# Arctic Mapping

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SYNOPSIS

Present program of tricamera reconnaissance mapping; difficulty of sparse horizontal control; the rigid camera mount an aid to accuracy; ice photographs used in bridging water gaps; radar photographs used in extending control; interpretation; contouring by radar altimetry; locating isogonic lines; topographic mapping.

This paper deals with the actual preparation of the maps of the Canadian Arctic.

To meet the insistent demand for aeronautical charts during World War II, all the mapping material available was assimilated into complete coverage of Canada at the one inch to eight mile scale. The map sheets developed in the Arctic were found to be highly unsatisfactory and incomplete. In general they consisted of small areas of exploratory sketches, heresay topography in broken line, and large blank spaces. There was no information concerning relief.

## PRESENT PROGRAM

The present program, initiated in 1944, comprises complete coverage by adequate aeronautical charts at scales of 1 inch to 8 miles and 1:1,000,000 (1 inch to 16 miles, nearly). Larger scaled maps are surveyed from time to time as required by civil development or military needs. It can reasonably be anticipated that it will eventually be necessary to cover the Arctic with contoured maps at a scale of 1:250,000 or 1 inch to 4 miles.

## THE AERONAUTICAL CHARTS

The planimetry for the aeronautical charts is extracted from tri-camera or trimetrogon air photographs; the contouring is from radar altimetry control. The 1:1,000,000 series conforms to the well known ICAO index and specifications. The one inch to 8 mile charts, Canada's version of the 1:500,000 scale, are in the National Topographic Series Index and are on a transverse mercator projection. The general practice is to plot details to suit the 8 mile scale and make deletions and adjustments at the manuscript stage for the 1:1,000,000 scale. Over 60 per cent of the $1\frac{3}{4}$ million square miles of the Arctic has been plotted, and 150,000 sq. miles have been controlled for contouring; 30,000 sq. miles remain to be photographed.

The plotting is carefully done and the resulting planimetry is of a higher order than reconnaissance. Working sheets for special field purposes, as geology, are made at suitable scales as required.

## CONTROL

As the mapping progressed northward the astronomical control points became more scattered and the regular 60 mile spacing stretched to as much as 300 miles. In the north Arctic Islands an area of 300,000 square miles has only 17 reliable ground control points, whereas conventional plotting requires about one hundred. Under these conditions advantage must be taken of all favorable appliances and circumstances conductive to accuracy.

## THE RIGID CAMERA MOUNT

Probably the most important of the appliances is the rigid camera mount described by W/C Ross. Plots resulting from its use are not only more accurate but the speed with which they are produced is increased by about ten per cent. The increased accuracy is particularly effective when the distance between control points is great.

The constant known relationship of the cameras is an aid in strengthening plots where data are missing due to clouds, water or snow.

## ICE PHOTOGRAPHS

Ordinarily there is a difficulty in tying the plots of islands together because of the water gaps between them. The intersection method generally used is never very satisfactory and the errors in it increase with the distance and multiply with extended systems. In the Arctic Islands, as W/C Ross has explained, advantage is taken of the ice by photographing it when it is sufficiently melted to form water pools which may be identified from photo to photo. Accurate plots may be made for there are no changes in relief, and, with a constant photographic height, a constant scale.

RADAR PHOTOGRAPHS

Radar photographs taken by the U.S.A.F. have proven to be of great help in bridging gaps between controls. The method adopted is to mosaic the photographs using common image points pricked on the overlap between carefully selected pairs. Photos at a scale of one inch to 15 miles using a range of about thirty miles per photo have given good results. A test over a 250 mile strip gave a maximum error of 1 mile. A circuit 640 miles in length tied to three astronomic fixes was used to control the north end of Baffin Island. Photos have also been used to establish the relationship between some of the Arctic Islands. They are, of course, used only when no more accurate means is available.

INTERPRETATION

Generally, with the exception of marsh and low flying indefinite coast lines, the interpretation of topographical features for the one inch to 8 miles scale is not difficult. In the exhibit you will find photographs illustrating the terrain of the new Prince Charles Island in Foxe Basin, the large meteoric crater in Ungava, odd features on Mellville and Ellef Ringnes, Islands which look like volcanoes, and some strange land formations lying off shore from Ellef Ringnes and Borden islands.

CONTOURING

No elevations established by conventional means are available to control contouring. Using the sea as a bench mark elevations are established by airborne radar altimeters in straight lines sixteen miles apart. In an experimental flight with the altimeter a profile 440 miles in length between control elevations has been made. Eighty per cent of the water elevations established were in error less than 20 feet and eighty per cent of the land elevations less than 30 feet. This accuracy is sufficient to control 500 foot contours, and there is no known reason why the lengths of flights cannot be greater than 440 miles. There should, therefore, be no technical difficulties in obtaining complete coverage by taking full advantage of the long sea inlets of the Arctic.

On the small number of tri-camera flights on which radar altimeter profiles have been recorded the camera heights have been used to test and correct the scale of the plots.

MAGNETIC MAPPING

Isogonic lines are essential to aeronautical charts. Since 1943 the Dominion Observatory has established magnetic stations on all the main islands of the Arctic Archipelago and the contiguous mainland. There are now over 400 stations north of 60 degree latitude. The position of the north magnetic pole area has been determined by stations which completely surround it, and a check of its movement is maintained by two magnetic observatories in the Canadian Arctic.

LARGER SCALED MAPS

In the 1930's several uncontoured one inch to four mile map sheets within the Canadian Arctic were mapped with oblique photography by the perspective grid or Canadian Method.

There is now no set program for one inch to four mile mapping or larger. However it can be expected that contoured maps of a considerable part of the Arctic will be required at a scale of 1 inch to 4 miles or 1:250,000. Photography will be vertical. It will necessarily be spread over a considerable period of time because the photographic weather each year is very short and because of other difficulties.

An operation carried out this past summer may indicate one method to be used in establishing horizontal control. The position of a photographic plane in flight was determined by electronic measurements from tri-lateration stations previously established. In this way the positions were determined of the ground plumb points of photographs taken along east-west flight lines spaced at 20 minutes in latitude and north-south lines spaced at one degree in longitude. An area of about 60,000 square miles was controlled.

In many areas the only means of obtaining vertical control will be by radar altimeter. Local distribution of elevations may be undertaken by the helicopter aneroid combination. No accurate elevations are available for use at larger scales.

Mapping photography may be from an altitude of about 35,000 feet.

CONCLUSION

The foregoing is based on present day knowledge and practice. The discoveries and developments of tomorrow may radically change the picture. For one thing the effect of radar altimeter measurements on photogrammetry is not fully assessed. Dr. Lyle G. Trorey touched on the subject in his paper before your Society on January 11, 1950. Mr. T. J. Blachut of the National Research Council, Ottawa, gave a paper on the subject before the International Congress of Photogrammetry in September of last year. Mr. Blachut is continuing his investigation. Developments along other lines are probably in the making. At any rate it seems safe to say that before the Canadian Arctic is completely mapped, mapping processes will be much simpler than they are today.

## Mapping in the Arctic*

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SYNOPSIS

This paper discusses briefly the mapping and charting of Alaska from 1898 to the present time. It emphasizes the development of methods and techniques used principally by the Geological Survey in conducting Arctic mapping operations, with special emphasis on the use of Trimetrogon coverage combined with earlier planetable surveys to produce the 1:250,000 map scale coverage of Alaska, as well as the use of shoran altimetry, the helicopter and new photogrammetric techniques for modern mapping in the Arctic.

Arctic Alaska has been of interest to explorers and geographers since Captain James Cook made his famous voyage into the Arctic Ocean in 1778 in search of the "Northwest Passage." In 1826 Captain F. W. Beechey charted the north coast of Alaska to Point Barrow. There is little evidence that the Russians pushed north of the Arctic Circle in Alaska in quest of fur, although the Hudson Bay Company established trading posts on the Upper Yukon in 1847 and explored much of the Porcupine River basin.

In the period between 1843 and 1853, the British Government sent out several well-equipped expeditions to bring relief to the ill-fated expedition of Sir John Franklin on the Arctic coast. These expeditions prepared many maps and charts of the Arctic coast.

One of our first inland explorations after the acquisition of Alaska from Russia in 1867 was undertaken in 1869 by a small Army party under Captain C. W. Raymond. The mission of this party was to determine the position of the Alaska-Canadian boundary. As a result of Captain Raymond's observations at Fort Yukon, the Hudson Bay Company was forced to move its important trading post 50 miles up the Porcupine River. Two more moves and ten years later the post was finally established on the 141st meridian.

In 1881 the U. S. Signal Service established a meteorological and magnetic station at Point Barrow where observations were made for longitude and latitude. During the period between 1883 and 1886, officers of the Navy conducted noteworthy expeditions into the Arctic. Lt. George M. Stoney explored Kotzebue Sound, and the Kobuk, Noatak, and Koyukuk Rivers. One of his officers, Ensign W. L. Howard, led a party of 4 men from the Noatak River northward through the mountains and down the Etivuluk River to the Colville River near the present site of Umiat. The party portaged to the Ikpikpuk River and thence to Point Barrow.

In 1889, J. H. Turner and J. E. McGrath of the Coast Survey ascended the Yukon River to Fort Yukon where they separated. Turner continued up the Porcupine River to Rampart House where he established an astronomical observatory on the boundary, and then continued north to the Arctic coast by dog team. McGrath continued up the Yukon to Eagle where he made position observations for the boundary.

The Geological Survey began topographic mapping in Alaska in 1895. Field parties were small and, usually, topographic and geologic mapping was combined, work being concentrated in areas of potential mineral value. For 35 years, with a few exceptions, little attention was given to mapping north of the Arctic Circle. Peters and Schrader arrived at Alatna on the Koyukuk River by dog team in the spring of 1901, and, after the break-up crossed the Brooks range through Anaktuvuk Pass to the Colville drainage, finally arriving at

* Publication authorized by the Director, U. S. Geological Survey.