fact, one currently popular theory holds that an increase of temperature in the Antarctic would produce an expansion of the ice rather than a shrinkage, owing to the increased snowfall resulting from greater water vapor content in the atmosphere. This is entirely possible, but it too remains a speculation until more is known about Antarctic accumulation, wastage and the controlling meteorological factors. Recent scare headlines concerning the possibility of a disastrous rise of sea level within the next few decades overlook the difficulties of increasing the wastage of Antarctic ice. A warming of the atmosphere may actually cause a fall of sea level.

Evidence of former fluctuations in volume of the Antarctic ice sheet will be carefully studied with the aim of relating them to climatic fluctuations of identifiable type and magnitude. The history of the ice sheet for the past 500 to 1,000 years will be read in part from cores from deep drill holes. In this study the oxygen-isotope researches of Caltech's Sam Epstein will play a major role. Epstein, associate professor of geochemistry, and his colleagues, have shown that the annual layers of accumulation in snow and ice on glaciers can be identified by the differences of oxygen-isotope ratios (O^{18}/O^{16}) which reflect the temperature at which precipitation occurred. This relation, plus the fact that secular variations in relative temperature are indicated by these ratios, will show whether colder or warmer periods in Antarctic history have resulted in an increase or decrease of net accumulation.

Ice packs and glaciers

Many other phases of glaciological research will be pursued in the Antarctic and on other parts of the globe by the more than 50 nations participating in IGY. The Arctic will come in for its share of attention and considerable work is planned for the ice pack covering the north polar sea, both by the U.S. and Russia. The large islands of old thick ice within this pack will be of special interest, partly because of their possible strategic use. A Caltech crew will be engaged in detailed studies of the Blue Glacier in the Olympic Mountains, Washington, with the objective of determining the mechanical behavior and flow laws of that "plastic" rock, ice, as it exists in such natural bodies.

The IGY is designed primarily to yield coordinated studies of various geophysical phenomena, particularly those for which synchronous observations in a number of widely separated localities are especially valuable. The behavior of the earth's many ice bodies is related to worldwide conditions, and IGY glaciological research is designed to determine what these conditions and relations are.