Preliminary Report on the Petrology of Southampton Island, Northwest Territory[1]

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Introduction

In August 1957 an expedition including scientists from Purdue and Indiana Universities carried out investigations on Southampton Island in northern Hudson Bay. This report covers preliminary findings of a portion of the geologic investigations made at that time and carried out subsequently in the laboratory.

Largest of the islands in the Canadian Inland Arctic Sea, Southampton Island is approximately 18,000 square miles in area. The island lies near the Arctic Circle, between the sixty-third and sixty-sixth parallels. Its location is shown in Figure 1. The climate and vegetation of the island are dominantly arctic in character. Average daytime temperatures during the August field season were in the low forties, and night temperatures ranged in the low thirties. Pack ice surrounded most of the island, and made most coastal areas in the central and northern areas unapproachable from the sea.

Paleozoic carbonate and Precambrian metamorphic rocks comprise the bedrock of the island. The Paleozoic carbonate rock typically forms lowlands, usually only a few tens of feet above sea level. In marked contrast the Precambrian rocks of the east coast exhibit fair relief. Here are peaks often over 1500 feet in elevation and ranging up to 1750 feet. In general, the eastern third of the island is Precambrian rock. The rest of the island is carbonate rock, frequently veneered with postglacial beach sand and gravel deposits. This distribution is shown on the generalized geology map after Bird (3) in Figure 2.

Previous work on the petrology of the island has been general in nature. Manning (5) reported briefly on a contact observed between limestone and the Precambrian gneiss on the east coast, and Armstrong (1) recorded the presence of granite and gneiss in the eastern part of the island. He also noted limestone of Niagaran age in the extreme north and strata of Niagaran and upper Ordovician in the southwest of the island. The most complete account of the island was written by Bird (3), and this report includes physical and human geography as well as a brief description of the general geology.

Field work covered in this report was carried out from the base camp of the expedition at the Coral Harbor eskimo village and Hudson Bay post. Field investigations were made in the vicinity of Coral Harbor, in areas to the west, and along the east coast. Trips to these field areas were made by 40-foot eskimo Peterhead boats and by Norseman float

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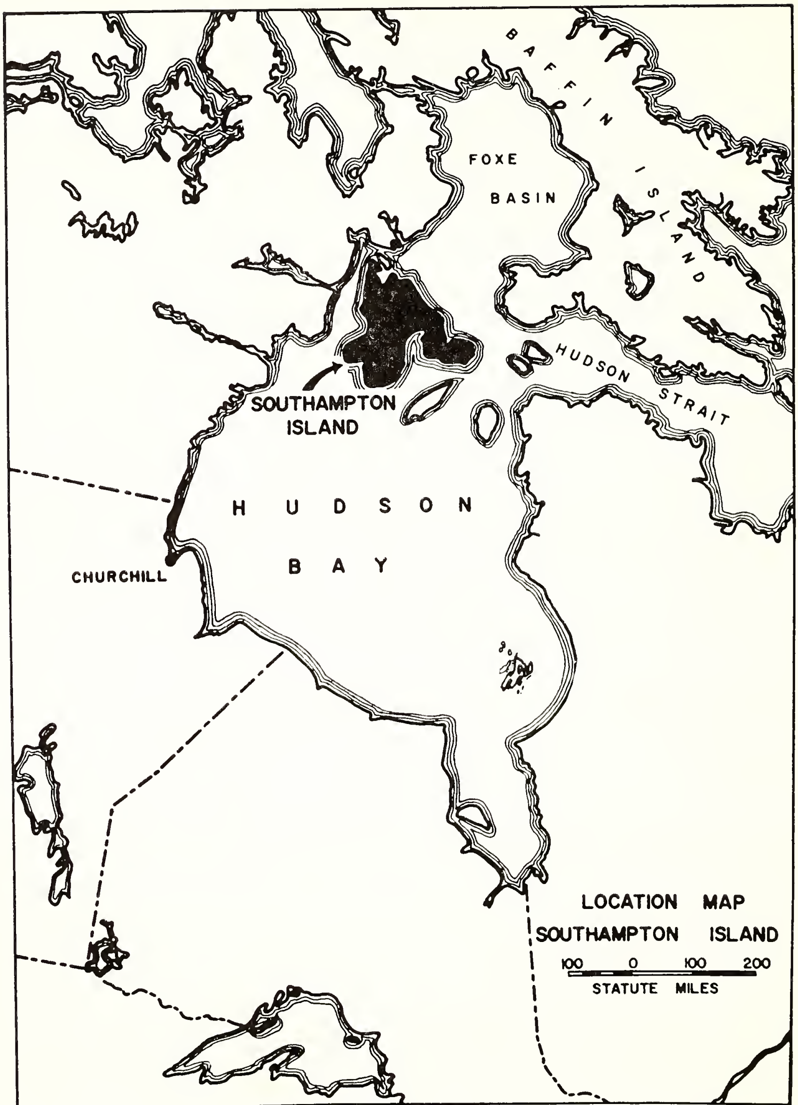

FIGURE I.

plane. Attention was directed chiefly to the study of the Precambrian rocks. Mineralogy, petrology, and structure of the crystalline rocks were investigated. Where it was possible, pace-compass traverse maps of certain areas were made. Selected samples have been sectioned and studied, and these form the basis for the petrologic descriptions given in this report.

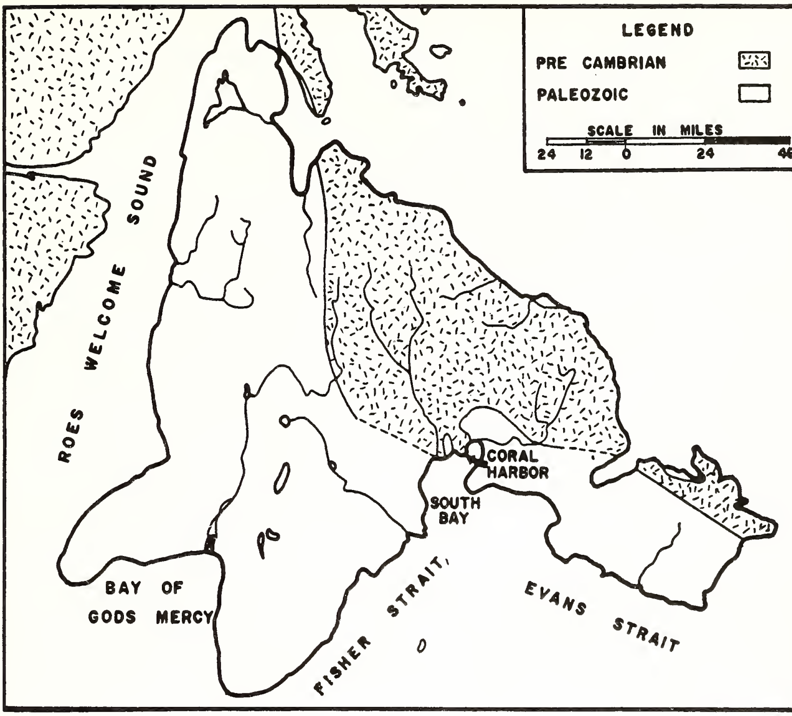

FIGURE 2. SOUTHAMPTON ISLAND GENERALIZED GEOLOGY
(AFTER J.B. BIRD)

Petrology

In the crystalline rock area, gneiss is the dominant rock type. The gneissic terrane near Mathiassen Brook in the east coast upland is shown in Figure 3a. The gneisses are chiefly pink and gray in color, and generally show good foliation. Most of the gneisses are coarse-grained, and locally porphyroblasts of feldspar several inches long are not unusual. The composition of the gneisses varies considerably. Biotite gneiss with potash feldspar, oligoclase, and quartz, and hornblende-biotite gneiss are the chief varieties. The quartz content is variable, too, and quartz-poor types are not uncommon.

A typical specimen from the vicinity of Coral Harbor contains oligoclase laths 2 to 4 mm. long, biotite and microcline with minor quartz, apatite, and magnetite. The specimen has gneissic texture and decussate grain boundaries. Another gneiss from the vicinity of Mathiassen Brook is essentially free of dark minerals with the exception of minor garnet and contains microcline 2 to 3 mm. long and a small amount of quartz. A fine-grained variety with crystals less than 0.5 mm. in length collected in this locality exhibits quartz, biotite, garnet, magnetite, and more oligoclase than potash feldspar. The texture suggests crushing and recrystallization.

Figure 3 A

Figure 3 B

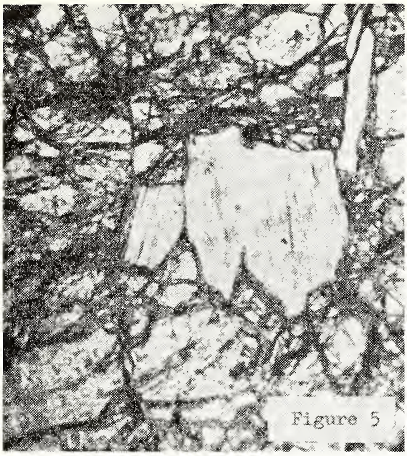

Figure 5

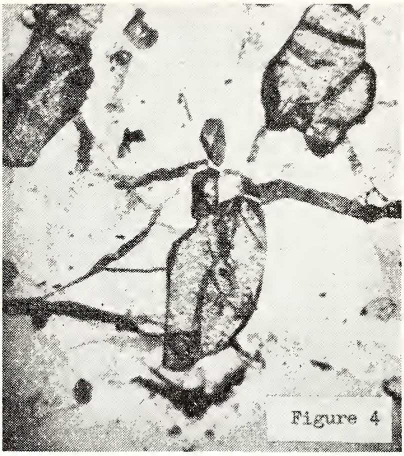

Figure 4

Garnet gneisses are fairly common, especially along the east coast. Although the garnet in these rocks is usually small, in the Mathiassen Brook area one zone in the gneiss complex contained garnets up to one inch in length. A garnet-rich gneiss is shown in Figure 4. About half of this rock is composed of garnet, and the remainder is quartz. The composition of the rock suggests derivation from an impure sandstone or other siliceous rock.

Enclosed in the gneiss complex are related schists and bands of amphibolites. Biotite and biotite-hornblende schists are most common among the former, while the latter are essentially hornblende andesine rocks, with or without biotite. Foliation of the schists is parallel to that of the gneiss, and they grade into the gneisses by increase of feldspar and decrease of dark minerals. None of the schist zones is very extensive, and most are only a few tens of feet wide and hundreds of feet long. The amphibolite zones are also very restricted. Generally these are bands less than a foot wide and of the order of hundreds of feet long. The bands are parallel to the foliation of the gneiss. In other instances the amphibolite occurs as boudins or lenses and pods up to several feet wide in the gneiss. A typical specimen from the Coral Harbor shore has decussate texture and grain size less than 1 mm. in diameter. The rock is about half hornblende and half andesine with a little biotite, magnetite, and chlorite. Amphibolite zones were found in all of the areas studied, but they are particularly abundant and well exposed along the shore at Coral Harbor. The origin of these boudins is discussed later. The amphibolite is interpreted as developing from the metamorphism of a basic igneous rock such as dolerite or basalt. The distribution and size suggest that the original rocks may have been dikes or sills.

Pegmatites

Pegmatites are abundant throughout the crystalline rock area. Figure 3b shows a typical pegmatite dike cutting an amphibolite boudin.

Most of the pegmatites are very coarse grained, pink in color, and rich in feldspar and quartz. Individual crystals 6 to 12 inches long were observed, although in most dikes the grain size was less than ½ inch. The dark minerals in these pegmatites are commonly hornblende and biotite, and in one area pegmatites were found with magnetite crystals six inches long. Most of the pegmatites are rich in quartz.

The pegmatite dikes vary in size from those only a few inches wide to ones 10 feet in width. In some areas there is a paucity of dikes, but in most areas the gneiss is literally riddled with pegmatites. Here the feldspathization of the gneiss related to growth of the dikes transforms it into granite. Foliation is absent or poorly defined in such zones.

In some areas several generations of pegmatites can be seen where dikes exhibit cross-cutting relations to other dikes. Several types of contacts are observed between the pegmatites and surrounding rock. The contact may be sharp and clearly defined with cross-cutting relations, or it may be gradational. In this case it is difficult to differentiate between pegmatite and host rock. The pegmatites also show conformable relations with the gneiss, and occur in bands parallel to the foliation. The cross-cutting relations shown by the pegmatites are believed to have originated through localization of the growing pegmatites in shear and tension cracks. The mechanical properties of the host rock have strongly influenced localization of the pegmatites, and this is particularly true of the brittle amphibolites, which are more competent during deformation than gneiss.

The field and laboratory evidence strongly suggests that the pegmatites are metamorphic in origin. The field occurrence of the Southampton pegmatites supports the points emphasized by Ramberg (6) for the non-magmatic origin of the West Greenland pegmatites. Among other points the dikes have no observable connection with magmatic bodies, and there are no proven magmatic parent rocks known. Barth (2) described pegmatite dikes with no visible channels through which magma flowed as ductless bodies, and this aptly describes the Southampton pegmatites which are enclosed bodies in the gneiss. The writers plan to continue studies of these rocks.

Ultrabasic Rocks

Perhaps the most interesting mineralogy is displayed by the ultrabasic rocks that occur as pods, lenses, and blebs in the gneiss. These rocks are composed entirely of ferromagnesian minerals, and are closely related to the pegmatites. Further study is being made of these ultrabasites, but they also appear to be metamorphic in origin. Figure 5 shows a biotite pyroxenite, one of the chief varieties of this group. Augite and biotite are the principal minerals in this rock.

Structures

The predominant structure in the gneiss is the foliation defined by the alignment of dark minerals and elongate feldspar crystals. Foliation in the gneiss is fairly uniform in given areas. Although the dominant trend is northwest in strike and steeply dipping to the northeast, some areas show nearly flat foliation. Locally the foliation may become severely contorted, and the gneiss frequently shows ptygmatic folding. One type of "crumpling" of the foliation is related to the genesis of the pegmatites, particularly the dilation-type dike.

Several stages of deformation are illustrated by the structures in the gneiss. Some features including pinch-and-swell structure of the conformable pegmatites are synmetamorphic, while other structures such as folds in the gneiss and conformable pegmatites are of later origin. In many places foliation is disrupted and becomes poorly defined adjacent to pegmatite dikes of later origin.

One of the most prominent features in the crystalline rock area is the boundinage structure of the amphibolites in the gneiss. Cloos (4) has summarized the development of thinking on the origin of boudins or sausage-shaped rock structures. An excellent description of natural and experimental boudinage has been given by Ramberg (7), who offers an origin that explains the field relations observed by the present writers. He indicates that boudinage in amphibolites originates from compression with consequent elongation, producing tension fractures in originally continuous basic bands. The fragments or blocks then tend to separate. Further tension produces "necking-down" of the separated basic blocks and sausage-shaped structures. Figure 3b shows several amphibolite boudins "necked-down" at the ends and cut by pegmatite dikes. The location of many pegmatite dikes around the peripheries of boudins and cutting across the length of the boudin, approximately at right angles, suggests growth of the pegmatite in tension and shear cracks. Such tear-drop shaped structures are especially abundant in the vicinity of Coral Harbor.

Summary

Field studies and laboratory analyses indicate that the crystalline rocks comprising the eastern third of Southampton Island in northern Hudson Bay are metamorphic in origin.

These rocks are chiefly gneisses and pegmatites with minor occurrences of schists, amphibolites, and ultrabasic rocks. The gneisses are believed to have been derived in part from siliceous rocks and the amphibolites from basic igneous rocks. Boudins of amphibolite are prominent in the gneiss, and the field relations indicate that they have formed by compression, elongation, and tensional fracturing.

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