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The chronology and petrography of the Gardar dykes between Igaliko Fjord and Redekammen, South Greenland

by

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THE CHRONOLOGY AND PETROGRAPHY OF THE GARDAR DYKES BETWEEN IGALIKO FJORD AND REDEKAMMEN, SOUTH GREENLAND

by

Jan H. Allaart

With 5 figures, 1 table
and 1 map

1969

Abstract

The intrusion of the Precambrian dykes of the area between Igaliko Fjord and Redekammen probably spans the greater part of the Gardar period. These dykes consist of various generations of lamprophyres, olivine dolerites, feldspar xenocryst dykes, and just saturated and undersaturated microsyenites. Often the alkaline dykes are composite. A tentative chronological interpretation, mainly based on intersections, is presented.

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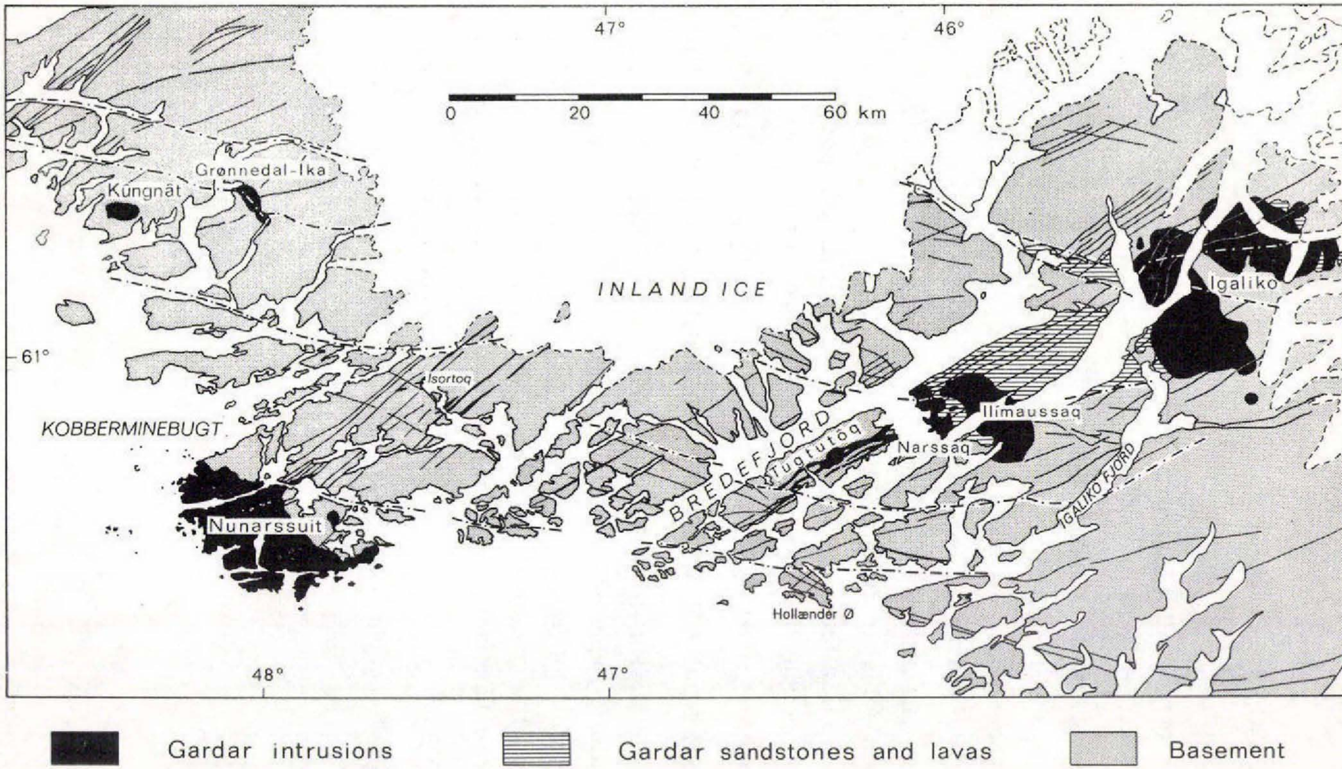


Fig. 1. Sketch map of part of South Greenland showing major intrusions and dyke swarms in the Gardar igneous province (slightly modified after Watt, 1966, fig. 1).

INTRODUCTION

This report describes the Precambrian Gardar dykes of an area east of the Ilímaussaq intrusion mapped during the summers 1958 and 1959.

The map area includes a section of the south-eastern part of a 25-30 km wide Gardar dyke swarm which extends in an ENE direction from Tugtutôq in the west to the Inland Ice in the east (see fig. 1). To the east the early members of the Igaliko intrusion are crosscut by many of the dykes, some of which are intercepted by late members of the intrusion. Westwards the swarm is partly intercepted by the Ilímaussaq intrusion and partly continues south of it, decreasing in frequency towards the open sea.

The dyke swarm is a regional swarm and appears to have no direct connection with any of the Gardar intrusions in the vicinity. It comprises lamprophyric rock types, dolerites, andesitic rock types and both under- and oversaturated alkaline rocks. In the area investigated no oversaturated rocks have been encountered, except for one isolated 0.5 m wide dyke. However, on Tugtutôq (Upton, 1962) and on Narssaq peninsula (Stewart, 1964), towards the north-east, quartz microsyenites and alkali microgranites are frequent.

There is no systematic change in composition with age of the successive dyke generations. It is evident that in general the magmas of the different rock types have been available at least twice.

The dykes of the area investigated have been emplaced into granite. They do not have xenoliths of Gardar sandstone, but numerous dykes are known to cut the sandstones that occur to the north-east.

The dykes of the area are more or less schematically indicated on the map (Map 1). This does not give a completely true picture of the frequency throughout the area as occasionally bad exposures did not permit the tracing of the dykes. In spite of the badly exposed areas the field observations permit the conclusions that the frequency throughout the northern part of the area is relatively high, with a crustal opening of 4.5 %, that the well exposed high ground east of Redekammen really has few dykes, and that south of Tasiussaq the dykes decrease in number (see fig. 2).

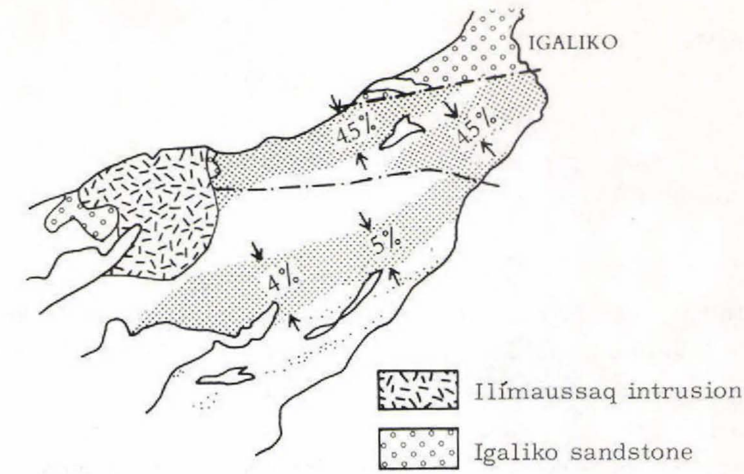


Fig. 2. Dyke frequencies in the map area based on field observations in both well and badly exposed ground.

In fig. 2 it is also clear that sinistral E-W faulting in the central part of the area has had a considerable influence on the distribution of the dykes, and that the displacement has been several kilometres. Observations on a couple of individual dykes suggest that there have been at least two phases of movement along the main fault in the area.

In the north-easternmost part of the area slightly undersaturated microsyenites constitute an important part of the dyke volume, while in the south-eastern part strongly undersaturated microsyenites are very common. If the dykes of the south-eastern part are the continuation of the dykes of the north-eastern part of the area, then it can be concluded that the degree of undersaturation in the microsyenites decreases from WSW to ENE.

The dykes probably span the greater part of the Gardar period (see chronological table p. 22). The oldest dykes are represented by some thin NNW-trending lamprophyres and several thick dolerites with an average E-W trend. These dolerites form the continuation of several WNW-ESE-trending dolerites to the west of the Ilímaussaq intrusion. To the east of the area investigated the continuations of these dolerites trend ENE. This is part of a general anti-clockwise change in the trend of early

Gardar dolerites as they are traced from Isortoq in the west to east of Igaliko Fjord. There are two generations of early Gardar dolerites and these are followed by a few representatives of just-saturated and nepheline-bearing microsyenites, both of which can be components of multiple and composite dykes. The nepheline-bearing microsyenites may be correlatable (see table 1) with the early Gardar composite Hviddal giant dyke (with margins of syenogabbro and a central component of undersaturated syenite) of Tugtutôq (Upton, 1962). Moreover Walton (1965) has described potassic microsyenites, trending NW-SE, north of Narssarssuaq, to the north-west of the Igaliko intrussion, as early members of the Gardar suite in that area.

There is only one probably early representative of nepheline-rich microsyenite. No age relations could be established for other distinctive representatives of this group, but to the east of the area investigated Emeleus (in press) found identical dykes which could be shown to occur early in the chronology.

The giant-feldspar dykes, which elsewhere are considered to be mid-Gardar (Bridgwater and Harry, 1968), predate an early phase of E-W faulting in the area. This is probably followed by a second generation of just-saturated microsyenites, trending NE, and by tinguaite dykes which probably predate a second phase of E-W faulting. Still later are, successively, undersaturated microsyenites (hedrumites and nepheline-rich microsyenites) and monzonitic feldspar xenocryst dykes. The youngest dyke in the area is a nepheline-rich microsyenite which is petrographically very similar to the kakortokites of the Ilímaussaq intrusion.

LAMPROPHYRES

There are few lamprophyric dykes in the area. They are always thin and difficult to follow. Basic hornblende-albite dykes, forming a conspicuous swarm which has been mapped in the north-eastern part of the area, are greenish black in colour, trend NNW and are relatively old (perhaps older than the early dolerites, see discussion p. 21). No chronological relations could be established for other lamprophyric dykes.

Hornblende-albite lamprophyres

These trend NNW and are thin, not thicker than 2 m. One swarm of 4 to 5 dykes is schematically indicated on the coloured map. The rock is very basic, hornblende strongly predominating over feldspar. Albite is irregularly twinned and usually slightly clouded. It often contains considerable quantities of epidote and clinozoisite. The earliest generation of hornblende is brown in colour and contains relics of clinopyroxene. The brown hornblende has rims of bluish-green hornblende which in turn has been altered into a very light green actinolitic hornblende. Locally parts of the rock have been altered into asbestiform hornblende which postdates all the other varieties. A green mica is possibly later than the bluish-green hornblende rims and earlier than the actinolitic hornblende. Accessories are titanite, apatite and ore.

Pyroxene-olivine porphyries

These are black in colour and trend ENE. The dykes are rich in phenocrysts of strongly oscillatory zoned titanaugite, plagioclase (An_{70}), olivine which has been altered, ore and a fine-grained mica-like aggregate. The groundmass consists of small tabular crystals of plagioclase, titanaugite, red-brown hornblende and calcite. Although dykes of this type occur close to the fault between the granite and the Igaliko sandstones they are remarkably fresh. This may indicate that they are rather young. However, as no intersections with other types of dykes have been encountered their chronological position is unknown.

DOLERITES AND ANDESITIC DYKES

Early Gardar olivine dolerites

There are several important doleritic dykes. Although the individual dykes often show a tendency to follow various older joint directions, they generally trend E-W (see map). Observations outside the area investigated show that at least the dykes in the broad E-W valley between Agpat and Sigssardlugtoq are part of a swarm of thick dykes which can be traced over 50 km towards the west and the same distance towards the east. The dykes usually form furrows or small valleys in the surrounding granite and weather brown in colour. However, where the influence of glacial erosion has been strong the dykes stand out as ridges. Various joint directions are present in the dykes; the most common are joints parallel to the contacts and these can be closely spaced (fig. 3); other directions are perpendicular or oblique to the contacts.

The width of the dykes varies between a few tens of metres and 130 m. They are usually strongly affected by faulting; some have been displaced over distances of at least a few kilometres by E-W faults and in most places the dykes are mylonitised and deformed along their margins and internally (see fig. 3). They are cross-cut by all other dykes types in the area, except perhaps the hornblende-albite lamprophyres. These relations suggest that they were intruded during the early stages of Gardar dyke development. In two other areas in South Greenland two generations of early Gardar dolerites can be distinguished; one is the Julianehåb peninsula (Nesbitt, 1961), the other Qaersuarssuk (Watt, 1968).

The dykes consist of plagioclase (An_{40-60}) in ophitic relationship with pinkish clinopyroxene. Olivine is almost without exception replaced by serpentine, iddingsite or bowlingite and finely divided ore. Accessories are ore and apatite. Brown or reddish brown biotite occurs occasionally as irregular, late crystals. Interstitial quartz was seen in one thin section.

Fig. 3. Early dolerite with regular jointing parallel to contacts. Through the middle of the picture there is a deformation zone with quartz mineralisation in the foreground. In the background the joints have been bent into an S-shape as a result of the deformation.

Younger doleritic dykes

A few unimportant ENE-trending basic dykes have been mapped. Immediately south of Redekammen one of these crosscuts an early composite alkaline dyke which could be shown to postdate an early dolerite. No other intersections have been found. These ENE dolerites may be of similar age as the mid-Gardar dolerites elsewhere.

A few doleritic dykes occur within the late monzonitic feldspar-xenocryst dykes (see below) and send apophyses into them without trace of chilling.

Under the microscope the rock consists of a fine-grained aggregate of tabular crystals of basic plagioclase, with rims of alkali feldspar, in random association with rounded grains of olivine ($2V_{\alpha} = 81^{o}$) and anhedral to subhedral titanaugite. Ore is abundant. Accessories are reddish biotite and apatite. The rock is very fresh. Secondary minerals are sericite and serpentine.

Andesitic dykes

There are three occurrences of dykes which are trachydoleritic or andesitic in composition. Two of them trend E-W and the third ENE. The dykes are 8 to 10 m wide and brown in colour. They are slightly porphyritic with plagioclase xenocrysts a few centimetres in length. An ophitic texture is usually not developed. The plagioclase crystals are rather short and tabular with wide rims of alkali feldspar. Biotite and clinopyroxene are the mafic minerals and ore is an important accessory. These dykes are usually strongly altered and there are only intersections with a few very young alkaline dykes so that the chronological position of the dykes under discussion is virtually unknown.

FELDSPAR-XENOCRYST DYKES

There are three types of feldspar-xenocryst dykes; all are composite.

Giant-feldspar dykes (GFd)

The giant-feldspar dykes belong to a group of dykes which have a very wide distribution throughout South Greenland. They have been thoroughly described by Bridgwater and Harry (1968).

10 to 20 m wide representatives of this type occur in the northern part of the area. One of these dykes is displaced by the fault between the Igaliko sandstones and the Julianehåb granite. Another dyke belonging to

this type in the central part of the area investigated, is also displaced sinistrally several kilometres by an E-W fault and continues into the area mapped by S. Andersen (personal communication) on the eastern side of Igaliko Fjord.

The giant-feldspar dykes have trachytic margins and basic to intermediate cores. The central component of the dykes is usually finer grained along the boundary with the marginal component, but there are no glassy margins. In the central parts of the dykes there are often numerous xenocrysts of plagioclase, with a size up to 2 m, and aggregates of anorthosite. These giant crystals and aggregates usually form great concentrations in some parts of the dykes while in other parts large numbers of small xenocrysts occur. In some places it can be shown that these small xenocrysts originated by the shattering of larger xenocrysts.

Monzonitic feldspar-xenocryst dykes (monzonite porphyries : MP)

The second variety of feldspar-xenocryst dykes is monzonitic to syenitic in composition. The dykes of this variety are also composite. The marginal phase is usually slightly porphyritic or aphyric while the central component is always very porphyritic. As in the giant-feldspar dykes the central component does not show glassy margins; only slightly finer grained margins have been observed in contact with the marginal phase. These contacts can be rather irregular (see fig. 4). Large anorthositic aggregates or xenocrysts are extremely rare in these dykes. There are three different types of xenocrysts, none, as a rule, greater than 2 cm in size. a) Basic plagioclase, usually with well-developed polysynthetic albite twinning. In their central parts many of the crystals are sieved by small inclusions of ore and pyroxene. The xenocrysts always have a thin rim of alkali feldspar. These basic xenocrysts are not frequent. b) Intermediate plagioclase showing submicroscopic albite twinning. These are also surrounded by alkali feldspar rims. c) Alkali feldspar (?) with well-developed anorthoclase twinning and locally mantles of albite. Xenocrysts of types b) and c) usually occur in equal amounts, but often plagioclase is predominant. Phenocrysts of olivine and clinopyroxene (prismatic) have been observed occasionally. The groundmass generally consists of an aggregate of very short tabular crystals often with plagioclase cores and

Fig. 4. Irregular contact between very porphyritic central component and slightly porphyritic marginal phase of monzonitic feldspar-xenocryst dyke.

thick rims of alkali feldspar (often microperthitic). In a few cases the feldspar crystals are more elongate and show flow orientation. Clino-pyroxene, in sub- to anhedral crystals, and brown biotite are the most common mafic minerals, although a brown hornblende occurs occasionally. Accessories are apatite and ore. It seems that in general the amount of acid to intermediate plagioclase in the dykes of this type is not small and it is probable that the dykes are monzonitic in composition. Precise determinations are impossible because the feldspars are generally clouded.

The monzonitic (?) feldspar-xenocryst dykes constitute one of the youngest dyke generations of the area. One of the dykes crosscuts the great E-W fault in the central part of the area, 2 km NE of Sigssardlugtoq.

Very porphyritic nepheline-rich microsyenite

Not far south of Sigssardlugtoq a 30 m thick composite dyke occurs with a marginal component of slightly porphyritic nepheline-rich microsyenite and a central part, up to 15 m wide, of very porphyritic nepheline-rich microsyenite which also contains a great number of frequently zoned nepheline phenocrysts and inclusions of nepheline syenite. The feldspar xenocrysts all consist of alkali feldspar and they have a pronounced platy-tabular habit which is so typical of feldspar xenocrysts in other nepheline-rich microsyenites. Along the whole course of the dyke the xenocrysts decrease towards the contact of the central component and are absent at the contacts. The inner component of the dykes shows glassy margins against the outer component. The age relations of this dyke are not known. Farther to the ENE Emeleus and Harry (in press) have mapped similar dykes which predate the giant-feldspar dykes and one of the mid-Gardar centres of the Igaliko syenite complex.

JUST SATURATED MICROSYENITES ($MiSy_1$, $MiSy_2$)

There are at least two generations of microsyenite which contain neither quartz nor nepheline.

The only certain representative of the younger generation is a NE-trending dyke of slightly porphyritic microsyenite, 5 to 10 m wide, and continuous over more than 12 km. The phenocrysts are small and consist of a) polysynthetically twinned basic plagioclase with mantles of alkali feldspar; b) mantled plagioclase with submicroscopic albite twinning; c) alkali feldspar with or without anorthoclase twinning; these are also mantled with alkali feldspar which has the same refractive index as the cores of the phenocrysts; the plagioclase xenocrysts are clearly dominant; d) prismatic crystals of clinopyroxene and ore are the mafic phenocrysts. The groundmass is an aggregate of equidimensional, sub- to anhedral alkali feldspar, subhedral clinopyroxene, brown biotite and ore. Locally plagioclase occurs with thick mantles of alkali feldspar. Pseudomorphs after olivine do occur; these consist of serpentine or iddingsite surrounded by rims of ore. Most of the feldspar in the groundmass is clouded. Sericite is an alteration product of plagioclase.

Members of an older generation of microsyenite trend E-W to ENE. These are 10 to 20 m wide and have a brown or reddish weathering colour. Along their margins their mafic minerals are biotite and ore; in the central parts alkali feldspar is the dominant mineral making more than 80 % of the volume. In some dykes the feldspar crystals are tabular and show flow orientation although often they are randomly oriented. In other dykes the crystals are very short and tabular without orientation. Carlsbad twinning is extremely common. The mineral is practically always clouded by kaolinite, and is perthitic to microperthitic. Rare unclouded patches are always homogeneous. Along the grain boundaries thin rims of finely twinned albite usually occur. In a porphyritic dyke the phenocrysts consist of plagioclase. Clinopyroxene, hastingsitic hornblende and dark brown biotite constitute the mafic minerals. The hastingsitic hornblende is locally replaced by a greenish-blue amphibole. Ore and apatite are accessories. Usually the dykes are strongly altered. The mafics are chloritised and small quantities of carbonate are regularly distributed throughout the rock. These altered parts of the dykes are red in colour.

NEPHELINE-BEARING MICROSYENITES (HEDRUMITES: He_1, He_2)

Dykes of hedrumite are especially common in the northern part of the area investigated; in the southern part of the area the alkaline dykes are generally much richer in nepheline. Two generations of hedrumite have been recognised with certainty in the north-eastern part of the area; an older of thick often discontinuous dykes trending ENE, and a younger generation of thinner NE-trending dykes. The older generation occurs either as single dykes or as possible components of thick composite dykes in association with just-saturated microsyenites. The single dykes can be multiple. There are no petrographical differences between the two hedrumite generations.

The thinner dykes of less than 10 m width and the marginal parts of thicker dykes usually display good flow orientation of the tabular feldspar crystals. This is also clear in hand specimens in which freshly broken surfaces parallel to the dyke contacts show a silky lustre due to the parallel orientation of the minute feldspar tablets. The central parts of the thicker dykes generally show no preferred orientation.

The central parts of the thickest members of the older generation are medium-grained and often relatively fresh. They are distinguished from the feldspathoid-rich microsyenites (p. 17) by the smaller amount of nepheline and analcite. Alkali feldspar takes about 60 % of the volume and is generally partially clouded. It is usually perthitic, especially in the clouded parts of the crystals. The ratio of albite to the potassic component is generally higher than in the microsyenites just described. Nepheline (about 5 %) does not develop its own crystal faces and is bounded by the faces of the feldspar tablets. The same is true for analcite which forms at most 5 % of the rock volume. They are clearly late crystallisation products.

The mafics which take the remaining 30 % of the rock volume usually occur in small clusters. Subhedral crystals of clinopyroxene are either rimmed by aegirine or by dark brown hornblende. Independent crystals of the same brown hornblende are xenomorphic and rimmed by arfvedsonite. Aegirine also occurs as independent crystals in the analcite. Dark brown biotite forms irregular grains. Occasional grains of olivine are always rimmed by ore and partly altered into serpentine and iddingsite.

In the thinner dykes with pronounced flow orientation it is clear that olivine, clinopyroxene and alkali feldspar are early crystallisation products, these minerals always displaying their own crystal form. The other minerals, as for instance hornblende and biotite, are well oriented and bounded by the crystal faces of the feldspar tablets. However their crystallographic orientation is always at random and they have evidently crystallised later than the flow in the dykes. The latest minerals crystallising are analcite, a second generation of aegirine and albite.

FELDSPATHOID-RICH MICROSYENITES

Four generations of this group can be distinguished, each petrographically different.

Analcite-nepheline microsyenite (NMS)

A 20 m thick dyke of analcite-nepheline microsyenite occurs in the north of the area. It has a reddish colour and seems to be strongly altered. In thin section aegirine, alkali hornblende and ore, grown together or separately and with slightly irregular distribution, are bedded in an aggregate consisting mainly of analcite and nepheline (together 50 %) in which thin laths of microcline occur with random orientation. Some of these laths cross-cut occasional short tabular crystals of an older generation of alkali feldspar which is clouded, but homogeneous and without polysynthetic twinning. The nepheline is completely altered into brownish aggregate of very finely divided grains (oxides?) and this is responsible for the red colouring in the dyke.

Tinguaites (Ti)

In the north-eastern part of the area investigated there are a few conspicuous dykes of tinguaite which mainly consist of nepheline, aegirine and microcline, i.e. the mineral composition typical of green lujavrite. One of the dykes continues to the great E-W valley and has been displaced by the Agpat-Sigssardlugtoq fault. To the south-east of Sigssardlugtoq there is another occurrence.

In the field the dykes are conspicuous by their greyish-green colour due to the presence of aegirine as the main mafic mineral. Their width varies between 3 and 15 m. The rock is rather melanocratic and consists of randomly oriented, tabular microcline crystals bedded in an aggregate of tiny aegirine needles. Nepheline, in euhedral crystals, occurs regularly distributed in the aegirine aggregate and as inclusions in the microcline crystals which also enclose abundant aegirine needles. The microcline is thus clearly a late crystallisation product. In the central part of the thickest dyke the subhedral microcline crystals form a more coherent aggregate and the aegirine prisms and needles are more regularly distributed throughout the rock. The nepheline and its alteration products fill the spaces between the faces of the microcline crystals. Here the crystallisation sequence is thus different from that in the thinner dykes. There are many other minerals. Olivine is mantled with ore and altered into serpentine and iddingsite. Many aegirine prisms contain small relics of partially altered clinopyroxene. There are two varieties of biotite, an earlier variety of euhedral crystals with a pleochroism of brownish-black to brownish-red and often mantled with ores and a later variety of irregular crystals with sepia brown to light yellow pleochroism. Occasional hornblende shows a fibrous habit and radial arrangement of the fibres. Nepheline has been altered into cancrinite, natrolite, a fine-grained mica-like aggregate (gieseckite?), or analcite usually starting from the borders of the nepheline crystals. Apatite and aenigmatite are accessories.

The tinguaites are probably relatively young. One dyke has probably been displaced by an E-W fault for about 1 km. As these dykes are mainly confined to the north-eastern part of the area it is possible that they are connected with a magma chamber in the vicinity of the Igaliko batholith.

Nepheline-rich microsyenites (NMS)

Although there are some nepheline microsyenites close to the ENE fault in the north between the granite and the Igaliko sandstones they are mainly concentrated in the south-east in an ENE-trending strip between the Hvalsey church ruins and Sigssardlugtoq. The dykes of this strip can be followed much farther to the north-east (S. Andersen, personal

Fig. 5. Central part of a 15 m wide nepheline-rich microsyenite dyke with inclusions of dark fine-grained rock rich in alkali feldspar and nepheline phenocrysts.

communication), and also to the west-south-west towards the Julianehåb peninsula (Nesbitt, 1961) and still farther on Hollænderø (E. Breval, personal communication).

Two varieties can be distinguished. Rather thick dykes of 10 to 20 m or more are greenish-grey in colour with black to dark grey margins. In the central part of the dykes the rock is medium-grained and porphyritic, slightly porphyritic or even non-porphyritic with phenocrysts of nepheline and very thin tabular or platy alkali feldspar. Dark rounded inclusions of fine-grained rock (fig. 5), often with phenocrysts of alkali feldspar and nepheline, are in many places very common. They represent chilled material taken up by later intruded material. Other inclusions of deep-seated rocks, i.e. medium- to coarse-grained syenite and nepheline syenite, have also been found in many of the thicker dykes of the strip mentioned. There is usually no flow orientation in these dykes, the feldspar tablets having a random orientation. On weathered surfaces the interjacent nephelines are slightly weathered out producing a texture similar to ophitic texture.

The other variety is formed by relatively thin dykes (3-8 m) which are black or dark grey. In these dykes flow orientation is often conspicuous.

In contrast to the nepheline-bearing microsyenites (hedrumites) the nepheline-rich microsyenites contain about 20-30 % nepheline, sodalite and analcite; albite or sodic microcline is generally strongly predominant over untwinned potash-rich feldspar; in the thicker dykes biotite and alkali hornblende are more abundant than in the hedrumites.

In the thick dykes randomly oriented laths of alkali feldspar (albite and potash-rich feldspar intimately intergrown) enclose angular areas of nepheline, sodalite and analcite (total 30 % at least). The feldspar laths are occasionally seen to replace an older generation of short tabular alkali feldspar. The mafics consist of green aegirine with occasional centres of clinopyroxene, occasional olivine with thick rims of ore, arfvedsonite, red-brown biotite and aenigmatite. Aegirine and arfvedsonite predominate over the other mafics. Secondary colourless aegirine is an alteration product of biotite.

The thinner dykes usually show clear flow orientation. The feldspar is microperthitic with albite dominant. The dykes contain considerable quantities of nepheline and some analcite. They have the same mineralogical composition as the broader dykes, although they contain a little less nepheline.

There are not sufficient intersections with other dykes to determine their age relations with certainty. However, the dyke rocks are always extremely fresh and a few members of the swarm appear to cross-cut the great E-W fault north of Sigssardlugtoq. Therefore it is probable that the dykes are very young and they might be of the same age as the second generations of hedrumites (see however discussion p. 24).

Micro-kakortokite (MiKa)

An impressive nepheline porphyry dyke 20 to 30 m wide proceeds from the southern part of the Ilímaussaq batholith towards ENE and seems to stop not far from Sigssardlugtoq. The dyke is very similar to the kakortokites of the batholith and is interpreted as a hypabyssal extension of the kakortokite body. The dyke cross-cuts a monzonite porphyry and the dyke rock is very fresh. It is probably the youngest generation of the whole dyke suite.

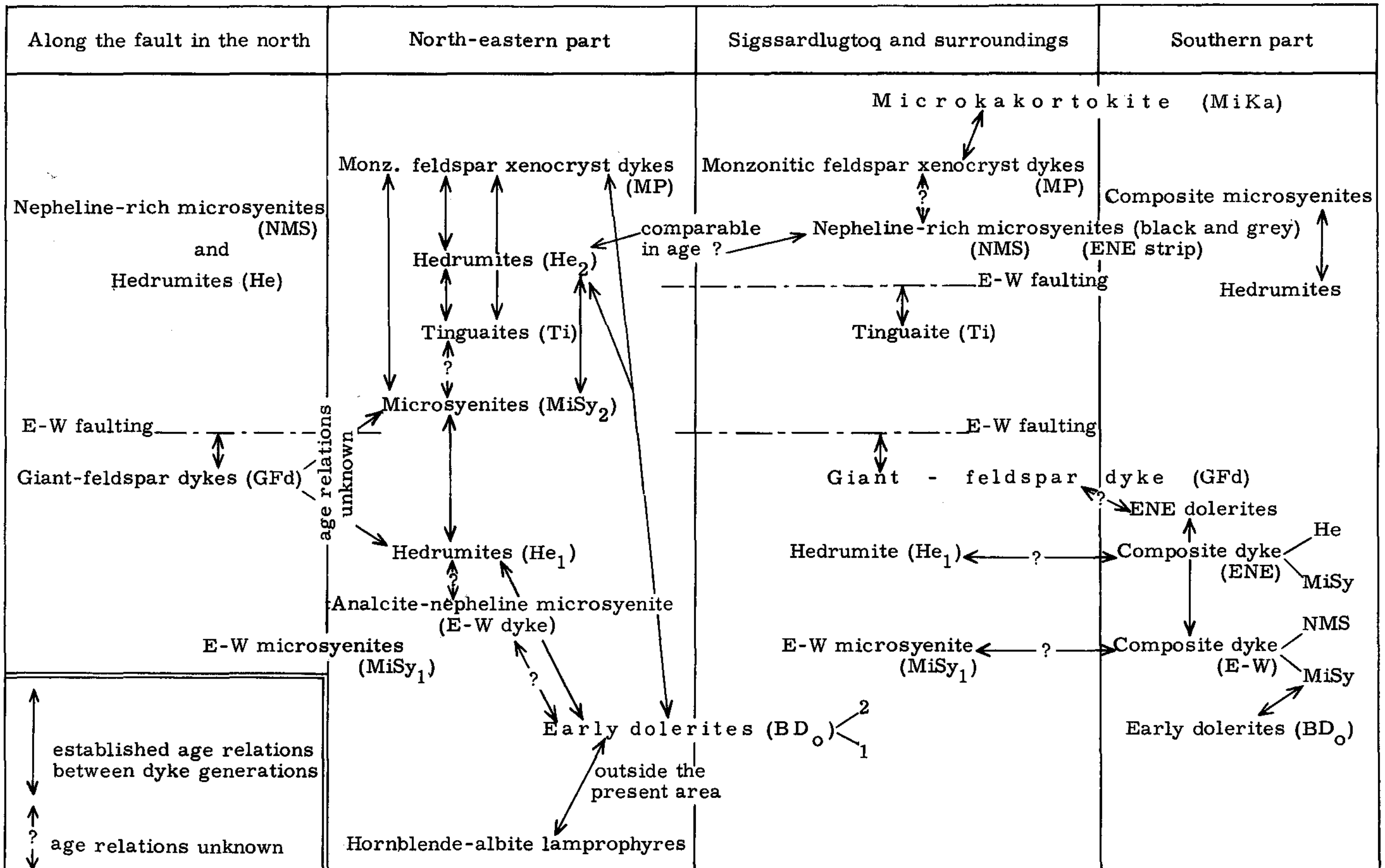
DISCUSSION

In table 1 a tentative chronological interpretation is given. In the north-eastern part of the map area the chronology is reasonably well established (second column in the chronological table). Elsewhere there are many loose ends. Therefore continuous observations along the course of long dykes on their degree of alteration, on the presence of internal mylonites and on hydrothermal formations along their contacts were useful for judging whether such dykes might be relatively old or young. Furthermore, all E-W-trending dykes with well established age relations appeared to be early in the chronology. Consequently isolated occurrences of E-W trending dykes which were mylonitised internally and with strong hydrothermal alteration were also interpreted as being relatively old.

The following points have to be discussed:

1) In the area investigated there are no intersections between the hornblende-albite lamprophyres and the early Gardar dolerites. However, in the field the lamprophyre dykes are displaced by numerous small faults and shear joints in various directions; they are internally mylonitised in many places and along their margins there is very frequently red colouring in the surrounding granite. In addition they are cut by the

TABLE 1 DYKE CHRONOLOGY



four last generations of the second column of the chronological table. Moreover to the north-east of the map area Steen Andersen (personal communication) found identical NNW-trending lamprophyre dykes which were cross-cut by the eastern continuation of some of the early dolerites of the map area. In this case it is evident that the field relations give a clear indication about the position of the dykes in the chronology, but these dykes occur in well-exposed terrain where systematic observations along their whole course were possible.

2) Alkaline dykes which predate the early dolerites do not occur in the map area. It is however probable that the early generations of the just-saturated microsyenites ($MiSy_1$) with E-W trend and the ENE-trending nepheline-bearing microsyenites (hedrumites, He_1) are relatively early. The E-W-trending microsyenites in particular are generally strongly altered and have a reddish colour and are also mylonitised in many places while quartz-veining is not uncommon. These microsyenites and the oldest generation of hedrumites could be shown to postdate the early dolerites. The hedrumites are in turn cross-cut by most other dyke generations (e.g. second column of the chronological table). Intersections of the E-W-trending microsyenites with other generations are not known except for two much younger dykes: tinguaite, monzonite porphyry. However, their consistent E-W trend and their strong degree of alteration suggest that they are early and even older than the giant-feldspar dykes.

The absence of typical chilled contacts between the hedrumite and microsyenite components of some composite dykes in the southern part of the area might suggest that the types of dykes under discussion are of similar age. It is tempting to correlate the old hedrumites with the Hviddal syenites of the Hviddal giant dyke of Tugtutôq (Upton, 1962; 1964).

3) The chronological position of the giant-feldspar dykes could not be established. It could only be shown that giant-feldspar dykes have been displaced by both big faults of the area. This is in accordance with the observations by Emeleus and Harry (in press) in the Igaliko intrusion. Close to Sigssardlugtoq the displacement of a giant-feldspar dyke (after interpolating the course of part of the dyke into the fjord) amounts to

about 3 km. Moreover the probable displacement of the thickest tinguaite dyke (42450) of the area along the same fault (also with a little interpolation) is a little more than 1 km. That could mean that between the intrusion of the two dyke generations faulting took place and also that the giant-feldspar dykes predate the tinguaites. The fact that the giant-feldspar dykes trend ENE suggests also that they postdate the E-W-trending just saturated microsyenites.

4) On p. 20 it has been suggested that the swarm of nepheline-rich microsyenites of the ENE-trending strip between the Hvalsey church ruins and Sigssardlugtoq are very young and of comparable age as the youngest generation of hedrumites which are most common in the north-eastern part of the area. It should also be noted that this swarm continues into the area to the south-east of the Igaliko intrusion mapped by Emeleus and Harry (in press) and by Steen Andersen. In this area the nepheline-rich dykes appear to be early in the chronology. This might imply that at least some of the nepheline-rich microsyenite dykes of the above strip are also early and comparable in age to the old hedrumites and the E-W trending microsyenites.

In this connection the question has to be considered of whether at least some of the hedrumites and the nepheline-rich microsyenites belong to the same generation. In other words it could be possible that the degree of undersaturation varies along the course of individual dykes and across the trend of a group of parallel dykes of the same age. Systematic observations along some hedrumite dykes, e.g. the most important old hedrumite in the northern part of the area, show that these dykes can maintain their field and petrographical characters over long distances. The same can be said of a few nepheline-rich microsyenite dykes, but still the possibility that the degree of undersaturation may vary in individual dykes should be considered as highly probable.

5) The possibility that some nepheline-rich microsyenites might be early in the chronology is a little surprising because in the strip between the church ruins and Sigssardlugtoq these dykes are generally fresh and practically unaltered. This could mean that in this strip faulting and

hydrothermal activity have been unimportant after the emplacement of the possible early dykes. This shows also that chronological interpretations exclusively based on field appearance are dangerous.

REFERENCES

Bridgwater, D. and Harry, W.T. (1968) Anorthosite xenoliths and plagioclase megacrysts in Precambrian intrusions of South Greenland. Bull. Grønlands geol. Unders., No. 77 (also Meddr Grønland, Bd. 185, Nr. 2).

Emeleus, C.H. and Harry, W.T. (in press) The Igaliko nepheline syenite complex, South Greenland. Meddr Grønland, Bd. 186, Nr. 3.

Nesbitt, R.W. (1961) The petrology and structure of the country around Julianehåb, south-west Greenland. Unpublished Ph.D. thesis, Durham University, England.

Stewart, J.W. (1964) The earlier Gardar igneous rocks of the Ilímaussaq area, South Greenland. Unpublished Ph.D. thesis, Durham University, England.

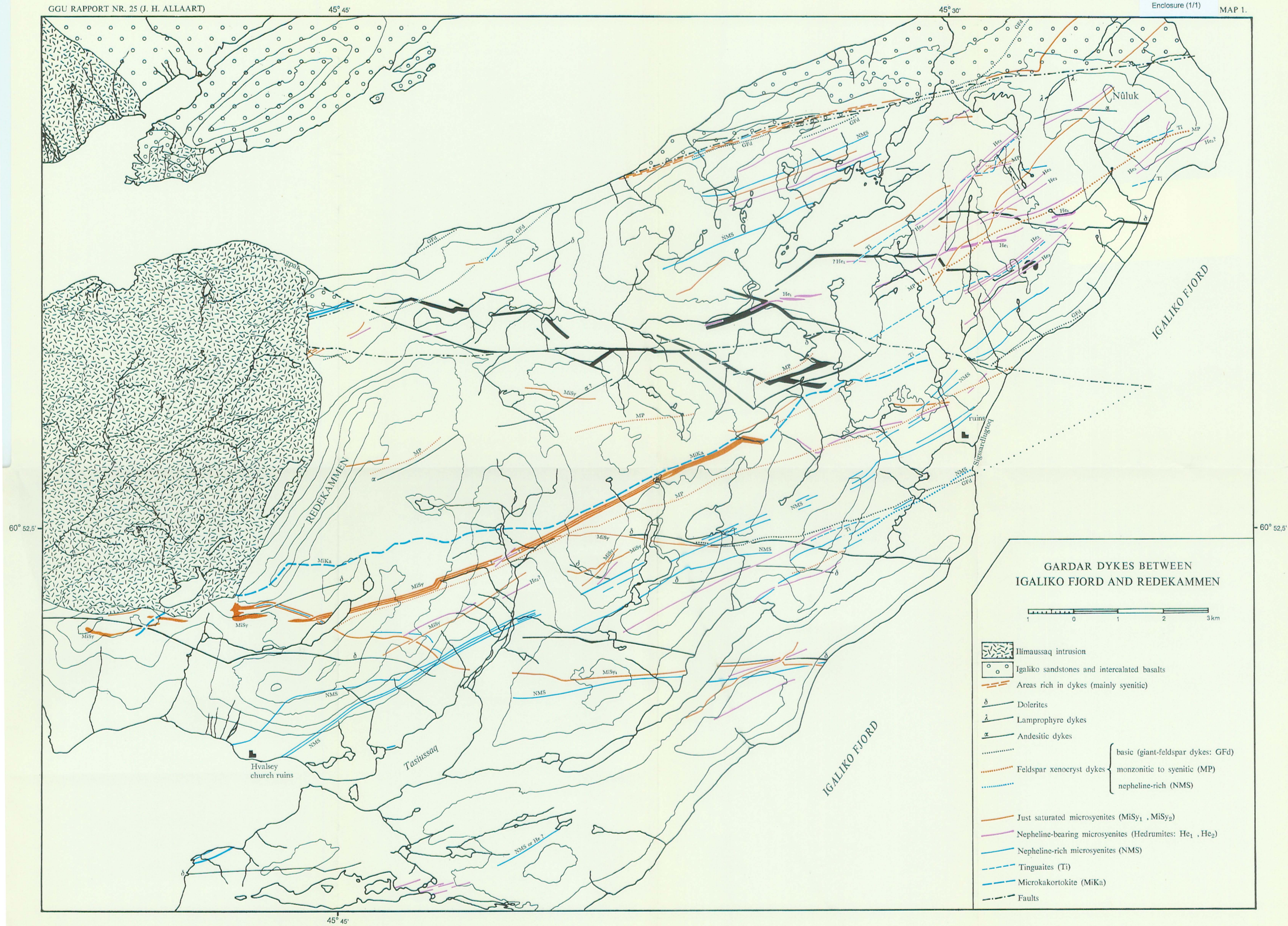
Upton, B.G.J. (1962) Geology of Tugtutôq and neighbouring islands, South Greenland. Part I. Bull. Grønlands geol. Unders., No. 34 (also Meddr Grønland, Bd. 169, Nr. 8).

Upton, B.G.J. (1964) The geology of Tugtutôq and neighbouring islands, South Greenland. Part IV. The nepheline syenites of the Hviddal composite dyke. Bull. Grønlands geol. Unders., No. 48 (also Meddr Grønland, Bd. 169, Nr. 3).

Walton, B.J. (1965) Sanerutian appinitic rocks and Gardar dykes and diatremes, north of Narssarssuaq, South Greenland. Bull. Grønlands geol. Unders., No. 57 (also Meddr Grønland, Bd. 179, Nr.9).

Watt, W.S. (1966) Chemical analyses from the Gardar igneous province, South Greenland. Rapp. Grønlands geol. Unders., Nr. 6.

Watt, W.S. (1968) Petrology and geology of the Precambrian Gardar dykes on Qaersuarssuk, South Greenland. Rapp. Grønlands geol. Unders., Nr. 14.


GARDAR DYKES BETWEEN
IGALIKO FJORD AND REDEKAMMEN
1 0 1 2 3 km
Ilimaussaq intrusion
Igaliko sandstones and intercalated basalts
Areas rich in dykes (mainly syenitic)
Dolerites
Lamprophyre dykes
Andesitic dykes
Feldspar xenocryst dykes
basic (giant-feldspar dykes: GFd)
monzonitic to syenitic (MP)
nepheline-rich (NMS)
Just saturated microsyenites (MiSy₁ , MiSy₂)
Nepheline-bearing microsyenites (Hedrumites: He₁ , He₂)
Nepheline-rich microsyenites (NMS)
Tinguaites (Ti)
Microkakortokite (MiKa)
Faults
45° 45'
45° 30'
60° 52,5'
Nûluk
IGALIKO FJORD
REDEKAMMEN
Agpat
Sigssardlugtoq
ruins
Hvalsey
church ruins
Tasiussaq

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