GEOLOGIC INVESTIGATIONS *

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Scientific Background

The concept of developing airstrips in Greenland with minimum construction effort goes back to 1942. At that time the U. S. Army Air Force examined several sites along the east coast, but little or no specific site selection and development was accomplished. In 1952, with the establishment of Station Nord in the northeastern corner of Greenland, the development of arctic airfields with minimum construction effort became a reality.

In examining North Greenland in connection with site selection for Nord, a large number of sites suitable for heavy duty airfields involving no construction effort were identified. Most of the data pertaining to these sites were derived by photogeologic techniques; many of the sites were in areas that had not been examined by explorers. Subsequent field work to check the data derived from photo-interpretation brought to light many interesting features. Most of the sites are in a climatic zone characterized as High Arctic Desert. Annual precipitation is in the order of 2 to 4 inches a year; summers are relatively mild, and the land is snowfree for most of the summer. Unlike many other arctic areas the north part of Greenland has dry soils. Drainage presents no problems as the annual precipitation is so low that it has little effect on the soil. Permafrost conditions pose no problems as the active zone is low in moisture and no surface disturbances are apparent.

The terrain in northern Greenland consists of mountains and plateaus cut by long fjords. Raised beach flats, dry lagoon bottoms, clay plains, river terraces, and broad, level river valley bottoms provide a number of sites that can be used as natural landing fields. The arid conditions of the climate, reflected in the dry soil, along with uniform permafrost conditions, give rise to strong, dense soils. Although similar soils occur in small, discontinuous areas elsewhere in the Arctic, it is only in Greenland that they are extensive enough to be significant for use in developing natural landing areas for heavy aircraft.

The airfield sites that have been visited are on different types of terrain. At Centrum Lake the site is on a broad river terrace at the west end of the lake. This flat, triangular in shape, is almost two miles long on a side. The Brønlunds Fjord airstrip is on the site of a former lagoon connecting with the fjord. It is 7500 feet long and 300 to 800 feet wide. Polaris Promontory is on a glacial outwash plain over 10 miles long and 3 miles wide.

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The identification of natural airfield sites is based on photogeology supplemented by broad arctic field experience of the geologists involved. In the treeless Arctic, photogeology is greatly simplified, and greater data can be derived from the photos than is possible elsewhere. Texture, patterns, and color are very distinct and have not been altered by man. By using ordinary 35 mm kodachromes in combination with either vertical or oblique black and white aerial photos, soils, rock, and slope can be identified with a good degree of accuracy. Moisture conditions can be predicted accurately enough for planning purposes.

Experience in photogeology has brought out the many contrasts in the elements of terrain in the Arctic. Terrain patterns in one part of the Arctic reflect certain conditions in one place while the same patterns indicate completely different conditions at another place. Thus a certain polygonal pattern in the wet areas of Alaska may be indicative of fine-grained soils, while similar polygonal patterns in the arid area of Greenland may be typical of gravel soils. In addition, the engineering characteristics of materials will vary between regions. Silt and clay in Alaska generally are weak foundation materials; in the arid portion of North Greenland they form the strongest foundations. Because of the many elements that are integrated in any terrain form, it is not possible to use stereotyped methods, such as keys or guides, in interpreting aerial photos for terrain features in the Arctic. The only sound basis for such interpretation is extensive field experience in the Arctic along with a broad geologic background.

The cost of site location based on photogeology is inexpensive. The production of an arctic areal geology map on which much of the site selection is based involves about 1 man month of effort for 10,000 square miles of area. The cost is about 10 cents per square mile. To this must be added a cost of 6 to 7 cents for processing, printing, and administrative effort, making the total cost 16 to 17 cents per square mile.

Detailed interpretation of a specific site costs about $600 and involves an average of 100 man hours of effort. Of this sum, about $400 are for professional services; the remainder covers processing, printing and administration.

Operation Groundhog has produced some interesting scientific results and reports on them are now in preparation. Previous to Operation Groundhog there was very little known concerning glacial geology in North Greenland. Observations on glacial deposits at Centrum Lake, Bronlunds Fjord, and Polaris Promontory have provided the framework for glacial sequence and the base for mapping of glacial deposits in North Greenland from aerial photos. In addition, radiocarbon dates have been obtained on key features in the area.

In brief, the glacial record covers only the last glaciation. Evidence of previous glaciations has been erased. In North Greenland, the initial advance of the last glaciation covered all of the area; subsequent retreat accompanied by minor advances occurred until a period approximately 5900 years ago (based on carbon-14 dates of marine shells). At this time the ice was somewhat less extensive in the upland than at present and valley glaciers were much shorter than now. During the stage of maximum retreat, marine silt and clay up to 500 feet thick was deposited in protected parts of the sea; most of the long fjords were free of pack ice at this stage. Subsequent readvance and slight retreat brought the glaciers to the position where they now stand. This last readvance is dated by carbon-14 methods as between 3500 and 5900 years ago. This is based on unique shells on marine terraces that are cut into the moraines. Informal exchange of information with Canadian geologists working on Ellesmere Island indicates that the last wide spread advance of the Greenland Ice Cap probably extended into central Ellesmere Island. This is based on the presence of unique red granite pebbles in the glacial deposits.

Permafrost studies have brought to light interesting new features. Because of the extreme aridity of the area, the behavior of the active zone is very different from that of permafrost in wetter areas. The extremely strong, dense soils are believed to reflect uniform, low moisture content of the soils and a uniform permafrost level throughout the year unaffected by surface thaw. Several little known surface features, such as silt filled shrinkage cracks, are common in the arid area.

Cursory notes on bed rock have been made, but no effort has been given to areal mapping. The most interesting observations pertain to tectonic features between Independence and Frederick E. Hyde Fjords where the folds of North Greenland are intersected by offshoots of the East Greenland folded belt. This occurs to the west of Schley Fjord.

Terrain of Polaris Promontory

Polaris Promontory is essentially a lowland 10 miles wide flanked by low mountains. The lowland trends southwest-northeast for 25 miles across the promontory.

The mountains flanking the plain are formed of limestone of Silurian age. On the southeast side the limestones are flat lying and thin bedded; massive limestone occurs on the upper half of the higher mountains. Similar conditions are northeast of the plain but the rocks are folded; along the coast at Kennedy Channel the folding, accompanied by faulting, is intense in a narrow band.

The central plain is formed of silt and clay that was deposited in a shallow embayment during a relatively recent glacial recession. The clay and silt are probably 300 to 400 feet thick and are overlain by two major moraines, one parallel to Newman Bay, the other following the shore of Polaris Bay. These moraines are a series of multiple ridges 30 to 300 feet above the clay-silt plain.

Adjacent to the moraines the plain is covered by outwash material up to 20 feet thick. It consists of rounded cobbles and pebbles tightly packed in a silt-sand matrix.

Adjacent to major rivers the outwash has been planed off and the surface is gently sloping with only minor irregularities. These irregularities are relics of former braided stream channels and are up to 35 feet wide and a maximum of a foot deep.

Field geology on Polaris Promontory was carried on using an H47 helicopter. This permitted a thorough reconnaissance of the area, 800 square miles, in 10 days. By making numerous touchdowns to check on exposures and by flying at slow speed, close to the ground, the continuity of geologic features could be delineated with a high degree of accuracy on aerial photos. Reconnaissance for ramps leading from the ice cap to the land was also carried out by helicopter, and one suitable ramp was identified. In any geologic work in the Arctic, helicopters are a prime necessity; lack of such support restricts field work to areas in the immediate vicinity of base camps or along relatively short lines of ground traverse.

In the field, limited topographic surveys were made to orient the airstrip and to provide a large scale map in the site. A triangulation net connecting the major topographic features was set up across the Polaris plain. The base line was measured along the airstrip. To extend the base a station on the Monument, a prominent topographic feature, was tied to the base line and additional angles cut from it. The establishment of this station and other stations of difficult access was accomplished by using H47 helicopters.

All geographic positions and azimuths were from sun shots; the accuracy obtained for latitudes was low. Longitude, however, was tied at all points in the field by time signals picked up on a portable transistor short wave radio. The time signals from BBC, London were far superior in reception and more satisfactory in timing than those from WWV, Washington, D. C. The latter station is frequently blanketed by code on all its frequencies in the Arctic.

The topographic surveys were made with a T-2 theodolite by the geologist. He was aided by a Canadian surveyor borrowed from the Lake Hazen field party who were aboard the ice breaker on their way south.