GEOGRAPHICAL OBJECTIVES IN THE POLAR REGIONS*

By Isaiah Bowman, President Emeritus, Johns Hopkins University

IN this company it would be carrying coals to Newcastle to review the recent striking accomplishments in photogrammetry. Equally striking are the number of observations by physical instruments that can now be lifted off the ground, so to speak, with the definite assurance from preliminary laboratory and field tests that still more will soon be on the wing. Also unneccessary is a calculation of time saved by use in the air of photographic, radar, gravity, solar, and magnetic techniques under polar conditions where cloud and locally sustained high winds may severely restrict the hours or the accuracy of observation. I assume that you have asked me to speak on geographical objectives because you also wish another point of view to be maintained, namely, what are some of the geographical priorities of common interest to all who are engaged in the advancement of pioneer work in high latitudes.

The compass of polar research still includes the classic objective of "getting through." By this I mean the surface traverse of a still enormous extent of unexplored territory. It is necessary to say this to offset the easy untruth now current that by flying over territory one can carry out a substantially complete scientific program. Diverse as air techniques now are, there is still no substitute in many critical areas of research for a man with his feet on the surface, and if possible, on ice-free ground. Studies by air supply some inestimable advantages for ground work: photography shows where the surface is ice-free, the location of probable routes to likely places, and in some cases the relative importance of promising areas for future work.

Such is the glamour of the photograph, one must again emphasize the fact that a photograph is not a map. It supplies data that may be reduced to the symbols and conventions of a map. Maps have color and liveliness to the imaginative and interpretative mind, but for a photograph to lay claim to these and other assets of the "map" is a distortion of title. Whatever the reason for the distortion, the public is inclined and even encouraged to think that an explorer has "mapped" when he has only photographed. This may lead to the unwarranted assumption that the big job has been done and only details remain to be filled in. It is hardly necessary in this company to say that photographs without position and altitude controls have reconnaissance value only. Without such controls photography is primarily picture stuff so far as mapping is concerned. Systematic even if limited surface work is basic to any primary grid and to the calculation of relief from air observation.

However, *to get through* is still a highly desirable objective. Examples from the Arctic will illustrate the point. In both trade and war it is necessary to know the shifting position of the ice, whether of pack ice or of free-floating ice transported by currents either in open stretches of the Arctic Sea or beyond its exits. Ahlmann's researches, recently published,[1] show a contraction of ice in the high latitudes of the northern hemisphere. The drifting ice in the Arctic has been reduced in extent, in the Russian sector, by one million square kilometers, from 1924 to 1944. The cod on the coast of Greenland has migrated 1,000 km. north-

* Opening Address, Fifteenth Annual Meeting of the American Society of Photogrammetry, Washington, D. C., January 13, 1949.

[1] Hans W. Ahlmann: Researches on Snow and Ice, 1918–40, *The Geographical Journal*, Vol. 107, Nos. 1–2. Jan.-Feb., 1946. Also *Research Series*, No. 1, Royal Geogr. Soc. (London), 1948.

wards since 1917, and the catch has risen from 125 tons to 15,000 tons in the interval of 30 years. "At the same time, the largest herring fisheries in the world —north of Iceland—have now failed for four years in succession because the surface water has become too warm. The forests of North Scandinavia are rapidly spreading beyond the former timber lands, and the grain harvests per unit area have increased not only owing to improved seeds and cultivating methods, but also owing to longer [growing] periods."[2]

A widening of ship lanes along parts of the land border of Siberia has made more extensive shipping possible to and out of the large Siberian rivers. Surface craft will find the going less difficult if the retreat continues. But will it continue? The period of time of Ahlmann's data—150 years—is too short to give us a basis for a long-range prediction of the future advance of the ice in the limited areas from which it has slowly withdrawn. Theoretically interesting as scientific long-range prediction may be, the short-range picture is more important from the standpoint of rapidly changing and immediately urgent human events. Surface ships, using these seasonally free and presently wider channels that in places border Arctic lands, can become an important element in the development of the fringe of high-latitude outposts maintained for a wide range of scientific observation related, as in meteorology, to the improvement of weather forecasting both locally and in lower latitudes. One could hardly exaggerate the importance of such open water in the matter of supply for air-borne undertakings in time of war. We hope, of course, that no such use will ever be made of open water in high latitudes, but we cannot ignore the possibility.

It is clear that we must inaugurate a far more intensive scientific study of the withdrawal of the ice. *The time has come, indeed, when a diary of the ice must be kept.* We have mentioned weather forecasting and the possibility of correlating ice behavior with local weather, modified substantially, if our theories are correct, by the increasing extent of open water during part of the year. What the meteorological effect of increasing areas of open water may be at greater distances remains to be seen: local impulses may have an *indirect* effect of substantial importance at long distances. "The outstanding feature of the state of motion of the bulk (lower 9/10 of the total mass) of the atmosphere of the Northern Hemisphere, and undoubtedly also of the Southern Hemisphere, is the existence of an extensive circumpolar cyclonic (west-wind) vortex. This circumpolar vortex has its maximum intensity just beneath the tropopause, near the 12-km. level, in middle latitudes."[3] Arctic weather and circulatory influence outside the Arctic is an especially important question today with settlement extending into numerous distant outposts in Canada, Alaska, and Siberia. Every aspect of weather in our air age has become extremely important to communication, government, and defense at all times of the day and night at every point of observation.

We have all become conscious, through the after-effects of war, of the sensitive balance between mouths to feed and tons of food to produce. An immense amount of untriangulated prophecy has been mixed in with scientific and statistical findings. It would be well if we unscrambled the mixture for a moment. Before 1941, we had never been committed to a long war of all-out scale, nor one that made such great drafts upon two important elements of modern life, namely, large-scale machine production and large-scale world-wide trade dependent upon huge shipping fleets and commercial organizations of great com-

[2] Personal communication, Nov. 11, 1948.

[3] C. G. Rossby and H. C. Willett: "The Circulation of the Upper Troposphere and Lower Stratosphere," *Science*, Dec. 13, 1948, Vol. 108, p. 643.

plexity. Machinery had to be turned to war use principally and shipping had to be allocated to both war and a minimum of indispensable trade. Lost and rebuilt and increased on a war basis, shipping took a heavy toll of available energy. Also we had never before had so high a standard of living, such immense unfilled and mounting needs due to the all-absorbing demands of war, and such an exigent demand, following the surrender of enemy states, that the needs be met promptly. It was even assumed that the standard of living could be raised rather than lowered in the process.

I can see no way of paying for the colossal cost of war except through a lowering of the standard of living, or an increase in industrial and food production to sustain an enlarged world trade, or both. New means of communication also play their part but require time to develop, a longer time than it takes for a man to starve! Temporarily, at least, a lower standard of living therefore seems inescapable if debts are to be paid and support given to new defense measures that a declared enemy has forced upon us. We have not faced this fact—if fact it be—up to the present time. We must therefore find new ways of increasing the food supply. We must also provide for lower food costs. Nor is it sufficient, in view of the hazardous state of other countries with whom we trade, to increase the quantity of food and provide subsidies for the maintenance of prices, while leaving communications and monetary exchange to chance.

It is clear that parts of the job of fighting tendencies toward a lowered standard of living lead far into economics and politics, but there is one part of it that lies within the field of science—the sheer increase in world food supply. I think it supplies great drive to scientific research that this important factor of human welfare is in its keeping. It is natural in this connection, to turn to the ocean which covers three-quarters of the earth's surface and see what secrets it may hold. In addition to grosser forms of life that have been known and used for centuries, such as fish and sea mammals, there are smaller forms, especially plankton, whose study in systematic form in the different climatic zones of the sea is now a main objective of field work in geography and the sciences mothered by geography or that come within the wide circle of its traditional definition. Up to this time such studies have been mostly samplings. Some concentration is seen in areas where commercial fisheries are of great importance. Scientific studies in certain sectors of the Antarctic, where whaling has supplied an incentive, are noteworthy, and the same is true of the North Sea where commercial fisheries have reached a high state of development.

In the geographical distribution of biological, meteorological, and oceanographic phenomena, so-called "laws of distribution" are often little more than bundles of anomalies. The "laws" express only the *tendencies* of forces whose effects are broken up by the irregularities of the terrain and the ocean floor, and by the continuing interaction of the parts that are broken up. Broad generalization is a useful aid in sorting phenomena and in testing theory but it has limited value in forecasting local conditions at a specified point. Generalization and imagination tend, therefore, to outrun known detail as economic uses for land vegetation and plankton are conceived. For example, grasses differ in protein and vitamin content according to latitude, cloudiness, rainfall, and the like. Grass is not just grass anywhere and everywhere. Likewise, plankton and higher plant and animal forms have been found to vary in quantity of trace elements, as well as vitamin and protein content according to differences in the geographical environment. A new map of the sea is therefore required. Field work constantly extends the number of unexpected diversities and anomalies that challenge earlier generalizations. We are told that the earth is growing smaller as air transport is extended. With the advance of biochemistry it is becoming larger!

The abundance of life at low temperatures in the Antarctic has attracted the general attention of geographers, biochemists, and nutrition experts. Griffith Taylor, in "Antarctic Adventure and Research" (1930) has described the "protoplasmic cycle" peculiar to low-temperature waters. Rich in phosphates, certain masses of ice-bordering waters teem with diatoms, algae, and protozoa. In warmer waters of low latitudes, the protoplasmic content of such forms is quickly destroyed after death by the abundant bacteria in the water. The cold Antarctic waters, by contrast, are free of such bacteria and the protoplasm of dead plankton is thus kept in "cold storage and supplies unlimited food material for higher organisms" (pp. 203–4).

To the same effect is Rudmose Brown's description:[4]

> A few minutes' haul is enough to fill a silk townet with a gelatinous mass of . . . unicellular plants (diatoms). The wealth of the phytoplankton in cold seas is thought due probably to "the scarcity and decreased activity of denitrifying bacteria . . . , [and] the tendency for surface layers of water to sink and to be replaced by deeper layers rich in nitrates . . . , [while] the abundance of silica in polar seas" is due to replenishment by waste swept from the land by glacial scour.

Survey, survey, and survey may be said to be the three basic requirements of present-day polar research, and we do not restrict the word to cartography. Surveys will give us better maps or maps where none exist. They will analyze the air and sea currents whose location and strength may be critical factors in navigation by airplanes or surface craft in peace and war. They will probably increase the reliability of forecasts of considerable range as theory is refined, revised, or amended by new data. Field observations are an inexhaustible spring of inspiration for the mathematical, physical, and biological syntheses that are the foundations of scientific system and law, that is, constantly improving generalization.

Up to the present time, no sign of an ice-age earlier than the present one has been found in the Antarctic, though rocks of most geological eras have been discovered. This is particularly striking because Australia, in a presently temperate to tropical situation has repeatedly revealed "striking evidence of glaciation on a grand scale."[5] Permian ferns and Triassic trees, as well as coal and fossil leaves of a genus with wide range have been found.[6] Fossil leaves have been found within 300 miles of the South Pole. In Palmer Land (Graham Land) Cretaceous fossils have been found of kinds that imply "the existence of a mild climate with comparatively warm ocean currents at this period." How and when did the change of climate occur? Will further geological sections, yet unstudied, show older ice-ages? Was it a general and distinct change of climate that produced in such extraordinary high latitudes the mild-climate forms we have mentioned, or may they be explained at least in part, by changes in land and sea *outlines* with resulting changes in ocean currents that carried warm water into areas now occupied by cold water?

The determination of changes in land and sea areas and outlines, in high latitudes, are of value in searching for the causes of past glaciations and for the light they may throw on the probable future of present ice caps with their direct effect upon sea level and present port installations. Was the former more intense glaciation of Antarctica associated with higher land? It would seem to because of the abnormal depth of the continental shelf bordering Antarctic lands and

[4] R. N. Rudmose Brown, Antarctic and Sub-Antarctic Plant Life and Some of its problems, in *Problems of Polar Research*, Special Publication No. 7, Amer. Geogr. Soc., 1928, pp. 347–348.

[5] Sir Douglas Mawson, Unsolved Problems of Antarctic Exploration and Research, in *Problems of Polar Research*, Special Publication, No. 7, Amer. Geogr. Soc., 1928, p. 264.

[6] Griffith Taylor, *op. cit.*, p. 105.

presumed to be depressed by the *present* weight of the ice. New studies (1948) on crustal movements in high latitudes of the northern hemisphere seem to call for a revision of theories of crustal response to ice load but we are still far from understanding the dynamics involved.

In Siberia the coast west of the Lena River subsided (relatively) in post-Tertiary time and was broadly covered with marine deposits. It then emerged, revealing marine deposits overlying old moraines of the Scandinavian ice-sheet. "The largest part of Arctic Asia did not have glaciers of a general Ice Age" although parts of it with relief experienced local glaciation as in some off-shore islands and in the northern Urals.[7]

Animal migration theories of course depend heavily upon independent evidences of former land bridges. A migrating animal follows its accustomed food source. The long-term changes of land and sea have played a part in separating general distributions of food supply into fragments. A physical action, thus initiated, has its own special consequences, given time to bring them into being. I will content myself with references to a single paper (on past migrations) of remarkable clarity and suggestiveness by Simpson.[8] The evidence and argument are too complex to present in this brief sketch, but his conclusions are certainly a spur to further search for new paleontological material. Simpson's finding is that, "There is no known biotic fact that demands an Antarctic land-migration route for its explanation and there is none that is more simply explained by that hypothesis than by any other. . . . The general weight of the evidence is against such a connection. . . . It cannot be denied [that a connection] may have existed or that its existence may some day be proved." Simpson leaves the door open by reference to existing mysteries in distributions pointing to the greatest of all in the problems of southern mammalian faunas, a possible African-Antarctic connection.

In planning future work the requirements of theory are extremely important. Theory is not something to clutch possessively but to debate and, if necessary, to toss away the moment that the facts demand it. Theory is also a sort of shorthand or code. It is a great inciter of field search. Without theory a man may look at an object with the naïveté of a child. The thing observed has no frame of reference. Without theory a man with a find does not know where to look next. All this by way of preface to the argument that we need both spot observations and series of observations at fixed stations.

The case of Wilkins and his flight north of Alaska in 1928 will illustrate the value of spot observations. A theory had been advanced that assumed a substantial land mass north of Alaska. This was the Harris theory of 1904, based on an attempted correlation of tidal observations, and the pattern of the cotidal map. Nansen, whose deductions from data gathered during the drifts of the *Karluk*, the *Jeannette*, and the *Maud*, seemed to point to the opposite conclusion, thought the Harris theory shaky. On March 29, 1927, Hubert Wilkins landed 330 miles north of Wrangel Island, at 77°45′ N. and 175° W., and obtained a spot sounding of 5,440 meters, the greatest depth yet found in the Arctic Basin.[9] It seems probable from this and other observations by Amundsen, Ellsworth, Nobile, Wilkins, and Russian fliers that except for possibly a few small islands near the margin, no new land will be found in the central area of the Basin. On

[7] I. P. Tolmachev, The Geology of Arctic Eurasia and its Unsolved Problems, in *Problems of Polar Research*, Special Publication No. 7, 1928, pp. 83–84.

[8] George G. Simpson, Antarctica as a Faunal Migration Route, *Proc. Sixth Pacific Science Congress*, Vol. 2, 1940, pp. 755–767.

[9] *Problems of Polar Research*, Amer. Geogr. Soc., Special Publication No. 7, 1928, pp. 10 and 396.

his flight of 1928 from Point Barrow to Spitsbergen, Wilkins found no new land within sight of his plane. It was necessary to revise tidal theory applicable to the Arctic basin and seek a basis for tidal forecasts of greater reliability.

A second illustration of high current interest is the question of ice-free land in the Antarctic. In 1938, Lars Christensen published a report entitled, "My Last Expedition to the Antarctic, 1936–37." In it he reviewed his work and that of his captains in Antarctic whaling and discovery voyages during the preceding ten years. His review included the following description:

> From the head of Sandefjord Bay the airmen worked their way eastward past the Larsemann Mountains, which consisted of great mountain masses partly covered with ice and snow, and then past the Ranvik Mountains. A curious phenomenon in the mountains on this part of the coast was a great quantity of small fresh water lakes up in the mountains, quite open and without a sign of ice on the water or round the edges of them (pp. 8–9).

The locality is in approximately 70° East longitude near the Antarctic Circle. Ice-free land with open water was also discovered on the 1946–47 Naval Antartic Expedition, "Operation High Jump," Admiral Byrd. Yet in 1948, only a year later, "no open water at all existed where there had been salt-water embayments and inlets at the sea approach to the ice-free land area. The latter, 60 by 20 miles in existent, "is apparently high land which extends from a range of mountains in such a way that the continental ice flows to either side of it. The weather also seems to 'flow' to either side," with perfect weather within the area for two days while virtual blizzards at times almost completelysurrounded the shore party.[10] The area is made up of "a series of islands and part of the mainland." Ponds of "very brackish water" are found in this "desert" of scanty precipitation paradoxically called an "Antarctic Oasis" because free of ice! The location is several hundred miles east of Lars Christensen Land where ice-free lakes were found in 1937. The full significance of the local ice-free condition and its degree of permanence have yet to be determined.

In the Arctic, by contrast, the ice-free lands aggregate more than a third of the total area or 10 million square kilometers out of a total of 28 million.[11] Wide scope is provided thereby for studies in plant and animal physiology, for experimentation, and for the study of land forms under distinctive conditions of erosion and soil formation. Few systematic studies have yet been made in these fields important from both the physical and the biological points of view.

A word on serial observations at fixed stations. For some decades, and more intensively during the past twenty years, the need for permanent field stations has been emphasized. This is particularly true in meteorology. Thirty years is a minimum from which to draw even short-term conclusions. A series of technically reliable observations long enough to be useful is one of the hardest things in the world to maintain. Two short meteorological series in the Arctic, 1883 and 1933, maintained on an international cooperative basis, was followed by the "permanent" establishment of a number of scattered stations that give us the beginnings of a network to serve improved forecasts.

The Antarctic series is less advanced. From the economic as well as the theoretical standpoint, this is now, in my opinion, priority number one. Sustained meteorological observations are required to give meaning to ice retreat and advance, to determine the atmospheric structure and functioning that in turn influence ice discharge, cyclonic patterns, and correlation (if it exists) with

[10] David C. Nutt (Commander), Second (1948) U. S. Navy Antarctic Development Project, *Arctic*, Vol. I, No. 2, Autumn, 1948, p. 91.

[11] As defined by taking the poleward edge of the boreal forest. For criteria and a map see J. Büdel, Die Klima-Morphologischen Zonen der Polarländer, in *Erkunde*, Vol. 2, Nos. 1–3, 1948, p. 22.

South African and South American drought recurrences. Widespread and at times catastrophic drought effects are objectives of the highest order.

In a sense nothing is more dull than a series of data. In any event they are humdrum to the public. To the scientist they are the prerequisites of some of the most exciting scientific discoveries. There are no headlines in observations if one must wait at least 30 years for reasonably reliable averages! Yet once the probability of good and bad years becomes better known, better protective measures and a better livestock economy may follow. This means a better economy in general.

1947–1948 U. S. NAVY ANTARCTIC EXPEDITION*

R. C. Holl, Hydrographic Office, Navy Department

THE Second Antarctic Development Project was, from the Hydrographic Office viewpoint, a survey expedition supplementing the photographic accomplishments of the Highjump Expedition of the previous year. Highjump, through CNO, had turned over to Hydro. 60,000 trimetrogon mapping prints covering more than one half of the 12,000 miles of Antarctic coastline, together with the responsibility of producing maps from this coverage.

The planners of this Second Antarctic trip recognized the need of some type of geodetic control to obtain the maximum value from our compilations, and assigned top priority to the survey work. Task Force 39, therefore, was planned from the beginning toward the main objective of landing survey parties on the ice covered continent at as many pre-selected points as the short Antarctic summer would permit.

Lacking maps or charts of sufficient detail for a comprehensive scheduling of the four survey groups, mosaics were constructed utilizing the rectified trimetrogon photography controlled by the aerial navigation data of the Highjump pilots. The mosaics covered the two main priority areas, and probable survey locations were marked at specified intervals. These mosaics later proved to be invaluable in reconnaissance operations and final planning before landing.

Due to the anticipated problems of transportation from ship to shore which would necessitate reduction in size of shore parties to the absolute minimum, it was necessary that Hydro. personnel be competent not only in astronomic observation and surveying but also in photogrammetry and magnetic observations. In addition our shipboard duties included oceanographic and hydrographic observations. For several weeks prior to departure, intense training was given to party leaders in these various phases of our intended survey. Dr. Howe of the Coast and Geodetic Survey was extremely helpful in this respect. A very competent instructor in operation of the magnetometer and a veteran of the Highjump expedition, he both instructed us and counselled us on Antarctic conditions which we would encounter.

In November 1947, the two icebreakers U.S.S. Burton Island and U.S.S. Edisto, which comprised T.F. 39, set out from their home ports en route to their

* Paper read at Annual Meeting of the American Society of Photogrammetry, Washington, D. C., January 13, 1949.

EDITOR'S NOTE: As a part of "1947–1948 U. S. Navy Antarctic Expedition," Mr. Glenn R. Krause of the Hydrographic Office presented a very great number, highly interesting and informative pictures. His description was not only very instructive but at times, extremely amusing. No transcript of his remarks was made. It is hoped that later on Mr. Krause will prepare an illustrated article for publication in PHOTOGRAMMETRIC ENGINEERING.