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DEPARTMENT OF ENERGY, MINES AND RESOURCES

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GRANULITE FACIES ROCKS ON NORTHEASTERN DEVON ISLAND, ARCTIC ARCHIPELAGO

(Report, 2 figures, 1 table and 6 plates)

J. Krupička

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ABSTRACT

Rocks of the granulite facies occur on northeastern Devon Island in the Churchill Province of the Canadian Shield. These rocks probably represent elements of an Archean basement reworked during the Hudsonian Orogeny.

The rocks are high-grade hypersthene-quartz-plagioclase gneisses grading into retrogressively metamorphosed amphibolite facies gneisses. The granulites together with the retrograded rocks constitute a metamorphic series marked by: alteration and disappearance of hypersthene; decrease in the amount and in the An-content of plagioclase; increase in the amount of potassium feldspar and the development of typical microcline; increase in the amount of biotite and, in the most regressed stages, of chlorite; tendency to increasingly inequigranular texture and porphyroblastesis; and a general trend towards more massive and granite-like rocks. The whole process was essentially crystalloblastic, and only rarely has led to full-scale mobilization and capacity for intrusion.

Retrogressive metamorphism, microclinization and granitization were more intense where the process was supported by strong mechanical reworking.

The metamorphic complex is cut by younger diabase dykes, and is unconformably overlain by Cambrian sediments belonging to the eastern regions of the Arctic Platform. The sedimentary sequence starts with a thin basal sandstone, and continues with mainly dolomitic rocks.

RÉSUMÉ

On trouve des roches à faciès de granulite dans la partie nord-est de l'île Devon, dans la province de Churchill du Bouclier canadien. Ces roches représentent probablement des éléments d'un soubassement archéen remanié pendant la phase orogénique hudsonienne.

Ces roches sont des gneiss à teneur élevée en hypersthène, en quartz et en plagioclase, passant par degrés régressifs à des gneiss métamorphisés à faciès d'amphibolite. Les granulites et les roches régressives forment une série métamorphique marquée par une altération et une disparition de l'hypersthène, par une diminution en quantité et en teneur en An du plagioclase, par une augmentation de la quantité du feldspath potassique et le développement de microcline typique, par une augmentation de la quantité de biotite et, dans les stages les plus régressifs, de chlorite, par la tendance à une texture de plus en plus inéquigranulaire et porphyroblastique, enfin, par une tendance générale vers des roches plus massives et semblables au granite. Le processus entier a été essentiellement cristalloblastique, et n'a mené que rarement à une pleine mesure de mobilisation et de capacité d'intrusion.

Le métamorphisme régressif, la microclinisation et la granitisation furent le plus intenses lorsque le processus fut accentué par un fort remaniement mécanique.

Le complexe métamorphique est coupé de dykes de diabase plus jeunes et est recouvert en discordance par des sédiments du Cambrien appartenant aux régions orientales de la plateforme de l'Arctique. La succession sédimentaire commence par un grès mince à la base suivi surtout de roches dolomitiques.

PLATE I

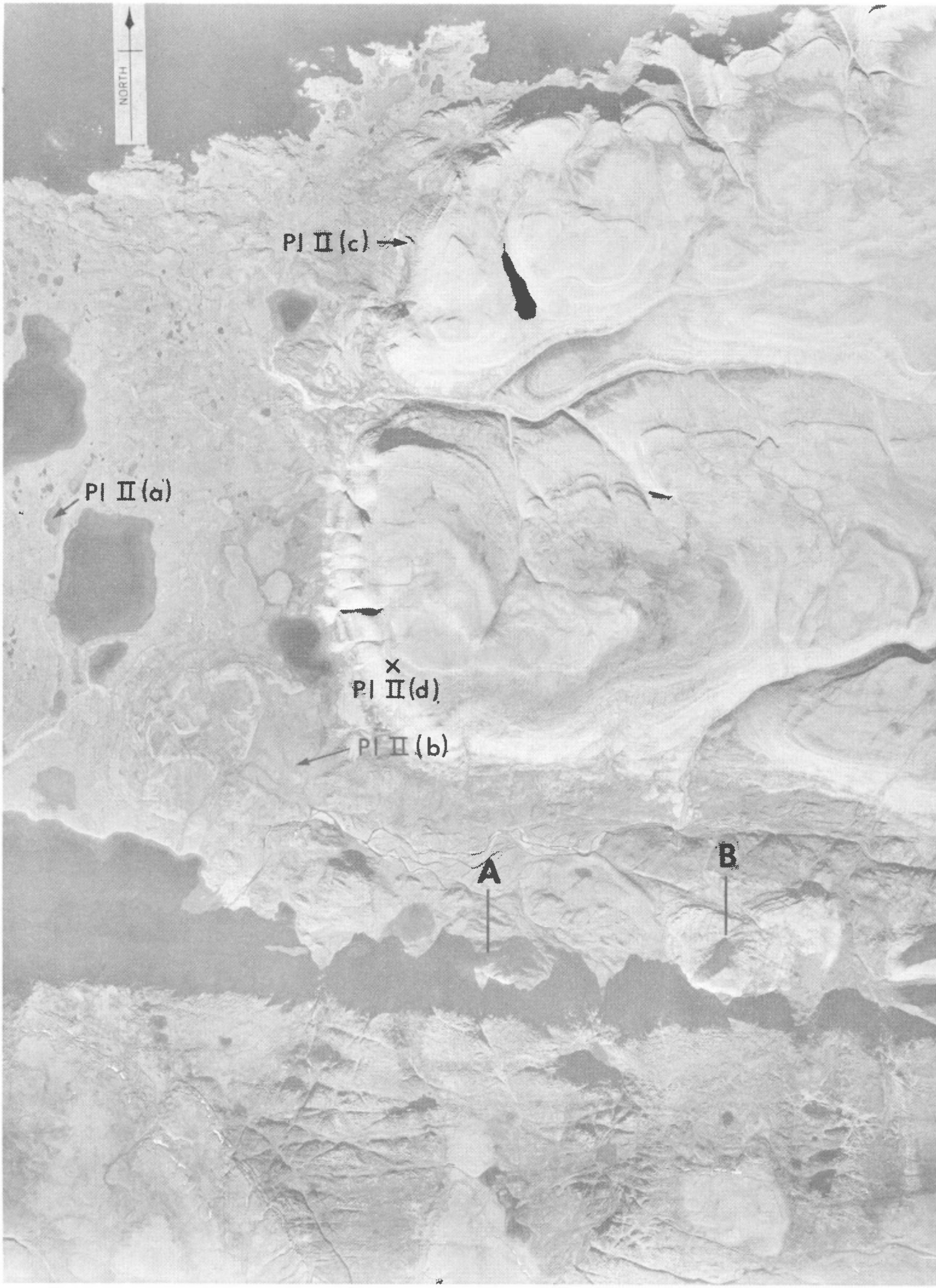

PLATE I

(National Air Photo Library)

Aerial view of the central and eastern part of the Truelove River lowland on the northeastern coast of Devon Island. Note the sedimentary plateau to the east, and the basement fault-line cliff and plateau to the south. The northern (sedimentary) block subsided by approximately 300 metres along an east-west normal fault, coinciding with the conspicuous cliff south of the river and the inlet. Sedimentary outliers (A, B and outliers to the east) belong to the subsided northern block.

The figures mark positions from which the photographs on Plate II were taken.

GRANULITE FACIES ROCKS ON NORTHEASTERN DEVON ISLAND, ARCTIC ARCHIPELAGO

INTRODUCTION

The report presents the results of a petrographic investigation carried out in 1971 in a selected area of the Canadian Shield on the northeastern coast of Devon Island. The work received field support from the Devon Island Project (Director, Dr. L.C. Bliss), which is part of the International Biological Program. Financial support was received from the National Research Council with approval by the Geological Survey of Canada.

The area investigated lies approximately half-way between Cape Skogn and Cape Newman Smith, along the lower reaches of the Truelove River and on the peninsula to the north of the river between 75°37' and 75°42'N, and 84° 25' and 84°40'W (*see* Fig. 1).

The area studied includes a coastal lowland and parts of the adjacent, higher plateaus: on the east, an erosional escarpment of sedimentary rocks; and on the south, an excarpment of a normal fault zone having steep cliffs. Crystalline rocks of the Canadian Shield underlie most of the lowland, the lower parts of the eastern escarpment and the cliffs to the south. The floor of Truelove River valley comprises mainly crystalline rocks.

The sedimentary rocks are part of the northern Interior Platform (or Arctic Platform of Douglas (1970, p.3), and unconformably overlie the crystalline rocks of the Shield.

The aim of the work was a detailed petrographic study of the crystalline rocks. From about 200 samples collected during the field work, 40 representative samples were selected for detailed description and modal analysis.

PREVIOUS WORK

In 1955, E.F. Roots (*in* Fortier *et al.*, 1963, p. 189-194) investigated the basement rocks west of Cape Sparbo, and one set of samples was collected "7 miles west of Cape Skogn" (*ibid.*, p. 189), which may be on or near the north shore of the Truelove River peninsula. He described the rocks as high-grade metamorphics but did not mention the presence of hypersthene. The main rock types established by him are feldspathic "granulite", quartz-feldspar-biotite-gneiss (partly garnetiferous), and biotite alaskite granite. His term "granulite", however, does not mean a granulite facies rock but refers to the granulitic texture.

Christie (1969, p. 232) determined the Precambrian rocks of the north coast of Devon Island to be mainly quartz-feldspar-biotite-gneisses, in places

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Author's address: Department of Geology, University of Alberta
Edmonton, Alberta

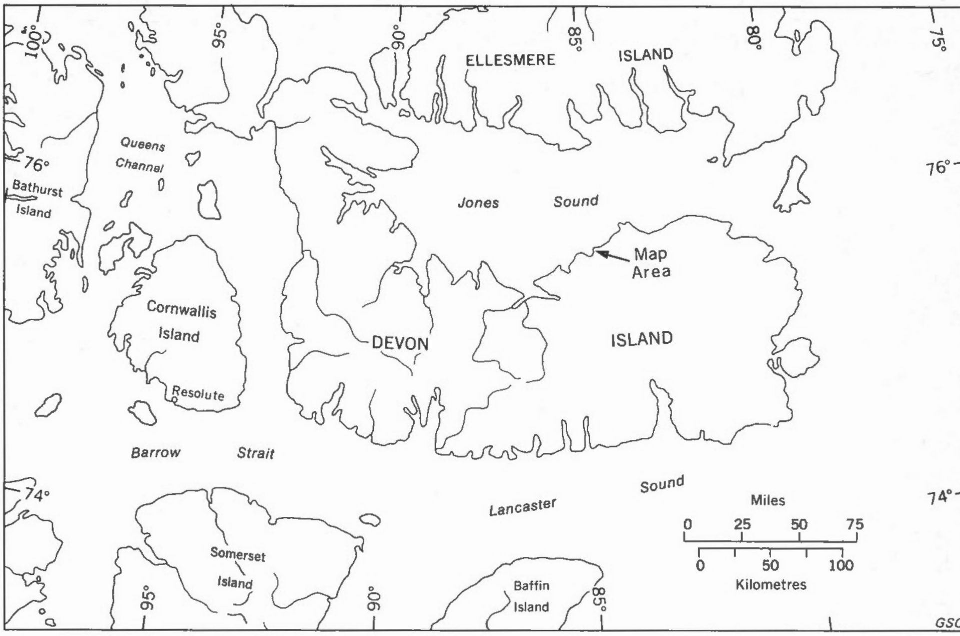

Figure 1. Map showing location of area

garnetiferous. West of Cape Sparbo, the gneisses are in part granitoid, but contain well-banded garnetiferous rocks of metasedimentary appearance. Lighter fractions have segregated to form pegmatitic dykes and veins.

Christie (1970, p. 206-7) also studied the Precambrian of the east and south coasts of Devon Island. The rocks on the east coast are of a similar character to those described by him from the north coast. Granitoid gneisses are widespread, but there occur also pyroxenitic and amphibolitic bands. On the south coast and, to some extent, in the east as well, the gneisses are cataclastic. Prest (1952, p. 14) earlier mentioned strong granitization on the south coast near Dundas Harbour.

In samples from the eastern part of Ellesmere Island, H. S. Washington (1916, p. 334-5) described charnockitic rocks, and compared them with the charnockites from southern India. In the area of Bache Peninsula on the east coast of Ellesmere Island, Christie (1967, p. 12) found dark gneisses containing bluish quartz, hornblende, pyroxene, biotite, banded gneisses (commonly garnetiferous), and granitic rocks. The granite appears, in some places, to be cutting the gneisses and in other places to grade into them. The pegmatites are related closely to the development of the gneisses. He discussed in detail the stratigraphy of the overlying unmetamorphosed sedimentary sequence, as did Kerr (1967) in areas to the north and west.

Investigations of the Shield areas of northwestern Baffin Island were carried out by Lemon and Blackadar (1963) in the area of Admiralty Inlet, and by Blackadar (1964) to the east of the inlet. Lemon and Blackadar (*ibid.*) considered the crystalline complex in the Admiralty Inlet area to be reworked Archean. The complex consists essentially of different varieties of amphibolite facies gneisses that are partly banded. They found some small granitic bodies cutting the gneissic rocks.

Blackadar (1964, p. 13) described the predominant rocks as plagioclase-quartz microcline gneisses with variable amounts of biotite and hornblende, and with locally abundant garnet. They are cut by shear zones. Granitic rocks are rather coarse grained, and contain potassium feldspar porphyroblasts in places.

In his latest report, Blackadar (1970, p. 31) published three new isotopic age dates from northwestern Baffin Island, all giving Hudsonian ages for the latest metamorphism of the gneisses. The dominant rock throughout the area investigated is granitic gneiss (partly granite) accompanied by migmatite, schistose gneiss, mafic gneiss, and banded gneiss (*ibid.*, p. 23). Granulites and charnockites were not found. Jackson (1969, p. 173) found granulites underlying a northeast-trending belt up to 25 miles wide across northern Baffin Island, and also parts of central and eastern Bylot Island.

In the Precambrian basement of Boothia Peninsula and Somerset Island, Blackadar (1967) found granulite facies rocks both in the mafic and in the felsic gneisses. The rusty biotite schists and gneisses of northern Boothia Peninsula and southern Somerset Island contain hypersthene in some cases, but more often biotite and hornblende are the principal mafic constituents (Blackadar, 1967). According to Blackadar (*ibid.*) the microcline-bearing felsic gneisses "resemble granulites from classic Precambrian terranes, such as Finland". Both the mafic and the felsic gneisses are classified as Aphebian in this paper.

Brown *et al.* (1969) also reported hypersthene-bearing rocks in the Boothia Arch. These authors placed the rocks in the transitional amphibolite-granulite facies because of the common presence of hydrous minerals (hornblende and biotite) together with hypersthene.

ACKNOWLEDGMENTS

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CRYSTALLINE ROCKS

GENERAL FEATURES

The crystalline rocks of the report-area are well exposed as large, glacially rounded outcrops in the lowlands region, although the ubiquitous lichen cover and widespread surficial debris provide some hindrance to geological study. The generalized outcrop areas are shown in figure 2.

Most of the rocks show little foliation in hand specimen. Many look massive and, in the case of the more felsic varieties, may have a granitoid appearance. On outcrop surfaces, however, foliation generally is easily determined, especially in the granulites, where quartz-rich bands stand out on the weathered surface. Schistosity is practically non-existent. Gneissosity is well developed in the migmatites. Lenticular and sill-like bodies of endemic granitic matter may emphasize the general trend of the foliation. Foliation in the more homogeneous rocks usually is due to subparallel orientation of mineral grains, more or less evenly distributed throughout the rock.

PLATE II

PLATE II

(a) View of the Truelove River lowland, with cliffs of basement rocks and downfaulted sedimentary outliers (A, B) in the background. View southeast.

(b) View southwestward toward the fault-line scarp on the south side of Truelove Inlet. Note the thin layer of Paleozoic sediments along the skyline, and the gentle westward dip of the unconformity. In the foreground are outcrops of crystalline rocks along the lower reaches of Truelove River.

(c) Granulite outcrop. Behind the outcrop is an elevated beach, approximately 80 metres above the present sea level. Although the beach is on crystalline bedrock, the gravel is derived almost exclusively from the dolomitic sediments outcropping higher on the slope.

The beach is visible as a white strip on Plate I.

(d) Stromatolites in a slab of silty dolomite. Frost-heaved outcrops on the edge of the eastern plateau.

Strikes and dips were measured usually in larger outcrops because of the intermixing of foliated and more massive rock types. The average strike is N10°W, and the structure appears little distorted except in strongly migmatized rocks. The dip is invariably steep, in many cases vertical or subvertical. The data for the strike agree with those of Roots (*in* Fortier, *et al.*, 1963, p. 189) who reported a strike of N10°W for the rocks west of Cape Skogn, but a westerly dip of 60 to 80 degrees. Christie (1969, p. 55) noted for the north coast of Devon Island mainly east-west strikes, but also some southeast-trending strikes. Northerly strikes were established by him (Christie, 1970, p. 207) on the south coast, west of Cape Sherard. Prest (1952, p. 14) found in the area of Dundas Harbour on the south coast, almost in due southward projection of the general strike in the Truelove River peninsula, the same general strike as in the Truelove River area.

The main features of the basement rocks in the Truelove River area are as follows:

1. The rocks are crystalline; there are no unmetamorphosed supracrustal rocks present.

2. By far the greater part of the pre-diabase rocks are metamorphic, with typical crystalloblastic and often cataclastic textures. No large, unmetamorphosed igneous body was seen. Mobile granitic matter appears only as endemic pegmatites (aplites) with transitional boundaries into the metamorphic substratum, and as a few sill-like forms with sharper boundaries.

3. The average metamorphic grade of the crystalline complex is high, and a considerable part belongs to the granulite facies. These rocks represent the oldest preserved metamorphic stage. It is very probable that most, if not all, of the relatively lower-grade metamorphics were derived from the granulites by subsequent amphibolite facies metamorphism. This is evident in those gneisses containing partially or fully altered hypersthene. Such undoubted retrograded granulites constitute at least one-half of the complex. Other rocks include migmatites, gneisses, granitic gneisses and blastomylonites belonging to the amphibolite facies, and a rather small proportion of microcline-rich granite-gneissic rocks (blastomylonitic) containing chlorite as the main dark mineral.

4. Cataclastic and protoclastic deformation is widespread, evidently associated with retrogressive metamorphism with more alkalic feldspathization, and with the development of granitic gneisses.

The mylonites of narrow zones along the much younger normal faults constitute a category of rocks entirely distinct from the retrogressive metamorphism of the complex.

PRINCIPAL ROCK GROUPS

The pre-diabase crystalline rocks of the Truelove River area can be divided into several groups based on lithologic criteria and petrogenetic considerations. These groups are:

Rock Group	Main Criteria
1. Granulites	Presence of fresh or only slightly and locally altered hypersthene

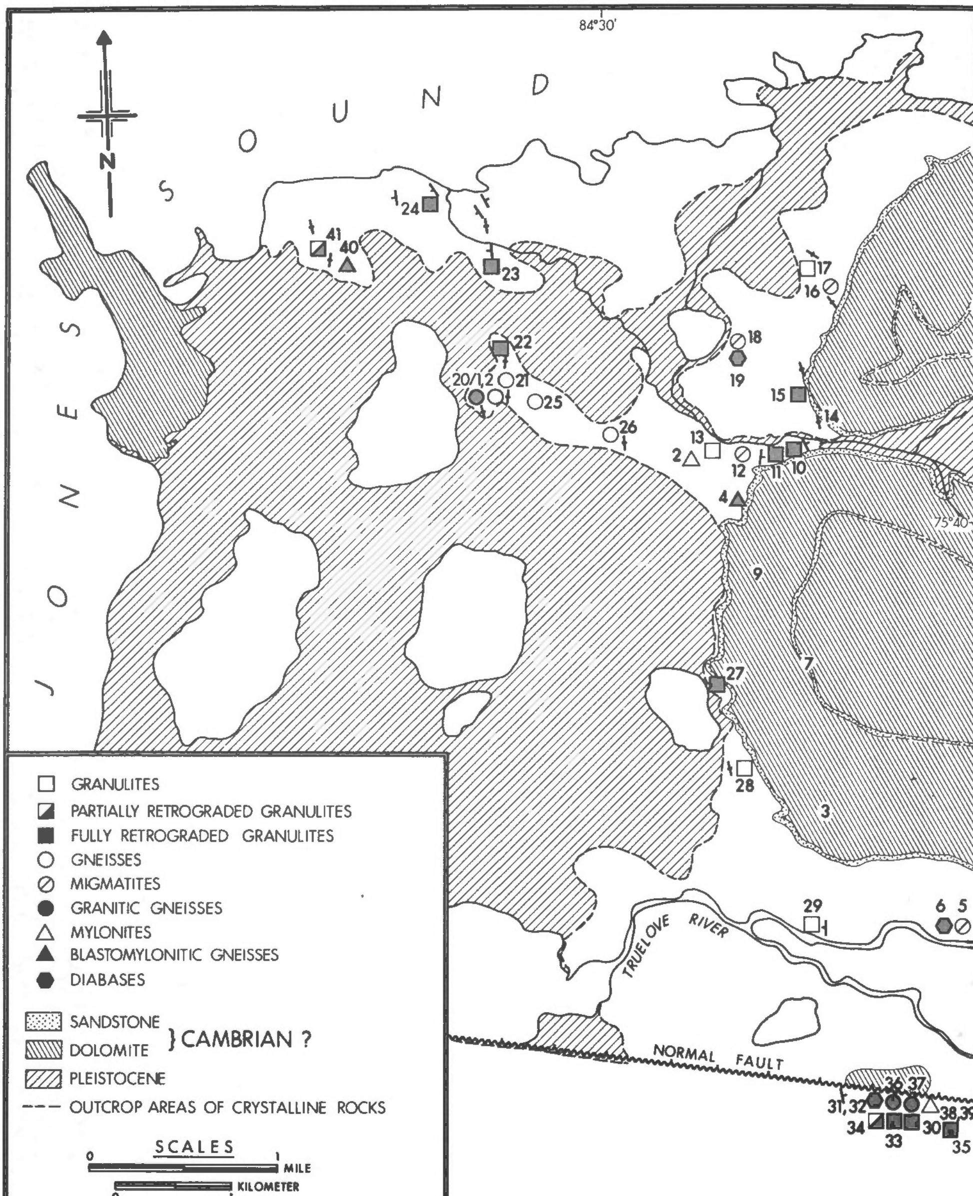

Figure 2. Map showing sample locations in the Truelove River area, northeastern Devon Island

Rock Group	Main Criteria
2. Retrograded granulites	Pseudomorphs after hypersthene, few remnants of unaltered hypersthene
No hypersthene or pseudomorphs	after it are present in the groups below:
3. Garnet migmatites	Massive migmatization with the development of garnet
4. Biotite gneisses	Biotite is the main dark mineral; no garnet
5. Granitic gneisses	Biotite (chlorite) gneisses with colour index less than 10; abundant microcline
6. Blastomylonites	Large-scale recrystallization outlasted deformation
7. Mylonites	Deformation strongly predominates over recrystallization

The groups defined on the basis of these criteria show other differences, both mineralogical and textural. These differences will become apparent from the discussion below.

Granulites

Granulites (i.e. unretrograded hypersthene-bearing quartz-plagioclase gneisses) occur in the northern outcrop area, near the base of the overlying platform sediments, throughout the whole southern area on both sides of the Truelove River, and in the great cliff wall of the fault south of the river. Outcrops are generally marked by rectangular jointing and by uniformly striking foliation. The foliation is vertical to subvertical and coincides with one set of the joints [Pl. II(d)]. The foliation is expressed mainly by straight-line, quartz-rich bands that stand out on the slightly weathered surface of an outcrop. These are almost lost on the fresh surface of a hand specimen, and this gives the impression of a massive rock.

The rocks appear darker than would correspond to their colour index, which is approximately 12. This is due mainly to the darker colour of quartz, which in larger grains exhibits a marked blue tinge, typical for quartz-bearing granulite facies rocks. The texture is generally homogeneous (except for those bands richer in quartz and visible only on weathered surfaces) and equigranular. Migmatization occurs only locally. Some small endemic granitoid phases were observed.

The texture is fully crystalloblastic. The felsic minerals are mainly anhedral, with some subhedral plagioclase; the mafic minerals are more frequently subhedral. The grain-size range is from 0.5 to 5 millimetres, the average being approximately 2 millimetres. Fragmented and partly crushed quartz and plagioclase grains of less than 0.1 millimetre in diameter occur only in strained rocks (sample No. 17).

Plagioclase is in most cases the only feldspar occurring in independent, discrete grains. Potassium feldspar appears as antiperthite, and only the strained sample No. 17 contains 6.2 per cent of independent grains of potassium feldspar. In the other samples the potassium feldspar contents are

0.4 per cent, 1.1 per cent and 0.3 per cent (hair perthite). But even this percentage includes some larger K-feldspar patches in plagioclase that have rather arbitrarily been counted as discrete grains although they still may represent antiperthitic exsolutions. Neither the potassium feldspar grains nor the larger patches in plagioclase show microcline grid structure, although the extinction may be migrating.

The plagioclase is andesine with an average An-content of 39 per cent. The highest An-content measured was 45 per cent. It usually is remarkably fresh. Undulose extinction or strong but diffuse zoning is characteristic. Twinning is common, but not very sharp as a rule. Antiperthitic K-feldspar is ubiquitous, and in some plagioclase grains its proportion approaches 50 per cent of the complex grain, thus clouding the distinction between antiperthite and perthite. The average content of antiperthite in plagioclase is 18 per cent for the granulites, the highest for all the rock groups of the Truelove River area.

Quartz, usually in small proportion, is present in the granulites. This mechanically susceptible mineral provides most of the evidence for post-crystalline deformation. Quartz grains are, in places, fragmented, and in a strained sample even granulated. This deformation has not produced the platy quartz which is considered typical for the classic European granulites (*Weissteine*). Platy quartz, however, does characterize the Devon Island blastomylonites, which evidently developed by strong shearing and recrystallization of the granulites and other rock types.

Myrmekite is rare, and appears only in strained samples with higher K-feldspar contents.

Hypersthene is usually the dominant dark mineral, forming 8.6 modal per cent of the average granulite proper. Its shape varies from almost euhedral to irregular and skeletal. The most perfectly formed crystals are found in sample No. 28, where hypersthene is the only mafic mineral.

The strong pink colour for α, which is characteristic for metamorphic hypersthene of the granulite facies, is always present. The grains are invariably cracked [Pl. III(a)], and it is along these cracks that the first signs of alteration are apparent [Pl. III(b)]. In the modal analyses, the whole grain was counted as hypersthene when the alteration was confined to the neighbourhood of the cracks. A more detailed description of phenomena accompanying the alteration of hypersthene is given under the heading "retrograded granulites" later in this report.

Hornblende is found only in very small quantities, as a subordinate product of hypersthene alteration in the true granulites. Garnet is absent.

Biotite, on the other hand, is rather common. It is strongly pleochroic, brown-red or red-brown for γ, and mainly subhedral in shape. Its amount is always much smaller than that of hypersthene, but the two minerals are evidently in complete equilibrium. Similar relationships between hypersthene and biotite were observed also by Dawes (1970, p. 2) in the Tassiussaq granulites of southern Greenland. The Greenland rocks, however, commonly do contain garnet. Dawes (*ibid.*) also mentions that hornblende appears only in subordinate amounts. Biotite of the Truelove River granulites is always fresh, without any signs of chloritization or bleaching, even where it is broken or partly crushed.

Hornblende appears in the cataclastic sample No. 41, a sample that defies classification with any of the rock groups defined in this paper.

Hornblende here is deformed, greenish brown, and occurs together with deformed hypersthene, biotite and clinopyroxene. Most of the boundaries between these minerals are sharp, but in some cases the change hypersthene → hornblende or hornblende → biotite can be observed. This rock is exceptional in several respects: it is the only one containing clinopyroxene, and contains a larger amount of potassium feldspar (17%) and a smaller content of quartz than any of the pyroxene-bearing rocks. Dawes (1970, p. 2) also has found hornblende rather antipathetic to free quartz in the Tassiussaq granulites.

A common accessory of the granulites is Fe-Ti oxide. Apatite is much less abundant than in the retrograded rocks, and zircon is found only in traces.

The rocks described above appear to be typical representatives of the granulite facies. No subclassification has been attempted in view of the confusion prevailing in the terminology of hypersthene-bearing rocks. The rocks are not charnockites proper, defined by a granitic ratio of feldspars, because of the great predominance of plagioclase over potassium feldspar. According to the terminology used by the geologists working in Greenland and used on the new Tectonic/Geological map of Greenland (1970), the Truelove River granulites are identical with the "enderbitic gneisses" of Greenland.

Retrograded granulites

Rocks containing pseudomorphs after hypersthene, with very little fresh hypersthene left, are found throughout the whole crystalline complex. They are rather uniformly distributed, with no evident tendency to form well-defined zones or concentrations. The retrograded granulites are the most common rock type in the investigated area.

In outcrop they differ from the granulites (described above) by more frequent migmatization and the development of endemic pegmatites. Because of the more common migmatization, they sometimes lose the straight-line foliation of the granulites proper. No change in attitude occurs where the granulites and their retrograded equivalents pass into one another, and the two rock types evidently are structurally conformable.

The original blue quartz was not much affected by the retrogressive metamorphism. A new feature is a local development of conspicuous euhedral porphyroblasts of potassium feldspar, as much as 3 centimetres in length, which are not found in the true granulites.

The texture is more inequigranular than in the granulites. The range of grain size is from 0.1 to 30 millimetres, not counting local granulation in small shear zones. All minerals tend to be anhedral in form.

Plagioclase is the dominant feldspar, but the proportion of free, discrete potassium feldspar is 12.18 per cent in the retrograde rocks compared to 1.84 per cent in the granulites. The largest amount of K-feldspar (25.5%) is found in the cataclastic and porphyroblastic sample No. 24. The average An-content of plagioclase in the retrograde rocks is 34 per cent, and the percentage of antiperthitic K-feldspare is 8 per cent, compared to 39 and 18 per cent, respectively, in the true granulites.

The plagioclase does not differ essentially from that of the granulites (similar undulosity in extinction, zoning and twinning - the latter somewhat denser and sharper in the retrograde rocks), but the relationships of plagioclase and potassium feldspar are more complicated. There occur symplektitic intergrowths of both feldspars resembling myrmekite. The antiperthite is often patchy, in contrast to the regularity of its forms in the granulites. Hair perthites with practically a 1:1 ratio of both feldspar components are frequent; they are characterized by a bluish reflection colour in plane light. In the cataclastic sample No. 24, potassium feldspar forms large, fresh idioblastic megacrysts enclosing altered plagioclase and quartz, and often surrounded by crushed plagioclase.

Very narrow K-feldspar rims along the boundaries of plagioclase grains between themselves or with quartz may become very widespread and make measurements of the refraction index of plagioclase with respect to quartz almost impossible.

Plagioclase appears, generally, to be less fresh than in the granulites, whereas potassium feldspar appears to be fresh. Optical extinction in this mineral is strongly undulose, suggestive of microcline; but microcline grid twinning is absent.

Myrmekite is much more common than in the granulites [Pl. IV(c)], especially where the rock shows strong signs of dynamic deformation. The potassium feldspar megacrysts of the cataclasite sample No. 24 are largely surrounded by myrmekite. Burwash and Krupička (1970, p. 1280) found a similar connection between the amount of myrmekite and the intensity of deformation in the basement rocks of western Canada.

The key criterion in defining the group as retrograded granulites is the presence of pseudomorphs or alterations of hypersthene. The percentage of these is 3.58 on the average. Plates III(c) and (d) show two such typical pseudomorphs. The development of these pseudomorphs and alterations from the original hypersthene can be followed step by step in the suite of specimens. The end products constitute such a typical assemblage that there can be no doubt of their origin even where no trace of hypersthene remains or where the shape of the pseudomorph is not apparent.

The detailed breakdown of the composition of the pseudomorphs and alterations gives the following average figures: chlorite - 1.54 per cent, carbonate (magnesite) - 1.1 per cent, green biotite - 0.56 per cent, antigorite - 0.18 per cent, hornblende - 0.1 per cent, talc(?) - 0.1 per cent.

These figures were obtained by point counting, using a high density of points. Nevertheless, they should be treated only as estimates because of the difficulties in identification of the densely intergrown components of the pseudomorphs. Especially difficult is the distinction between the highly pleochroic varieties of prochlorite with relatively high birefringence and the green biotite, or even between prochlorite and hornblende where the extinction angle of the hornblende cannot be ascertained. The grain size of the products is fine to very fine, and transitional forms between prochlorite and green biotite seem to be frequent. Typical penninite, however, is common and can be identified easily.

The very small amount of secondary hornblende developed from hypersthene is rather striking. This phenomenon may be related tentatively to a somewhat higher K-content in the rocks, manifesting itself in the larger amount of potassium feldspar, and leading to the formation of biotite instead of hornblende.

The change of hypersthene to green biotite evidently began along cracks in otherwise unaltered hypersthenes of the true granulites. No intermediate hornblende stage is apparent. The general pattern of this alteration resembles very much the common biotitization of garnets along cracks, where the secondary biotite is often pale green and weakly pleochroic. In the cataclastic sample No. 41, hypersthene has changed to hornblende along the edges of grains while biotitic matter fills cracks in the grains.

The secondary green biotite of the pseudomorphs differs greatly from the older, subhedral and well-formed biotite. The latter shows strong reddish brown pleochroism, and is of the same type as the biotite of the granulites. It is invariably fresh, even when strongly deformed, and where it bounds on the pseudomorphs the boundaries are sharp, without transitions.

The retrograded granulites contain somewhat more Fe-Ti oxide and much more apatite (0.69% against 0.1%) than the granulites. One sample (No. 15) contains also 0.8 per cent of deep green spinel; this rock has the lowest percentage (1.2%) of pseudomorphs after hypersthene.

Garnet migmatites

These rocks are characterized by the absence of pseudomorphs or alterations of hypersthene, by massive migmatization, by the presence of garnet and by the common occurrence of spinel and cordierite. Bluish quartz is absent. The garnet migmatites tend to be more concentrated spatially than the retrograded granulites.

The migmatitic character is associated with a very variable grain size (0.1-60 mm) and marked inhomogeneity in the rocks. More small-scale contortion of the foliation and microfolding is present in the migmatites than in the other rock groups, a fact indicating greater plasticity during metamorphism. The general strike and dip conform, however, with those in the other rock groups. Biotite-rich parts form schlieren in garnet-rich pegmatitic rock. The boundaries between them are transitional and agmatitic types are absent. Porphyroblastesis of garnet is common, and large (up to 6 cm) garnet porphyroblasts are characteristic for the area of sample No. 13 and that to the southeast. These coarse-grained pegmatoid rocks, crowded with large garnets, tend to be completely massive. Feldspar porphyroblasts also appear, but less commonly than those of garnet.

In contrast to the notable predominance of plagioclase over potassium feldspar in the granulites and retrograded granulites, the average amount of potassium feldspar in the garnet migmatites approaches that of plagioclase. The differences in the ratio of the two feldspars between the individual migmatite samples are, however, very considerable, and reflect the strong inhomogeneity of the rocks.

The measurements for feldspar content in the garnet migmatites are rather biased in favour of potassium feldspar because of the abundance of hair perthites (antiperthites), which reach their maximum development in these migmatites. For point counting purposes it is impossible to distinguish between grains containing approximately 55 per cent potassium feldspar and 45 per cent plagioclase, and those containing 55 per cent plagioclase and 45 per cent K-feldspar in a very dense intergrowth of hair-like lamellae. For this reason both hair perthites and hair antiperthites were counted as potassium feldspar.

In the study of individual grains the distinction between hair perthite and hair antiperthite sometimes can be made: that is, in those cases where the exsolution strings do not reach the margin of the grain so that the host mineral can be determined.

The average An-content of plagioclase in the garnetiferous rocks is small: 29 per cent (oligoclase-andesine). In the hair antiperthites it is generally still lower, approximately An_{25}.

Potassium feldspar shows undulose extinction but never the microcline gridding. Symplektitic intergrowths of both feldspars and K-feldspar rims around plagioclase are less common, and myrmekite is much less common than in the retrograded granulites.

The average amount of quartz in the garnet migmatites is the largest of all the crystalline rocks. It seems more probable that the original rock was rich in quartz than that the increase is due to migration of silica.

Biotite is rather well developed, has a strong red-brown (in one case brown-red) pleochroism, and is always fresh.

Garnet, often porphyroblastic, occurs both in closed and in open, corroded and skeletal forms. It is usually faintly pink and fresh, with only slight local biotitization along cracks or with narrow rims of rather pale mica. In sample No. 16 garnet forms complicated intergrowths with quartz, as does spinel in the same sample.

Two other characteristic minerals of the garnet migmatites are spinel and cordierite, mostly closely associated. Spinel, in many cases, is the older of the two, for cordierite has developed as a reaction product of spinel in a silica-rich environment [Pl. VI(b)].

Spinel is of the deep green pleonaste variety, and may become practically opaque in the deepest coloured portions. It is very commonly intimately intergrown with Fe-Ti oxide; in one case such intergrowths contain also a deep brown variety. In addition to intergrowths with magnetite on edges of grains, spinel may enclose magnetite, or contain magnetite ribs. The interiors but not the edges of the larger spinel grains tend to alter to talc and diaspore. In these cases, the altered parts are full of fine magnetite dust developed from the Fe-component of the pleonaste. In one case, spinel forms part of a leucoxene pseudomorph after ilmenite (or Ti-magnetite).

Generally, reaction rims have developed along the boundaries between spinel and quartz or feldspar. This indicates the incompatibility of spinel with free silica, and evidently in some cases even its easy reactivity with silicates.

Sample No. 16 contains an almost diablastic intergrowth of spinel with quartz; the spinel here, although in contact with free silica, shows only extremely narrow rims and is, in some places, in direct contact with quartz without any intervening reaction zone. This is a surprising phenomenon in view of the general relationships described previously.

Many of the reaction zones around spinel are definitely cordierite. These zones commonly widen and pass into larger cordierites exhibiting the typical two sets of twinning lamellae at approximately 50° [Pl. VI(a)], the channels of isotropic matter, and the chloritic and micaceous alteration products. Many spinels, and even some magnetite grains, are enclosed in larger cordierites. In sample No. 5, cordierite forms diablastic intergrowths with quartz in patterns that are very similar to myrmekitic intergrowths of plagioclase and quartz.

It is possible that some of the narrow rims around the spinel grains consist of sapphirine, but their narrowness makes exact determination impossible.

Biotite gneisses

The biotite gneisses occur in a rather limited outcrop area formed by low, west-northwest-trending ridges in the northern part of the lowlands. These gneisses differ from the garnet migmatites in the absence of garnet, a marked predominance of biotite among the mafic minerals and, where it occurs, a different character of migmatization. In the garnet migmatites, the migmatization is more massive and the metatect is usually coarse grained or pegmatitic. The biotite gneisses tend to contain more feldspars (and thus to lose their foliation) and to grade into granitic gneisses and more massive granitic-looking rocks. The association with and passage into granitic rock types is characteristic of the biotite gneisses. The gneisses are conformable structurally with the surrounding crystalline complex. The samples show evident signs of moderate cataclasis.

The ratio of plagioclase to potassium feldspar is about 2:1, compared to 4:1 in the retrograded granulites and 30:1 in the granulites. The proportion of antiperthitic K-feldspar in plagioclase is 3 per cent compared to 8 per cent and 18 per cent, and the An-content of plagioclase is 32 per cent compared to 34 per cent and 39 per cent, respectively. The amount of perthitic plagioclase in K-feldspar is about the same as in the other two rock groups.

The spatial relationships of both feldspars are rather complicated, but less so than in the granitic gneisses which represent a more advanced stage in the process of granitization. Complicated feldspar symplektites are rare, but partial replacement of plagioclase by potassium feldspar is common. Mechanical stress resulted in the local development of crushed plagioclase where plagioclase is in contact with larger K-feldspar grains, and in the bending of the twinning lamellae in some plagioclase grains. Myrmekite is common in strained biotite gneisses, as is generally the case in deformed rocks containing both feldspars.

Potassium feldspar forms rims on plagioclase in two of the samples. In larger grains, K-feldspar exhibits moderate migrating extinction but not microcline gridding.

Deformation of quartz is evident; in all samples it is fragmented. Locally, in narrow shear zones, it is finely granulated.

Moderate deformation also is evidenced by biotite. The lepidoblastic grains are bent and the edges commonly tattered. The pleochroic colour for γ is brown, without the red shade common in the retrograded granulites and always present in the granulites proper. Chloritization is weak, and biotite usually remains unaltered even when crushed in the narrow shear zones. Magnetite grains and clusters are usually intergrown or fully surrounded by biotite.

Hornblende constitutes 11.2 per cent of sample No. 21, which is one of only two samples of hornblende-bearing rocks from the basement complex, if the very small and infrequent occurrences of secondary hornblende in the pseudomorphs after hypersthene are ignored. Sample No. 21 also contains the second largest amount of Fe-Ti oxide (5.8%) and of apatite (1.8%). Consistently high proportions of Fe-Ti oxide (Ti-magnetite, ilmenite) and apatite are present in the biotite gneisses; the averages of modal analyses for these minerals are 3.97 and 1.03 per cent, respectively.

Granitic gneisses

These pink granitoid rocks do not show intrusive relations. They appear to have developed gradually from biotite gneisses or retrograded granulites through an increase in the proportion of feldspars and usually a corresponding increase in the massiveness of the rock. They are an excellent example of granitization in situ by microclinization. The same conclusion was drawn by Roots (*in* Fortier *et al.*, 1963, p. 163) from observation of rocks west of Cape Skogn. The possibility of K-metasomatism will be discussed later.

Syncrystalline and postcrystalline deformation are even more apparent in the granitic gneisses than in the biotite gneisses, from which, presumably, they mainly arose. The texture in the granitic gneisses is strongly inequigranular due both to complicated intergrowths and to mechanical deformation. One sample is porphyroblastic, with euhedral microcline megacrysts up to 2.5 centimetres in diameter.

The ratio of plagioclase to potassium feldspar in the granitic gneisses reaches 1:1, the lowest value of all the rock groups of the Truelove River area. The anorthite content in plagioclase also attains its minimum of An_{22}. There is no antiperthitic potassium feldspar in plagioclase. However, the textural relationships between the feldspars are more complicated than in any of the other rocks except the blastomylonites.

The intricate relationships between feldspars are due to various causes such as inequal deformation, replacement, and diablastic intergrowths. Considerable variation in alteration from specimen to specimen was observed, and this variation also could add to the complicated pattern. In strongly deformed samples of granitic gneiss, such as No. 20/1, clean larger grains of perthitic potassium feldspar grow in, or are surrounded by, a commonly altered, crushed plagioclase with grains from 0.1 to 0.01 millimetre in size. Preserved larger plagioclase grains frequently have bent twinning lamellae. In the porphyroblastic sample, large microcline megacrysts, without any trace of alteration, enclose or lie adjacent to strongly altered, small plagioclase grains [Pl. IV(d)] or plagioclase crush. Sample No. 37 shows the extreme of diablastic intergrowths of both feldspars, and a series of stages in the replacement of plagioclase by potassium feldspar.

Identical relationships between feldspars were described by Berthelsen (1960, p. 31) from the Tovqussap Nunâ complex in southwestern Greenland in the transitional varieties between "purple gneisses" and "light coloured biotite gneisses". As on Devon Island, the rocks described by Berthelsen form a continuous (retrogressive) series from granulites proper through the "purple gneisses" to the "light coloured biotite gneisses". The latter correspond to the granitic gneisses of this paper.

Potassium feldspar in the granitic gneisses occurs as microcline which, even in small patches and narrow braids, exhibits the characteristic microcline grid pattern [Pl. V(a)]. The granite gneisses are, in this respect, distinct from the other rock types, namely granulite, retrograded granulite, garnet migmatite, and biotite gneiss, already discussed.

Myrmekite is common, and is especially abundant adjacent to microcline megacrysts.

Quartz is generally fragmented. In the cataclastic sample No. 20/1, quartz occurs in lenses of crushed and recrystallized older quartz grains. The rock is thus transitional to the blastomylonites. It may seem surprising that the granitic gneisses, the most granitic-looking rocks with the lowest colour index of all the rock groups from the Truelove River area except the blastomylonites, show the lowest average amount of quartz, 19.17 per cent. This is 4.5 per cent less than in the very high grade granulites. The fact becomes less surprising if one takes into account the strong microcliniz-ation of the granitic gneisses, a process which must have consumed some of the original quartz if no silica import has occurred.

Among the dark minerals, chlorite predominates over biotite. Fresh biotite shows only medium brown pleochroism, weaker than in the other rock types and without any red shade. In the least deformed sample, No. 37, chlorite replaces biotite in well-preserved pseudomorphs. This chlorite is a typical penninite, lacking the higher birefringent prochlorite which is common in the pseudomorphs after hypersthene. The penninite is generally crowded with secondary Ti-minerals. Chloritization was supported by deform-ation. In these cases, biotite is broken, torn, and the flakes are chlori-tized or bleached. Muscovite appears only in traces.

Blastomylonitic gneisses

These rocks are defined by mylonitic textures healed either fully or predominantly by recrystallization that at least in part followed deformation. They are very different from the young mylonites associated with the Phanero-zoic normal faults. In the hand specimen the rock appears medium grained. Because of the small content of sheet minerals, the foliation is inconspicuous. Many varieties are red and, in the field, probably would be mapped as felsic granites. But, as with the granitic gneisses, nowhere could intrusive relationships be observed. The blastomylonitic gneisses developed from, and alternate with, the less deformed rock types of the complex. As mentioned above, sample No. 20/1 represents a transitional type between the undeformed gneisses and their microclinized blastomylonitic equivalents.

Two samples were point-counted: No. 4 and No. 40. They were chosen as representatives of two rather differing types of blastomylonites. The main difference is the ratio of feldspars and the degree and style of recrystallization.

Sample No. 4 is fully recrystallized. It contains three grain size groups:

a) Fine-grained matrix, granoblastic, with all deformation completely healed. It is composed almost entirely of feldspar, with plagio-clase predominating. The plagioclase grains average approximately 0.1 millimetre, and the potassium feldspar grains average 0.05 millimetre in size.

b) Very sharply bounded, parallel stringers of fully recrystallized, granulated quartz, with grain size from 0.2 to 2 millimetres.

c) Plagioclase porphyroclasts up to 5 millimetres in diameter, deformed, with antiperthite lamellae bent in some cases as much as 45° without cracking [Pl. IV(b)], and garnet porphyroclasts also up to 5 millimetres in diameter.

All minerals are anhedral.

Plagioclase (49%) predominates considerably over potassium feldspar (9%). Its average An-content is 32 per cent, and is the same in the clasts and in the matrix. Twinning is much more abundant and sharp in the matrix than in the porphyroclasts, and resembles the well-twinned plagioclase of many amphibolites.

There is a striking difference in the amount of antiperthite between the plagioclase of the clasts and that of the matrix. The clasts contain approximately 15 per cent antiperthitic potassium feldspar. The matrix plagioclase contains none at all but, on the other hand, there is about 25 per cent potassium feldspar in the matrix in the form of a fine network in the interstices between the plagioclase grains. Almost all boundaries between plagioclase and the quartz stringers are coated with a K-feldspar film.

The percentage of quartz (36%) is considerably above the average of the other rock groups. Quartz in the stringers shows undulose extinction, but is not fragmented; it evidently suffered no substantial deformation after recrystallization. The grains are platy, up to 4 millimetres long, and are suggestive of the platy quartz of the classical European granulites.

Garnet in porphyroblasts and porphyroclasts is the main dark mineral; its proportion is 5 per cent. It is slightly changed to bleached biotite and chlorite along the edges and cracks. Biotite occurs only as tiny, accessory flakes.

Sample No. 40 contains recrystallized quartz and is considerably microclinized. The texture is porphyroclastic (plagioclase) and porphyroblastic (microcline) at the same time. All minerals are anhedral. The rock is virtually massive both in hand specimen and in thin section. In contrast to sample No. 4, sample No. 40 is much richer in potassium feldspar (43.6%). The plagioclase content (including the sericitized portions) is 28.6 per cent. The latter is bimodal and occurs as very fine crush (0.01-0.005 mm) and as porphyroclasts up to 2 millimetres in diameter. It is usually strongly altered; the alteration obscures possible twinning and zoning. The refractive index of the less altered parts corresponds to An_{20}. In the hand specimen the plagioclase, especially in the crush, is markedly pink whereas the microcline blasts are whitish.

Potassium feldspar is always typical microcline. The grain size ranges from 0.3 to 6 millimetres; the bulk of the feldspar is contained in the porphyroblasts. All microcline grains are surrounded by finely granulated plagioclase which, in some cases, is found enclosed by microcline [Pl. V(b)]. On the other hand, very little deformation is seen in the microcline. Evidently it grew at the same time that recrystallization of the granulated quartz was taking place. The microclinization of plagioclase proceeded preferentially in the granulated parts; the plagioclase clasts generally are not microclinized.

Quartz appears in clusters of small, fully recrystallized grains. The quartz aggregates form lenses or stringers and bands between the feldspars. The recrystallization is complete, and is of a typical post-deformation character. The texture in the clusters is that of a serrate quartzite. No migrating extinction is apparent in the quartz.

The rock contains 0.4 per cent muscovite and remnants of bleached biotite, 0.4 per cent chlorite from biotite, 0.6 per cent carbonate and 0.2 per cent leucoxene. Zircon, apatite and pyrite are present as accessories.

Both by its texture and by its composition the rock corresponds to some of the microclinized blastomylonites found in drill cores from the basement rocks in western Canada (Burwash and Krupička, 1969, p. 1384).

Mylonites

On the Phanerozoic, possibly Tertiary, faults all rocks were crushed, but only in narrow zones along the fault surfaces. There was no substantial recrystallization other than the development of the low-grade sericite-chlorite assemblage. The process was that of a kinetic metamorphism of higher crustal levels, essentially different from the deep-seated deformation and recrystallization of the blastomylonitic gneisses. A similar situation has been described from the uranium-bearing Tazin Group in northwestern Saskatchewan (e.g. Tremblay, 1968, p. 297; Krupička and Sassano, 1972). No modal analyses of these rocks could be made because of the fineness of the grain.

Sample No. 38 comes from the wall of the large Truelove River fault, where the vertical displacement of Paleozoic strata is approximately 300 metres. The non-mylonitized rocks in the neighbourhood are granitic gneisses and retrograded granulites. The granitic gneisses are themselves partially blastomylonitic, but this deformation and recrystallization took place long before the movement along the fault. In hand specimen, the sheared rock from the fault zone is a very fine grained, brittle mylonite which, when broken, yeilds a completely irregular pattern of fractures with sharp edges.

The thin section shows scattered microcline porphyroclasts indicating that granitic gneiss was the original rock. These porphyroclasts are embedded in a mylonitic matrix with an average grain size of about 0.05 millimetre [Pl. V(d)]. There are numerous larger (0.1-0.5 mm) flattened quartz grains. The parallel texture is caused first of all by quartz stringers and flat quartz grains.

The fine-grained matrix is composed of altered feldspars, invariably dusted over or coated with hematite, and quartz. All original dark minerals, except some possibly primary magnetite, have disappeared, and have been replaced by penninite. Sericite forms an essential part of the mylonitic matrix.

Sample No. 2 is derived from a rather dark-coloured, garnet migmatite. It was found on a fault of uncertain strike occurring near the bottom of the eastern escarpment. It is a porphyroclastic mylonite with parallel bands of mechanically separated minerals. Ultrafine-grained (0.002 mm) feldspar-biotite bands with chips of garnet alternate with fine-grained (0.01 mm) bands of quartz. The presence of non-chloritized, although often bleached, biotite even in the finest crush may indicate a rather dry environment during shearing. The rock shows very little healing by recrystallization.

GENERAL TREND OF THE MAIN COMPOSITIONAL CHANGES IN THE SERIES GRANULITES - GRANITIC GNEISSES

Plagioclase: steady decrease in modal amount from granulites to granitic gneisses

An-content of plagioclase: steady decrease

Potassium feldspar: steady increase in amount; typical microcline appears at the end of the series

Percentage of antiperthitic K-feldspar in plagioclase: steady decrease to zero in granitic gneisses

Percentage of perthitic plagioclase in K-feldspar: remains practically unchanged

Quartz: no substantial change; minimum in granitic gneisses

Hypersthene: only in granulites (by definition)

Hornblende: appears only in one sample of biotite gneiss and in one unclassified sample (probably retrograded granulite)

Biotite: increase in the amount to biotite gneiss, then sharp decrease in granitic gneisses (by definition); change in colour from brown-red in granulites through red-brown in retrograded granulites, brown in biotite gneisses and light brown, partly bleached and chloritized, in granitic gneisses; these changes in colour indicate progressive lowering in the ratio Ti/Mg:total iron and a simultaneous lowering of the metamorphic grade (Deer *et al.*, 1962, p. 75, 76)

Chlorite: a) amount of discrete chlorite grains increases steadily from zero in granulites to a maximum in granitic gneisses

b) chlorite in mixed pseudomorphs after hypersthene is concentrated in the retrograded granulites

Apatite and Fe-Ti oxide: both reach their maxima in the biotite gneiss

The general trend in the series is from simpler to more complicated textural forms.

The garnet migmatites seem to stand somewhat apart from the main series granulites - granitic gneisses. They show a minimum of plagioclase, maximum of perthite, and maximum of quartz among all the rock groups. They are also the only rocks that contain cordierite, garnet (except, of course, the blastomylonites and mylonites derived from them), and, with one exception, spinel.

MUTUAL RELATIONSHIPS OF THE FELDSPARS

The evolutionary history of the feldspars is an integral part of the general evolution of the series granulites - granitic gneisses (and blastomylonites). The change of granulite facies assemblages of mafic minerals into lower-grade assemblages was associated with an increase in the amount of potassium feldspar and with a growing individualization of its forms. This process was accompanied by an increasing Ab-content of the plagioclase, an increase in the alteration of the plagioclase, and the development of typical microcline in the potassium feldspar.

In the granulites, potassium feldspar is present mainly in the form of antiperthite. The average amount of antiperthitic potassium feldspar in plagioclase is 18 per cent, which is equivalent to 11 per cent K-feldspar in the whole rock; the free K-feldspar averages only 1.84 per cent, and most of this figure is represented by one sample (No. 17).

The antiperthite in granulites originated, without any doubt, by exsolution during the granulite facies metamorphism. It appears as long, parallel strings or lamellae, as stringlets, or as rather rectangular beads. There are no signs of any potassium import from outside the grain. The strings usually stop short of the edge of the plagioclase host. Plate IV(b) shows antiperthite strings growing absolutely parallel with the twinning of the plagioclase. Both the strings and the twinning lamellae are strongly and conformably bent. The deformation of the rock, which in itself is fully healed by recrystallization, must have occurred after the exsolution of the antiperthitic strings.

The same applies to perthite in the granulites, which provides another example of a simple unmixing. The large antiperthitic plagioclase grain in plate IV(a) encloses a grain of hair perthite. The perthitic threads are evenly distributed and do not quite reach to the edge of the grain. The enclosing of the hair perthite in this manner suggests an early formation in the evolution of the rock, a suggestion that is corroborated by the textural behaviour of hair perthites as early constituents in other members of the series granulites - granitic gneisses.

The enclosed grain of hair perthite itself encloses two grains of subhedral biotite, although the rock is a high-grade granulite with 8.6 per cent hypersthene and only 0.4 per cent biotite. This indicates the primary character of the biotite; it must have existed in the rock before the formation of the strongly antiperthitic plagioclase, which in itself is a mineral characterizing granulite facies rocks. The enclosed biotite thus could belong to the pre-granulitic stage in the evolution of the rock, and would be the only evidence of the stage of progressive metamorphism leading to the formation of the granulites from rocks of lower metamorphic facies.

In the retrograded granulites, the content of discrete, independent potassium feldspar grains increases to 12.8 per cent, the amount of antiperthitic K-feldspar decreases to 8 per cent of the plagioclase = 3.6 per cent of the rock. Commonly there appear irregular, larger patches of new potassium feldspar in plagioclase, evidently younger than the exsolved stringers. One sample contains abundant intimate symplektitic intergrowths of plagioclase and potassium feldspar resembling myrmekite. In several samples, most of the plagioclase grains are coated with K-feldspar rims and films, a phenomenon which is never encountered in the granulites proper. It attests to the highly reactive nature of grain boundaries in general.

Sample No. 24 contains numerous euhedral potassium feldspar porphyroblasts with many inclusions. The porphyroblasts have little perthitic plagioclase (about 2%), which may indicate a low temperature for their formation. Plagioclase in this rock, on the contrary, has about 5 per cent of antiperthitic K-feldspar. Whereas the plagioclase of the granulites is fresh, the plagioclase of the retrograded granulite commonly shows moderate alteration.

Myrmekite, almost absent in the granulites, is quite common in their retrograded equivalents.

The biotite gneisses show a continuation of the trend in the feldspar relationships observed in the retrograded granulites. Discrete potassium feldspar grains form 22.57 per cent of the rock while the average amount of K-feldspar contained as antiperthite in plagioclase sinks to a mere 0.98 per cent of the whole rock. The average size of the K-feldspar grains approaches that of the plagioclases.

The evolutionary process culminated in the production of the granitic gneisses and blastomylonites. The average ratio of both feldspars is 1:1 in the granitic gneisses. Potassium feldspar dominates in size over plagioclase and shows a strong tendency to be porphyroblastic. It is present always in the form of microcline, even in the fine replacement patterns. Replacement of plagioclase becomes dominant in the generation of new potassium feldspar. Antiperthite is completely absent from the plagioclase grains, the average An-content of which drops to 22 per cent in the granitic gneisses and to 26 per cent in the blastomylonites.

Myrmekite is abundant in the granitic gneisses. In sample No. 37, myrmekitic plagioclases are partially replaced by microcline: patches of fresh microcline have developed in altered plagioclase that encloses quartz. This relationship is incompatible with Becke's explanation of the origin of myrmekite as being due to the replacement of potassium feldspar by plagioclase (cf. Burwash and Krupička, 1970, p. 1280).

In all samples of the granitic gneiss, there is a striking difference between the freshness of the microcline and the high degree of alteration in the plagioclase. In many cases, absolutely fresh microcline megacrysts enclose small, strongly altered plagioclase grains [Pl. IV(d)]. Here, the alteration cannot be explained by a higher resistance of microcline. The plagioclase grains must have been altered before the formation of the enclosing microcline.

Some diablastic intergrowths of feldspars are extremely complex. It is often impossible to say where microcline is still part of the replacement perthite and where it is already an independent grain. Braided and interlocking patterns of microcline cut through the plagioclase twinning (where it is still visible through the strong alteration) and pass outside the plagioclase into larger microcline grains. The K-feldspar component of the earlier hair perthites presumably has been mobilized and has destroyed the previous pattern.

Strong deformation is generally associated with abundant development of microcline, as seen in the blastomylonite No. 40 described above (under the heading "Blastomylonitic gneisses").

The question arises: cannot the uniform increase in the amount of potassium feldspar from granulites to granitic gneisses be explained as resulting from differences in the original composition of the rocks? In other words, do we not have here an essentially isochemical metamorphism of different original rocks, rather than different metamorphic stages of a retrogressive process beginning with the one rock, granulite? In the second case there is the necessity to assume some import of potassium, or at least a large-scale migration of potassium within the complex.

Both field and microscopic observations leave no doubt that the retrograded granulites developed from the granulites, and similarly that the granitic gneisses were derived from the biotite gneisses and the retrograded granulites. The blastomylonites also developed from other rocks of the complex. An open question is, however, the origin of the garnet migmatites which in some respects seem to stand apart from the "main series" just described.

A calculation, based on the modal composition of the rocks, can be made as to the sufficiency of the sources of potassium contained in the granulite for the subsequent increase of potassium feldspar in the retrograded rocks. This, of course, presupposes the easily assailable assumption that the original composition was more or less the same throughout the complex. The factors considered in the calculation are: the amount of discrete potassium feldspar and plagioclase, the amount of biotite, and the percentage of antiperthite and perthite, the latter recalculated to the whole rock. The ratio of the contents of potassium in biotite and in potassium feldspar is taken as 2:3.

The high antiperthite content in the granulite, representing 11 per cent of potassium feldspar for the whole rock, accounts for a substantial part of the potassium feldspar in the derived rocks. Nevertheless, this original source would not be sufficient to cover the full increase of potassium feldspar, especially in the granitic gneisses. The surplus amount of potassium feldspar, for which potassium would have to be supplied from outside, for the various rocks can be tabulated as follows:

	Total percentage of K-feldspar in the rock	Percentage of 'surplus' K-feldspar (of the total K-feldspar)
Retrograded granulites	12.8	42
Biotite gneisses	22.57	58
Granitic gneisses	37.57	58
Blastomylonites	26.30	61

These figures are speculative except for the retrograded granulites containing pseudomorphs after hypersthene. These must have had the same original composition as the granulites with preserved hypersthene. The same, of course, applies to blastomylonites derived from them.

However, the assumption of a higher original, premetamorphic potassium content in rocks that are now rich in potassium feldspar becomes considerably less plausible if one takes into account the following fact: the evident association of higher amount of potassium feldspar with higher deformation, and especially the evident lateness of the K-feldspar in the partly or fully recrystallized deformed rocks.

In these rocks, pulverized and very often strongly altered plagioclase forms mortar rims around fresh, larger microclines, or granulated plagioclase is found directly ingrown in them. Potassium feldspar commonly grew in younger, larger grains out of the plagioclase crush. Especially marked are late deformational or post-deformational textures in the porphyroblastic gneisses where large, fresh, idioblastic megacrysts of potassium feldspar grew in crushed and altered plagioclase (Nos. 24, 36). It is hardly plausible to assume that the rocks contained the same amount of potassium before deformation and that the plagioclase was totally crushed while the potassium feldspar remained unaffected, or that, in a crushed mixture of both feldspars, plagioclase would remain completely unaffected by recrystallization while potassium feldspar underwent complete recrystallization.

The association of microclinization with deep-seated shearing has been observed in various crystalline areas (cf. Burwash and Krupička, 1970, p. 1285, 1288). For the granulitic and retrograded rocks of southwestern Greenland, the relationship between large-scale microclinization and shearing was expressly stated by Berthelsen (1960, p. 29). A similar relationship of microclinization to strong syncrystalline deformation in the linear belts of southwestern Greenland has been established by Windley (1969, p. 158).

When taken together, regardless of the rock group to which they belong, the crystalline rocks of the Truelove River area that do not exhibit signs of superimposed dynamic deformation contain an average of 12 per cent potassium feldspar, whereas in the cataclastic and blastomylonitic rocks the average K-feldspar content is 26 per cent. It is hardly a coincidence that the only granulite with an appreciable amount of potassium feldspar (6.2%) is strained, that the retrograded granulite with the highest content of potassium feldspar (25.5%) is cataclastic, and that the two rocks with the maximum potassium feldspar content (53.9% and 43.6%) in the whole complex are a strained granitic gneiss and a blastomylonite.

BIOTITE AND CHLORITE EQUILIBRIUM ASSOCIATIONS

The following less common equilibrium associations have been observed in the crystalline rocks of the Truelove River area: biotite-hypersthene, biotite-chlorite and chlorite-microcline.

Brown-red biotite, strongly pleochroic, almost without radioactive haloes, is commonly found in the granulites as intimate intergrowths with hypersthene. Hypersthene along the common boundary is fresh, and the boundary itself is sharp. In the same rock, hypersthene may be seen to have altered along cracks to a very different, grey-green, slightly pleochroic secondary biotite, and into chlorite. Both of these secondary minerals are, in some places, sharply bounded by fresh, primary brown-red biotite. Dawes (1970, p.2) described a similar equilibrium assemblage of biotite-hypersthene in the Tassiussaq granulites of southwestern Greenland. Biotite in these rocks was folded during the first migmatization period (*ibid.*). Berthelsen (1960, p. 194) considered the coexistence of hypersthene and biotite in the Tovqussap granulites as representing incomplete adjustment of the granulite facies assemblage to the amphibolite facies assemblage because of an insufficient water content (dipsenic metamorphism).

The coexistence of primary red-brown biotite with chlorite, developed in the pseudomorphs after hypersthene, is common in the retrograded granulites of the Truelove River area. Biotite is completely fresh, with very strong pleochroism and no signs of chloritization.

Fresh, newly formed microcline coexists in the granitic gneisses with chlorite, arisen by partial or total chloritization of biotite. Locally, this equilibrium association is found also in the blastomylonites. It indicates a rather low temperature at the time of formation of the young microcline.

THE NATURE OF THE BOUNDARY BETWEEN THE BASEMENT AND THE PLATFORM SEDIMENTS

The boundary between the underlying crystalline complex of the Canadian Shield and the overlying unfolded and unmetamorphosed sedimentary cover is well marked in the field by the contrast between the light-coloured sediments and the dark basement. The contact was followed continuously for miles. Many places were observed where it is not covered by talus and the outcrops are bare; without exception, however, the lowermost member of the sedimentary sequence had been peeled off from the hard, flat surface of the crystalline basement by frost action, and slabs of the basal sandstone lie on the surface of the basement. A few metres higher the sedimentary beds may be found lying in situ.

The boundary is a classical nonconformity: horizontal sedimentary strata are in contact with a crystalline metamorphic basement. Most of the contact is original and transgressional. Its flat surface [Pl. II(b)], dipping gently to the west, shows that peneplanation of the crystalline complex occurred before the deposition of the sediments. The photograph shows the eastern outskirts of the sediments of the Arctic Platform which, approximately 50 kilometres to the west, reach sea level.

Along the big Truelove River cliff, however, the sedimentary rocks are faulted against the basement rocks [Pl. II(a)]. The northern block subsided along an east-west-trending normal fault, and the stratigraphic displacement is more than 300 metres. The entire north-facing cliff comprises crystalline rocks. Erosional remnants of the sedimentary cover of the subsided, northern block are visible in plate I (A, B, and other outliers to the east). The valley of Truelove River separates them from the main body of sediments. Plate II(a) shows the same features from the ground. The main fault lies north of the scarp which, however, does coincide with secondary fault planes. The steepness of the upper parts of the scarp, 70°-80°N, reflects the dip of the main fault plane.

The subsided northern block is tilted towards the south. The surface separating sediments and basement rises northwards [Pl. I, near the arrow marked Pl. II(c)]. In the area of Cape Skogn, 25 kilometres farther north, a high coastal cliff again is formed by basement rocks.

The author's work was specifically restricted to the study of the basement rocks, and the limited time did not allow a close study and measurement of the sedimentary cover. The following, therefore, is only a rough overview of the petrographic character of the rock types overlying the basement.

The lowermost member of the sedimentary sequence is a 2- to 3-metre thick, slightly dolomitic sandstone, sample No. 14. It is usually bimodal. The average grain size of the matrix is approximately 0.2 millimetre; the matrix contains phenoclasts from 1 to 4 millimetres in diameter. Frequent grains of bluish quartz point to granulite as one of the main sources. The phenoclasts are subrounded and consist of quartz, "quartzite" and feldspar (potassium feldspar predominating over plagioclase). The "quartzite" grains are, in reality, recrystallized quartz from the stringers and lenses in the blastomylonitic and cataclastic gneisses. They have the typical serrate texture of a sedimentary metaquartzite but are identical, down to minute details, with the recrystallized quartz crush from the sheared gneisses. Their presence in the basal sandstone is proof of the Precambrian age of the period of deformation and recrystallization of the basement rocks.

The matrix contains quartz as subrounded grains and feldspar as subangular grains. The feldspar here is both potassium feldspar and plagioclase, with K-feldspar dominating. The feldspar grains generally are only moderately altered; some K-feldspar grains are completely fresh. Clastic dolomite grains, showing some recrystallization and growth, form a smaller part of the matrix. Modal analysis gives 79.6 per cent quartz, 6.4 per cent "quartzite", 5.4 per cent feldspar, 7.6 per cent carbonate, 1 per cent leucoxene, and traces of magnetite and sericite.

The 180 to 200 metres of overlying sedimentary rocks are mainly dolomite. The sequence contains 3 horizons of massive dolomite forming conspicuous cliffs for long distances, separated by bedded silty and argillaceous dolomite and some dolomitic shale. The bedded sediments are almost always hidden under a thick cover of talus from which protrude the cliffs of massive dolomite. Above the uppermost horizon of the massive dolomite, on the edge of the plateau, lies a thin (approximately 2 m) bed of fine-grained quartzitic sandstone (orthoquartzite).

No outcrop was found on the plateau above the escarpment; all is covered by masses of debris from the underlying rock, disintegrated by frost action.

The bedded dolomite is a fine-grained, lutaceous rock. It shows numerous slump textures, and contains intercalations of intraformational conglomerates. The rock may be packed with ovoidal to, in places, elongated and curved phenoclasts suggestive of fossils. The only real organogenic fossil structures found in the whole sedimentary sequence were stromatolites [Pl. II(d)], which are rather common.

The sample of silty quartzo-feldspathic dolomite (No. 9) exhibiting slump textures has three layers: 1) a very fine grained iron-red coloured layer, with average grain size of less than 0.01 millimetre composed of approximately 90 per cent dolomite with somewhat larger subangular grains of quartz and feldspar; 2) a complex, brecciated zone where slab-like fragments of layer (1) float in a larger-grained (0.1 mm) matrix composed of 50 per cent dolomite and 50 per cent clastic quartz and feldspar [Pl. VI(d)]; 3) a more

	granulites	retrograded granulites	biotite gneisses	granitic gneisses	garnet migmatites	blastomylonites	granitic gneisses and blastomylonites
(number of thin sections) [7]	(8)	(22)	(8)	(6)	(6)	(4)	
plagioclase	61.28	45.08	39.27	36.30	26.20	38.80	37.30
anorthite content in plagioclase	39	34	32	22	29	26	24
amount of antiperthite in plagioclase (in %)	18	8	3	—	12	5	2
potassium feldspar	1.84	12.18	22.57	37.57	21.23	26.30	33.06
amount of perthite in K-feldspar (in %)	13	14	11	14	30	5	10
quartz	23.60	27.16	20.20	19.17	31.73	31.10	23.94
hypersthene	8.60	0.20	—	—	—	—	—
pseudomorphs after hypersthene	0.72 [4]	3.58 [5]	—	—	—	—	—
hornblende [1]	—	—	2.17	—	—	—	—
biotite [1]	2.26	8.45	9.62	1.53	7.35	0.15	0.98
chlorite [1]	—	0.33	0.97	3.43	tr	0.40	2.22
muscovite [2]	—	tr	—	tr	tr	0.35 [6]	0.14
garnet	—	—	—	—	6.55	2.50	1.00
cordierite	—	—	—	—	3.15	—	—
spinel	—	0.07	—	—	2.47	—	—
apatite	0.10	0.69	1.03	0.47	tr	tr	0.28
carbonate [1]	tr	tr	0.20	0.10	tr	0.30	0.18
zircon	tr	tr	tr	tr	tr	tr	tr
Fe-Ti oxide	1.60	2.20	3.97	0.73	1.32	—	—
secondary Ti-minerals [3]	—	0.06	—	0.70	—	0.10	0.44
traces of	pyrite	hematite	pyrite	hematite	talc diaspore	pyrite clinozoisite	hematite pyrite clinozoisite

GSC

1. excluding hornblende, biotite and carbonate in pseudomorphs after hypersthene, and chlorite in pseudomorphs after hypersthene and cordierite
2. excluding sericite in altered feldspars and cordierite
3. mainly sagenite and leucoxene
4. altered portions of hypersthene
5. chlorite 1.54%, carbonate (magnesite) 1.10%, green biotite 0.56%, antigorite 0.18%, hornblende 0.10%, talc (?) 0.10%
6. including fully bleached biotite
7. average number of counts per thin section:1200

Table 1. Averages of modal analyses of the main crystalline rock groups of the Truelove River area, northeastern Devon Island (volume %)

even-grained layer consisting of 70 per cent dolomite and 25 per cent quartz and feldspar; the remaining 5 per cent comprises vividly green glauconite, pleochroic biotite, and some muscovite.

About half of the felsic clastic minerals are feldspars, both microcline and plagioclase, markedly clear and unaltered. Their mainly angular character and freshness, as well as the preservation of biotite, indicate rapid disintegration of the parent rock and short transport, at least partly in the form of slumps.

The rock of the upper arenite bed is a dolomitic quartzitic sandstone (orthoquartzite) with abundant crossbedding. It is composed of 80.5 per cent quartz, 19 per cent dolomite, and 0.5 per cent feldspar, mostly potassium feldspar. Texturally the rock is a very good example of orthoquartzite. Well-rounded and well-sorted grains of clastic quartz are cemented together by accretion rims [Pl. VI(c)] growing in full optical continuity with the clastic grain. The accretion rims are marked by lines of minute (0.001 mm) unidentifiable grains. They are also of clastic origin, with subsequent partial recrystallization.

The sediments of the investigated area are assigned Cambrian and Ordovician ages on the new Geological Map of Canada (Douglas, 1970). Christie (1967, p. 14-25) and Kerr (1967, p. 8) consider analogous sediments in east-central Ellesmere Island to be Early Cambrian. The stratigraphic sequence there appears to be similar to that in the Truelove River area. The basal clastic, unfossiliferous beds (Rensselaer Bay Formation) are overlain abruptly by fine-grained dolomite (Cape Leiper dolomite) which, in turn, is overlain by massive, crystalline, vuggy dolomite of the Cape Ingersoll Formation. In the Truelove River area, however, the alteration of bedded and massive dolomite is a repeated phenomenon, and starts immediately above the basal sandstone. Glenister (*in* Fortier *et al.*, 1963, p. 185) considers equivalent rocks in the Sverdrup Inlet area, approximately 50 kilometres to the west, to be "Lower Ordovician and (?) earlier". On the south coast of Devon Island, near Dundas Harbour, Prest (1952, p. 14) also found a thin basal sandstone, which he classifies as Paleozoic, overlain by "limestone, sandy limestone and limy sandstone".

CONCLUSION

The Truelove River area on the northeastern coast of Devon Island is underlain by granulite facies rocks, and rocks derived from them by retrogressive metamorphism. The nearest granulite facies rock occurrences have been reported also from eastern Ellesmere Island (Washington, 1916, p. 334-5), northern Baffin Island (Jackson, 1969, p. 173), Somerset Island (Blackadar, 1967, p. 12-21), and from Boothia Peninsula (Blackadar, *ibid.*; Brown *et al.*, 1969, p. 525).

Granulites are known just across Baffin Bay, in Inglefield Land in northwestern Greenland, as described by Callisen (1929, p. 225-247). The Tectonic/Geological Map of Greenland (1970) shows much of the area of Inglefield Land to be underlain by enderbitic gneisses (= granulites).

The crystalline complex in the Truelove River area consists almost entirely of metamorphic rocks; the only unmetamorphosed crystalline rocks are younger diabases which cut the metamorphic rocks but do not penetrate their sedimentary cover. Granulites and gneisses directly derived from them form more than half of the area. Both rocks, the high-grade true granulites and their retrograded amphibolite facies equivalents, occur intermixed throughout the complex.

No evidence has been found for the existence of younger supracrustal rocks that have undergone progressive metamorphism under amphibolite facies conditions. Nor has there been found evidence of a preceding progressive metamorphism leading to the formation of granulite facies rocks from adjacent lower-grade rocks. Brown *et al.* (1969, p. 533-4) also could not find any older rocks from which the granulites of the Boothia Arch would have developed by progressive metamorphism. The possible remnant of a pre-granulitic stage [*see* Pl. IV(a)] does not link the Devon Island granulites with any existing adjacent rock. As to the possibility of the garnet migmatites representing a pre-granulitic stage of evolution, several very improbable processes would have to be assumed, of which the least probable would be a de-migmatization of the migmatites with the accompanying loss of the typical migmatitic textures.

The typical conditions of progressive metamorphism represented by sequences ranging from phyllites to gneisses, as found by Christie (1964, p. 16) and Frisch (1966, p. 5) in the much younger Hadrynian and lower Paleozoic complexes of northern Ellesmere Island, have not been encountered in the Shield rocks of northeastern Devon Island.

The observable metamorphic history of the Truelove River crystalline area begins with high-grade granulitic rocks, and develops as several stages of polymetamorphism under the relatively water-rich conditions of the amphibolite facies or, in some local cases, in the granitic gneisses even of the greenschist facies. Gneisses carrying pseudomorphs after hypersthene are linked by transitional types with biotite gneisses lacking identifiable alteration products of hypersthene, and these in turn are closely linked with granitic gneisses. Therefore it can be assumed that there exists a continuous retrogressive metamorphic series from granulites to granitic gneisses, and that the rocks of lower metamorphic grade than the granulites represent polymetamorphic products of original granulites.

Predominantly static, partial recrystallization led to the development of gneisses with abundant pseudomorphs after hypersthene. In addition, thorough mechanical reworking accelerated the process of recrystallization and granitization and resulted in the formation of microcline-rich granitic gneisses and blastomylonites. The spinel- and cordierite-bearing garnet migmatites, although without hypersthene, may represent an older period of migmatization, perhaps that occurring towards the end of the granulite facies metamorphism.

The granulites themselves suggest a sedimentary rather than igneous origin. They contain abundant, evidently primary (not introduced) quartz and a rather low proportion of dark minerals, which would not be expected were they derived from basic or intermediate igneous rocks. For an original acid igneous rock, the plagioclase is too calcic. The foliation of the granulites is not accompanied by the development of the typical platy quartz indicative of strong penetrative movement as is that of the blastomylonites. It probably is derived from original bedding rather than from mechanical reworking.

Dawes (1970, p. 28-9) found beautifully preserved sedimentary cross-bedding in the granulites of the Tassiussaq area of southern Greenland, and a common transition from these granulites to granitic gneisses. Supracrustal origin also is assumed by Berthelsen (1960, p. 6-7) for the Tovqussap Nunâ granulites.

The main features of the retrogressive metamorphism are: the alteration and disappearance of hypersthene; the decrease in the amount of plagioclase and in its anorthite content; the decrease in the amount of antiperthite;

the gradually rising degree of alteration of plagioclase; the growing separation and the increasing proportion of potassium feldspar accompanied in the later stages by the development of typical gridded microcline; the growing complexity of diablastic feldspar intergrowths in the middle stages of the process; the shift towards biotite and in the latest stages towards chlorite in the dark minerals; the tendency to ever more inequigranular and porphyroblastic texture; and the general tendency to more massive and granite-like rocks.

The whole process is essentially crystalloblastic, and there are only few and local cases suggesting mobilization and intrusive behaviour of granitic matter. Roots (*in* Fortier, *et al.*, 1963, p. 191-3) stated that, in spite of their igneous appearance, the granitic rocks, the rocks "7 miles west of Cape Skogn", are completely crystalloblastic and due to replacement, and are an excellent example of the development of a granitic rock by metamorphism.

It is generally accepted that dynamic reworking accelerates adaptation to new equilibrium conditions and promotes a general tendency to granitization. The increase in the amount of potassium feldspar and the decrease in the An-content of plagioclase are especially pronounced in intensely reworked rocks, and the most granitoid rocks are in reality blastomylonites and recrystallized cataclasites.

A similar connection between strong deformation and granitization (microclinization) was stated by Berthelsen (1960, p. 7) and by Windley (1969, p. 158) for the crystalline rocks of southwestern Greenland, and has been found widespread in the basement rocks of western Canada (Burwash and Krupička, 1969).

The increasing amount of potassium feldspar was provided in two ways. The first was by mobilization of the abundant antiperthitic exsolution material in the plagioclase of the granulites. This represented, in effect, a redistribution and individualization of the K-feldspar content already present in the rock, and may be considered as the more important source in the first stages of the retrogressive metamorphism. For the formation of the more advanced products of granitization, the granitic gneisses and the blastomylonites, an import of potassium must be postulated. It remains an open question whether this is merely a redistribution of the potassium content within the complex itself, or whether the source lies outside the complex. With the first explanation, of course, one would expect to find complementary K-impoverished rocks in the area. No such rocks have been found. The interpretation that the granulites themselves were a source (*see* Dawes, 1970, p. 2) meets with a fundamental objection: the granulites had lost their potassium long before the granitization of the complex started.

The textural relationships of the recrystallized cataclasites and mylonites show very clearly the younger nature of most of the potassium feldspar in them. Most notable are the K-porphyroblasts growing amidst granulated and altered plagioclase. This potassium feldspar appears mainly in the form of microcline, and is late deformational or post-deformational in age. Heier (1957) gives a temperature of about 500°C for the transition from monoclinic potassium feldspar to triclinic microcline, which would correspond to conditions of lower amphibolite facies.

Both types of granitization, the isochemical and the metasomatic, are assumed by Berthelsen (1960, p. 209) to have taken place in the Tovqussap granulites. Windley (1969, p. 158) also considers potash metasomatism to have been operative in the formation of the reworked microcline-rich belts in the granulite complex of southwestern Greenland. Dawes (1970, p. 116) states that widespread metasomatism occurred during the granitization in the area adjacent to the Tassiussaq charnockites, and (*ibid.*, p. 118) that the notable feature was the migration and diffusion of potash. Blackadar (1967, p. 39) assumed widespread potash metasomatism in all pre-Helikian rocks of the northern Boothia Peninsula and southern Somerset Island.

No isotopic ages have been obtained from the crystalline rocks of Devon Island. For the Arctic part of the Canadian Shield north of Baffin Island, only one date has been published (Christie, 1962): a K/Ar date for biotite in gneiss giving 1,760 m.y. A number of age determinations from northern Baffin Island also give Hudsonian ages, except for one whole-rock Rb/Sr date of 2,340 m.y. for a gneiss. Farther southeast, in central Baffin Island, another gneiss (granulite?) with a Rb/Sr date of 2,600 m.y. appears among the Hudsonian dates. Stockwell (1964) includes the whole Canadian Shield of the eastern Arctic in the Churchill Province where the last strong metamorphism occurred during the Hudsonian Orogeny, approximately 1,800 m.y. ago.

Most granulites in the Canadian Shield have been firmly established as Archean rocks. Some occurrences of granulite facies rocks in the Churchill Province, however, have been considered as prograded equivalents of adjacent lower-grade metamorphic rocks (Heywood, 1970, p. 144; Jackson, 1969, p. 173). This interpretation could imply the assumption of a Proterozoic age for the granulites. Blackadar (1967) includes the granulites of Boothia Peninsula and Somerset Island among Aphebian rocks.

On the contrary, most of the recent authors (with the exception of Berthelsen, 1960) discussing the granulites of Greenland consider them as Archean rocks which, in many cases, underwent later reworking accompanied by lowering of metamorphic grade. The 1970 Tectonic/Geological Map of Greenland interprets the enderbitic gneisses (= plagioclase granulites) occurring in the Ketilidian (Nagssugtoqidian) complexes, which correspond to the Hudsonian of the Canadian Shield, as reworked Archean rocks. Allaart *et al.* (1969, p. 859), discussing the Nagssugtoqidian mobile belt, which forms the whole ice-free coast of Greenland from 78°N to 66°30'N and lies opposite Devon Island, stated that it consists largely of older basement gneisses (originally of granulite and amphibolite facies) reactivated 1,700-1,800 m.y. ago. Apart from these, the Tectonic/Geological Map of Greenland contains enderbitic gneisses with ages greater than 3,100 m.y. Lambert and Simons (1969) obtained a K/Ar age of 3,200 m.y. for these rocks.

Dates of 3,600-4,000 m.y. have been obtained (Black *et al.*, 1971) for amphibolite facies rocks in the Godthaab area in Greenland; these are the greatest ages for any hitherto known rocks. These determinations should serve to remind us that highest-grade rocks (such as granulites) of a crystalline complex are not necessarily the oldest. Nevertheless, the author considers the granulites of northeastern Devon Island, from evidence obtained, to be Archean rocks that subsequently underwent intensive reworking, retrogressive metamorphism and granitization.

Without isotopic age dating it is futile to speculate whether the granulite facies metamorphism of the Devon Island rocks was Kenoran, or whether it may have been even older, corresponding to the 3,200 m.y. old granulites at Fiskenaesset. In either case there is little doubt that it was the Hudsonian metamorphism that left the last strong imprint on the original granulite complex.

REFERENCES

Allaart, J. H., Bridgewater, D., and Henriksen, N.
1969: Pre-Quaternary geology of southwest Greenland and its bearing on North Atlantic correlation problems; Am. Assoc. Petrol. Geologists, N. Atlantic - Geol. and Cont. Drift, Mem. 12.

Berthelsen, A.
1960: Geology of Tovqussap Nunâ; Medd. om Grønland, v. 123, no. 1, Copenhagen.

Black, L. P., Gale, N. H., Moorbath, S., Pankhurst, R. J., and McGregor, V. R.
1971: Isotopic dating of very early Precambrian amphibolite facies gneisses from the Godthaab District, West Greenland; Earth Planet. Sci. Lett., 12, p. 245-259.

Blackadar, R. G.
1964: Geological reconnaissance of the Precambrian of northwestern Baffin Island, Northwest Territories; Geol. Surv. Can., Paper 64-42.

1967: Precambrian geology of Boothia Peninsula, Somerset Island, and Prince of Wales Island, District of Franklin. Geol. Surv. Can., Bull. 151.

1970: Precambrian geology of northwestern Baffin Island, District of Franklin; Geol. Surv. Can., Bull. 191.

Blackadar, R. G., and Christie, R. L.
1963: Geological reconnaissance Boothia Peninsula, and Somerset, King William and Prince of Wales Islands, District of Keewatin; Geol. Surv. Can., Paper 63-19.

Brown, R. L., Dalziel, I. W. D., and Rust, B. R.
1969: The structure, metamorphism and development of the Boothia Arch, Arctic Canada; Can. J. Earth Sci., v. 6, p. 525-543.

Burwash, R. A., and Krupička, J.
1969: Cratonic reactivation in the Precambrian basement of western Canada. I. Deformation and chemistry; Can. J. Earth Sci., v. 6, p. 1381-1396.

1970: Cratonic reactivation in the Precambrian basement of western Canada. II. Metasomatism and isostasy; Can. J. Earth Sci., v. 7, p. 1275-1294.

Callisen, K.
1929: Untersuchung einiger Gesteine von Nordgrönland; Medd. om Grønland, v. 71, p. 217-255.

Christie, R. L.
1962: Geology, southeast Ellesmere Island, District of Franklin; Geol. Surv. Can., Map 12-1962.

1964: Geological reconnaissance of northeastern Ellesmere Island, District of Franklin; Geol. Surv. Can., Mem. 331.

1967: Bache Peninsula, Ellesmere Island, Arctic Archipelago; Geol. Surv. Can., Mem. 347.

Christie, R. L.
1969: Eastern Devon Island and southeast Ellesmere Island, District of Franklin; Geol. Surv. Can., Paper 69-1, Pt. A, p. 231-234.

1970: Eastern Devon Island and southern Ellesmere Island, District of Franklin; Geol. Surv. Can., Paper 70-1, Pt. A, p. 206-207.

Dawes, P. R.
1970: The plutonic history of the Tassiussaq area, South Greenland; Medd. om Grønland, v. 189, no. 3.

Deer, W. A., Howie, R. A., and Zussman, J.
1962: Rock-forming minerals. v. 3, Sheet silicates; Longmans. London.

Douglas, R. J. W.
1970: Geology and economic minerals of Canada; Geol. Surv. Can., Econ. Geol. Rept. no. 1.

Fortier, Y. O., Blackadar, R. G., Glenister, B. F., Greiner, H. R., McLaren, D. J., McMillan, N. J., Norris, A. W., Roots, E. F., Souther, J. G., Thorsteinsson, R., and Tozer, E. T.
1963: Geology of the north-central part of the Arctic Archipelago, Northwest Territories (Operation Franklin); Geol. Surv. Can., Mem. 320.

Frisch, T.
1966: Metamorphic rocks, northern Ellesmere Island; Geol. Surv. Can., Paper 66-1, p. 4-5.

Heier, K. S.
1957: Phase relations of potash feldspar in metamorphism; J. Geol., v. 65, no. 5, p. 468-479.

Heywood, W. W.
1970: Geological reconnaissance of Southampton Island, District of Keewatin; Geol. Surv. Can., Paper 70-1A, p. 144.

Jackson, G. D.
1969: Reconnaissance of north-central Baffin Island; Geol. Surv. Can., Paper 69-1, Pt. A, p. 171-176.

Kerr, J. W.
1967: Stratigraphy of central and eastern Ellesmere Island, Arctic Canada; Geol. Surv. Can., Paper 67-27, Pt. I.

Krupička, J., and Sassano, G. P.
1972: Multiple deformation of crystalline rocks in the Tazin Group, Eldorado Fay Mine, NW Saskatchewan; Can. J. Earth Sci., v. 9, no. 4, p. 422-433.

Lambert, R. St. J., and Simons, J. G.
1969: New K/Ar age determinations from western Greenland. I. Reconnaissance programme; *in* Report of Activities, 1968, Rapp. Grønlands Geol. Unders., no. 15, p. 82-86.

Lemon, R. R. H., and Blackadar, R. G.
1963: Admiralty Inlet area, Baffin Island, District of Franklin; Geol. Surv. Can., Mem. 228.

Prest, V. K.
1952: Notes on the geology of parts of Ellesmere and Devon Islands, Northwest Territories; Geol. Surv. Can., Paper 52-32.

Stockwell, C. H.
1961: Structural provinces, orogenies, and time-classification of rocks of the Canadian Precambrian Shield; Geol. Surv. Can., Paper 61-17.

1964: Fourth report on structural provinces, orogenies, and time-classification of rocks of the Canadian Precambrian Shield; Geol. Surv. Can., Paper 64-17, Pt. II.

Tectonic/Geological Map of Greenland
1970: The Geological Survey of Greenland, Copenhagen.

Tremblay, L. P.
1968: Geology of the Beaverlodge mining area, Saskatchewan; Geol. Surv. Can., Mem. 367.

Washington, H. S.
1916: The charnockite series of igneous rocks. Am. J. Sci., 4th Ser., v. 41, no. 244, p. 323-338.

Windley, B. F.
1969: Evolution of the early Precambrian basement complex of southern West Greenland; Geol. Assoc. Can., Spec. Paper no. 5, p. 155-161.

PLATES III TO VI

PLATE III

(a) Granulite (sample No. 17). Hypersthene with plagioclase (An_{40}) and slightly fragmented quartz. Two Fe-Tioxide grains (black) bound on hypersthene. Crossed nicols.

(b) Granulite (sample No. 28). Note the early state of alteration of hypersthene to green biotite along cracks in the hypersthene. Bead anti-perthite in plagioclase. Crossed nicols.

(c) Retrograded granulite (sample No. 24). The pseudomorph after hypersthene consists of green biotite (light-coloured network), chlorite (darker filling in the network), and some carbonate. The whole biotite network extinguishes simultaneously. Quartz slightly fragmented. Crossed nicols.

(d) Retrograded granulite (sample No. 33). Original hypersthene is completely replaced by carbonate (most of the light-coloured patches in the pseudomorph), prochlorite and green biotite. Crossed nicols.

PLATE III

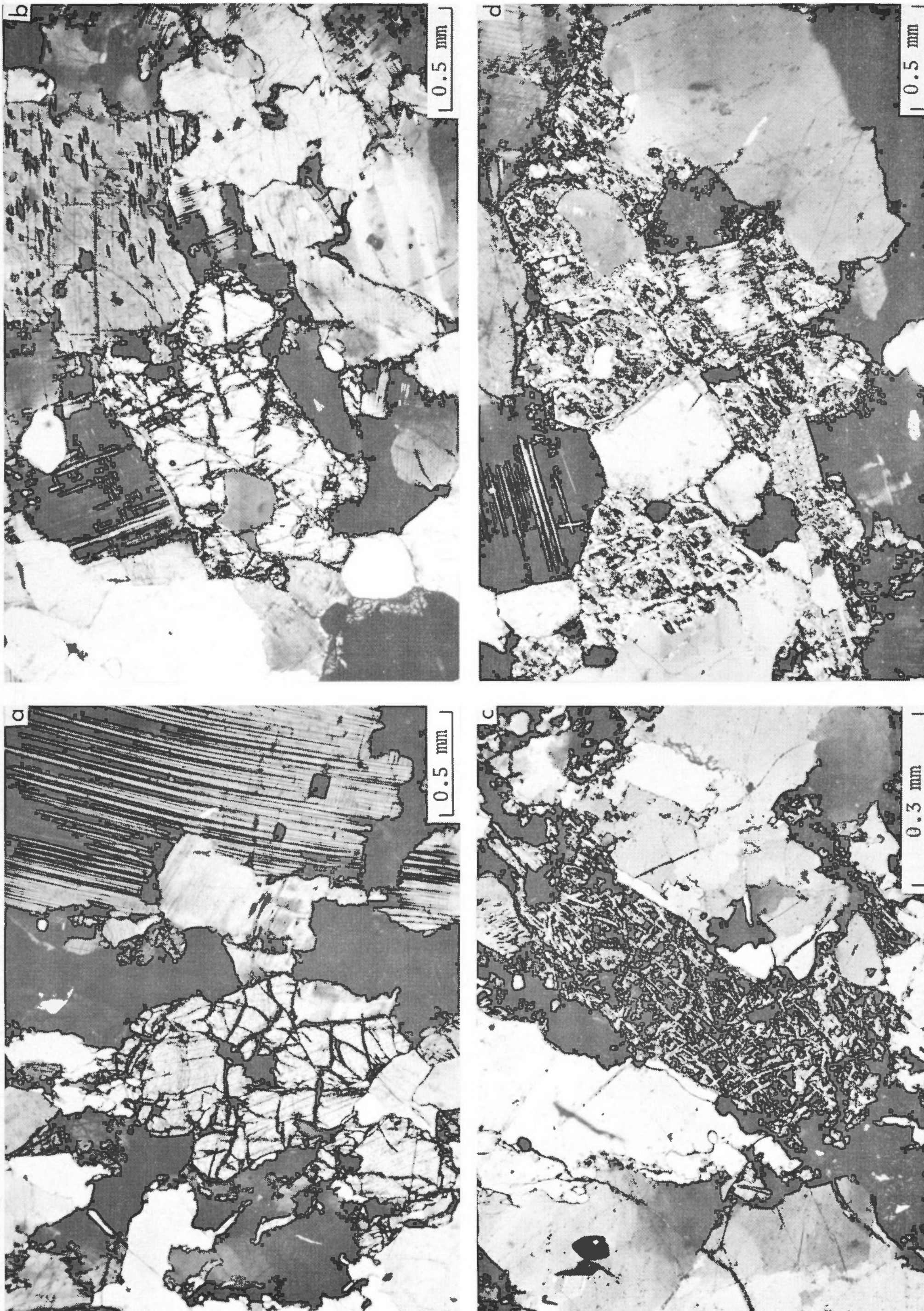

PLATE IV

(a) Granulite (sample No. 13). A large plagioclase grain, with bead and string antiperthite, encloses a hair perthite grain. The exsolved perthitic strings of the latter do not reach to the edge of the grain. Two older biotite grains are enclosed in the hair perthite. Plane light.

(b) Blastomylonitic garnet gneiss (sample No. 4). Predeformational, parallel antiperthitic strings in plagioclase are strongly bent and twinning lamellae are not visible. The matrix around the grain is complsed of fully recrystallized crushed plagioclase. Crossed nicols.

(c) Retrograded granulite (sample No. 35). Myrmekitic intergrowth of moderately altered plagioclase and quartz forms an embayment in strongly perthitic, fresh potassium feldspar. Crossed nicols.

(d) Porphyroblastic granitic gneiss (sample No. 36). Fresh non-perthitic microcline megacryst encloses and bounds on strongly altered plagioclase grains. Crossed nicols.

PLATE IV

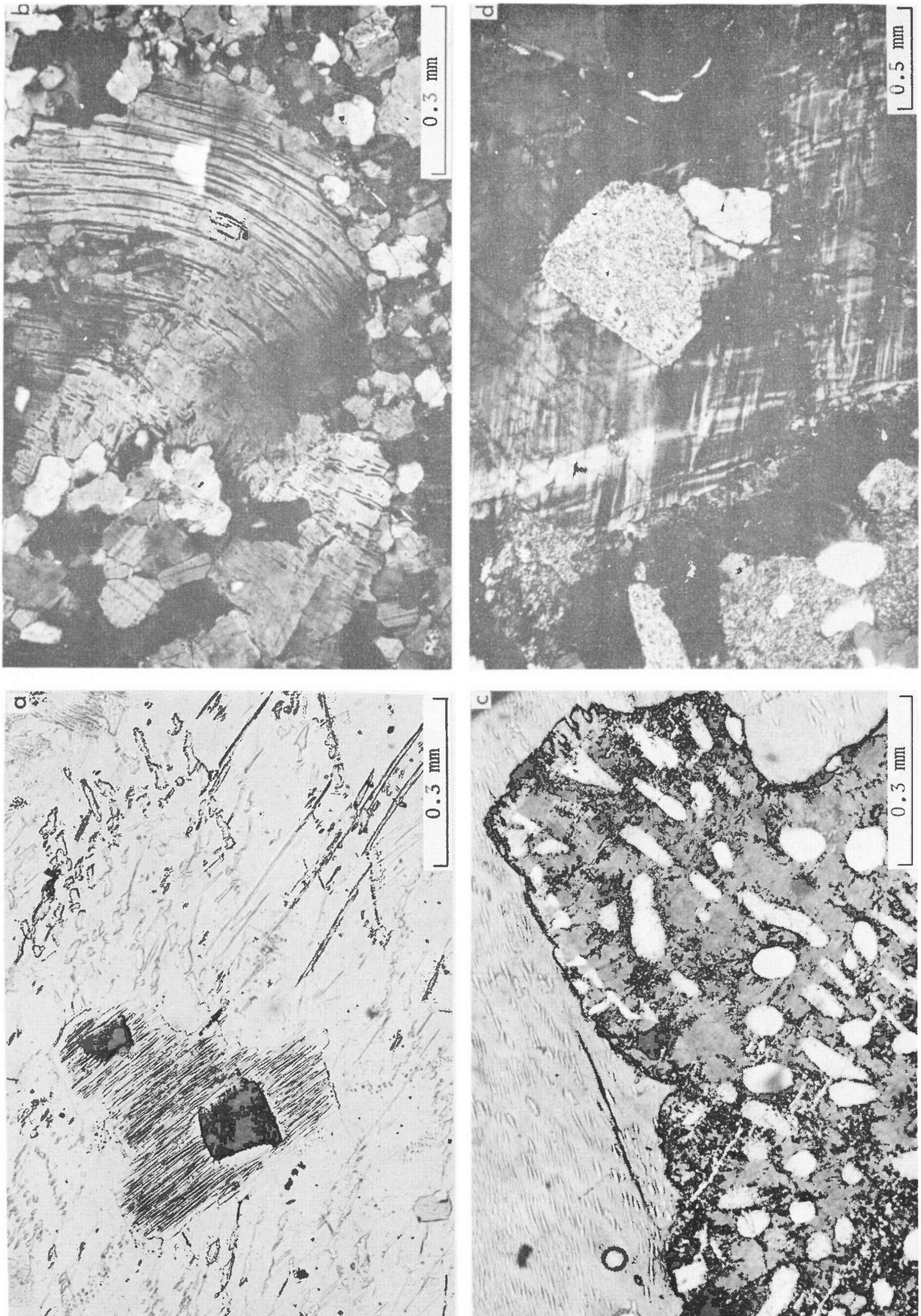

PLATE V

(a) Granitic gneiss (sample No. 37). Finger-like and braided relacement of plagioclase by microcline results in complicated intergrowths of both feldspars. An older exsolution hair perthite grain is seen on the left side. Crossed nicols.

(b) Blastomylonitic gneiss, massive and granite-like in hand specimen (sample No. 40). A larger grain of fresh, post-deformational microcline encloses and bounds on a belt of non-recrystallized crushed plagioclase. A stringer of recrystallized granulated quartz separates the larger microcline from a small microcline grain at the bottom, which is surrounded by finely granulated plagioclase. Crossed nicols.

(c) Blastomylonitic garnet gneiss (sample No. 4). Full kinematic separation of minerals. Original granulated quartz recrystallized to medium-size grains and forms stringers. These bound sharply on finely recrystallized, quartz-free plagioclase matrix. Garnet porphyroclast on the left. Crossed nicols.

(d) Phanerozoic mylonite (sample No. 2). Kinematically derived foliation, little recrystallization. Dark bands are composed of ultrafine-grained (0.002 mm) feldspar, biotite and chlorite; the light-coloured bands contain predominantly quartz (0.01 mm). Crossed nicols.

PLATE V

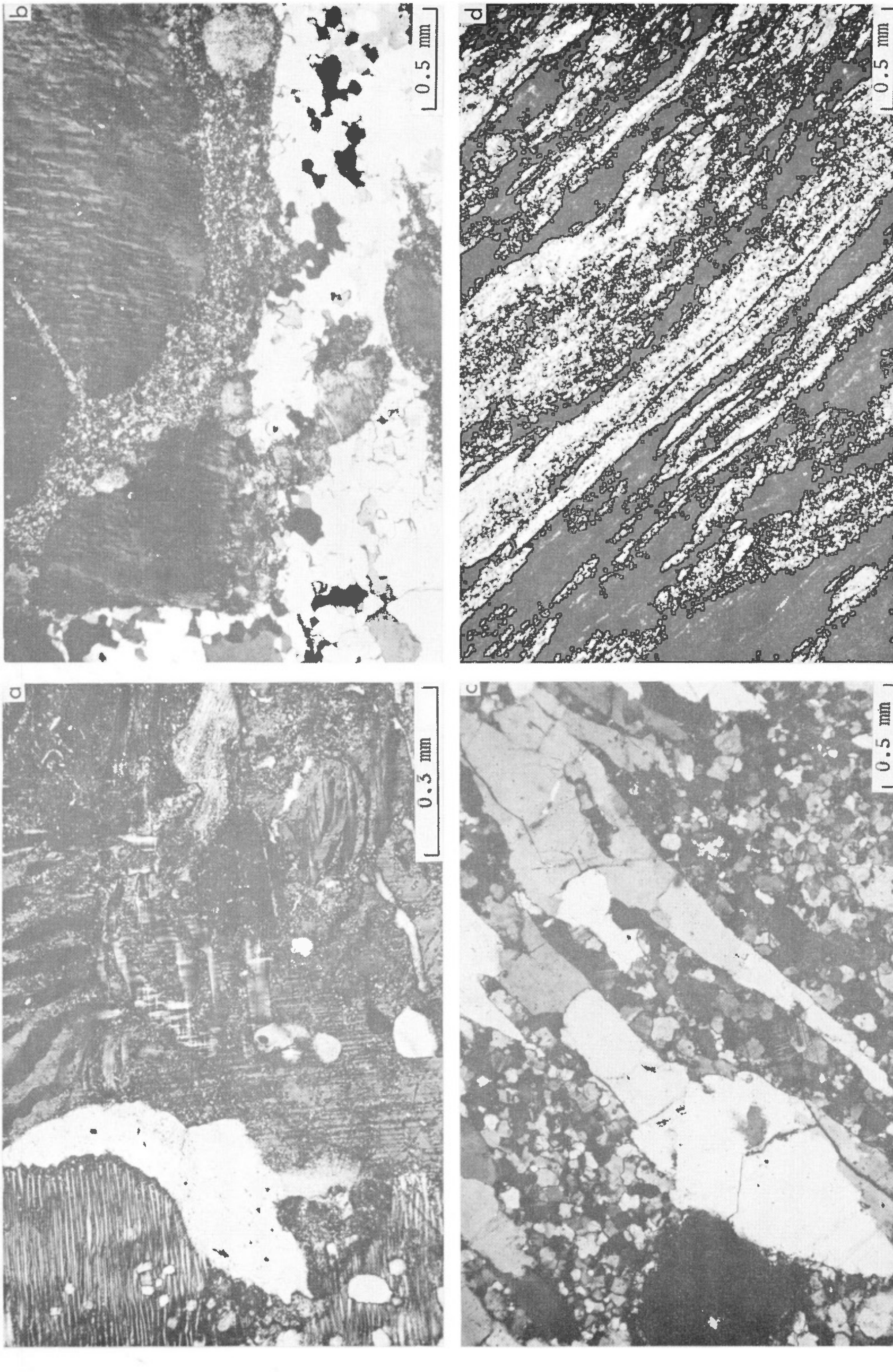

PLATE VI

(a) Garnet migmatite (sample No. 5). An intergrowth of spinel and Fe-Tioxide (large black N-S elongated grain in the center) is completely enclosed in cordierite (light-coloured, partly extinguished mineral occupying the main central part of the picture, locally showing twinned sets at approximately 50°). Biotite in lower right part (grey), another spinel-magnetite grain in upper right part (black). Crossed nicols.

(b, Garnet migmatite (sample No. 5). Spinel (black) is rimmed by cordierite. The white spots in spinel are secondary talc. The reaction rim develops here at the contact with feldspar, not with quartz (the white grain in the upper right part also is feldspar). Symplektitic intergrowth of cordierite and quartz is seen in the lower left part. Crossed nicols.

(c) Quartzitic sandstone (sample No. 7). Rounded clastic grains of quartz are cemented by quartz accretions that grew in full optical continuity with the clastic grain. The angular grey grains are dolomite. Plane light.

(d) Quartzo-feldspathic dolomite, slump texture (sample No. 29). A fragment of very fine grained dolomite is enclosed in a subangular clastic matrix composed of approximately 50 per cent dolomite and 50 per cent quartz + feldspar. Crossed nicols.

PLATE VI