

GANE-1
GANK-1

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Greenland drill holes GANE-1 and GANK-1,
with notes on trapped hydrocarbons**
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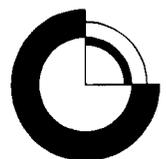


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Summary

The near-500m thick volcanic succession in GANE-1 consists of ten units of submarine hyaloclastite breccia of alternating plagioclase-phyric and aphyric basalt, and two units of siltstone and volcanogenic sandstone with fossils (units 5 and 7). The succession can be correlated to the upper 89m, perhaps 130m, in the Marraat-1 drill hole.

The near-100m thick volcanic succession in GANK-1 consists of ten units of alternating submarine hyaloclastite breccias and sandstones to mudstones with a large volcanogenic component. The almost aphyric basalts require chemical analysis for correlation to the established volcanic stratigraphy.

Scattered oil impregnations occur throughout GANE-1 and in parts of GANK-1. In addition, the GANE-1 core is completely oil-saturated in the intervals 3–10m (top unit 1), 147.5–149.5m (unit 6), and 152.0–158.2m (top unit 8). Units 5+6 and 7+8 form two repeated seal+reservoir systems that serve as natural models for oil traps in this kind of volcanic association. Accordingly, they should be investigated in more detail.

Introduction

GANE-1 (grønArctic Nuussuaq Eqalulik) and GANK-1 (grønArctic Nuussuaq Kuussuaq) were drilled in July–August 1995 by grønArctic Energy Inc. The objective was to penetrate the Tertiary volcanic rocks exposed at the surface and the Tertiary or Cretaceous sediments below, searching for hydrocarbon accumulations. The holes were cored in full length with core diameters of 63.6 mm changing to 47.6 mm and subsequently 36.5 mm at deeper levels, and the core recovery was very close to 100%. Well site geological description was carried out by GEUS geologists Kevin J. Bate and Karsten Dahl, and summary reports were prepared (Bate, 1995; Dahl et al., 1995) which were released to the public in April 1997.

GANE-1 is situated on western Nuussuaq at 70°28.25'N, 54°00.40'W, elevation 114 m a.s.l. It reached a depth of 641.29m, and the interval 0–496.5m consists of volcanic rocks and the rest of sediments with a few igneous intrusions. The subsequent side-track GANE-1A penetrated sediments with a few igneous intrusions from 533.4m to 707m.

GANK-1 is situated on western Nuussuaq at 70°28.35'N, 53°51.69'W, elevation 91 m a.s.l. It reached a depth of 398.8m, and the interval 0–114.9m consists of volcanic rocks and the rest of sediments with a few igneous intrusions. The side-track GANK-1A penetrated sediments with a few igneous intrusions from 218.5m to 332.85m.

The sediments in both cores have been logged in detail by Gregers Dam, GEUS, and the ensuing reports (Dam, 1996a, b) were released in April 1997. This report presents a lithological log and description of the volcanic parts of the drill cores, with notes on oil-impregnated intervals and a preliminary correlation to the volcanic succession in the previously drilled Marraat-1 core (Dam & Christiansen, 1994; Christiansen *et al.*, 1994).

The location of the drill holes on western Nuussuaq is shown in Fig. 3.

GANE-1: Summary of the volcanic units

The volcanic stratigraphy of GANE-1 is shown in Fig. 1.

Unit 1, 3.6m–74.5m

Unit 1a, 3.6m–54.4m. A very coarse, blocky deposit with blocks up to 40cm. The large blocks have no chilled margins and are probably lava blocks; some are vesicular and others are not. Glass rinds are seen on smaller clasts and also on a few larger ones. The matrix consists of unsorted volcanic rock and glass fragments. Many clasts are angular or irregular. The dominant rock type is a strongly plagioclase-phyric basalt with ca. 10% plagioclase in 1–3mm clusters. There is also a subordinate component of fine-grained aphyric basalt both in blocks and smaller clasts.

At 16.16m–17.25m there is a ca. 1m interval with a medium-grained doleritic rock. It looks like a dyke but no contact relations are preserved.

Unit 1b, 54.4m–74.5m. From 54.4m downwards the clasts become smaller and there is much more matrix. The rock looks more like a normal hyaloclastite breccia.

Unit 2, 74.5m–126.5m

Hyaloclastite of fine-grained aphyric basalt. Clasts are up to 25cm, usually only up to 15cm, very lobate, irregular, chilled, with a lot of glass. Scattered vesicular fragments occur; most clasts are not vesiculated. The upper 2.5m of this unit is massive basalt with irregular, pillowed lower boundary. It is probably a sheet flow that covers hyaloclastite from the same eruption. From ca. 104m downwards there is an increasing number of plagioclase-phyric basalt clasts, and from ca. 107m the clasts are dominantly of plagioclase-phyric basalt with 2–5% plagioclase in tiny 1mm clusters. There are still some clasts of aphyric basalt. The change in lithology has led to a subdivision into units 2a and 2b at 107m; there is no clear unit boundary.

Unit 3, 126.5m–140.0m

Clast-rich hyaloclastite of aphyric basalt. The clast size is usually 1–10cm, and there are many lobate clasts and much glass. Matrix is subordinate. There are occasional clasts of plagioclase-microphyric basalt.

Unit 4, 140.0m–143.3m

Coarse, clast-rich hyaloclastite of plagioclase-microphyric basalt. Angular clasts and not much glass. Some 0.5cm fragments of red-oxidised material.

Unit 5, 143.3m–147.5m

Siltstone with mud and hyaloclastite glass. Grain size variations indicate bedding, with coarser beds of glass grains. Irregular bedding, slump structures and sparse small shell fragments are found. This unit was originally logged as a lava flow (Bate, 1995).

Unit 6, 147.5m–149.5m

Hyaloclastite with up to 10 cm clasts of plagioclase-microphyric basalt.

Unit 7, 149.5m–152.0m

Bedded hyaloclastite sand. Normal grain size up to 0.5cm; scattered basalt clasts up to 10cm. Picrite?? Some coarse intervals with up to 1cm fragments. Remains of chalk-shelled fossils including corals are found.

Unit 8, 152.0m–180.0m

Hyaloclastite with clasts of aphyric basalt and much glass. A quite variable unit with 1–2m thick intervals of coarser and finer material and variable angularity of the clasts.

Unit 9, 180.0m–364.0m

Hyaloclastite of plagioclase-microphyric basalt with scattered 1mm plagioclase clusters. Scattered vesicular lava fragments and small red-oxidised clasts are seen. There are some coarser and finer intervals but no sharp boundaries and no changes in basalt lithology. Fine-clastic intervals may show bedding outlined by grain size variations.

207.75m–215.0m: An intrusive dolerite sheet with chilled upper and lower contacts. The contacts are inclined ca. 55° ; the vertical thickness of 7.25m corresponds to an inclined dyke with a thickness of ca. 4.2m.

268.5m–316.5m: Clast-rich, clast-supported interval sometimes looking more like pillow lava.

358.5m–364.0m: Relatively fine-clastic bottom layer.

Unit 10, 364.0m–456.5m

Hyaloclastite of aphyric basalt with up to 10cm clasts. No sharp boundaries above or below.

431.75m–434.75m: Intrusion. Massive, vesicle-free, with chilled upper and lower glass contacts.

Unit 11, 456.5m–461.7m

Clast-rich hyaloclastite with many up to 25cm clasts of vesicular lava; aphyric basalt.

Unit 12, 461.7m–496.5m

Hyaloclastite with up to 10cm clasts. In the upper part it is aphyric basalt, but at ca. 482m the lithology changes to picrite with frequent up to 2mm olivine phenocrysts. Therefore, unit 12 is divided at 482m into a and b sub-units.

The boundary to the underlying non-volcanic mudstones is not preserved. It must be fairly sharp.

In the sediments at 689.4m–696.4m in GANE-1A there is a 7m thick intrusive sheet of picrite with up to 3mm olivine crystals.

GANK-1: Summary of the volcanic units

The volcanic stratigraphy of GANK-1 is shown in Fig. 2.

Unit 1, 34.9m–40.0m

Matrix-rich hyaloclastite with up to 10cm clasts of aphyric to olivine microphyric basalt.

Unit 2, 40.0m–54.3m

This unit has on top a ca. 50cm thick zone with white to cream-coloured carbonate in irregular masses, partly with breccia structure and partly with soft, convoluted structures. The carbonate may be of sedimentary origin, but no fossils were found.

The hyaloclastite of unit 2 is matrix-rich. Large parts have clasts <1cm; some intervals have clasts <0.5cm, and some intervals have larger clasts up to 10cm. The rock type is aphyric to olivine microphyric basalt similar to that in unit 1. There is a sharp boundary to unit 3.

Unit 3, 54.3m–84.3m

Unit 3 has on top a 15 cm interval with very fine-grained, bedded hyaloclastite sand. Below this follows matrix-rich hyaloclastite of aphyric to olivine-microphyric basalt similar to that of unit 2. The number of fine-clastic horizons increases downwards. The boundary between units 3 and 4 is placed arbitrarily in the middle of a fine-clastic horizon.

Unit 4, 84.3m–ca. 93.0m

Matrix-rich hyaloclastite of olivine-phyric basalt. Clasts are only rarely >2cm; a few are up to 10cm. The boundary between units 4 and 5 is placed where clasts >1cm disappear. It is not sharp.

Unit 5, ca. 93.0m–103.6m

Bedded hyaloclastite sand. Several depositional events can be discerned in grain size variations.

Unit 6, 103.6m–103.75m

15cm of dark brown non-volcanic mudstone.

Unit 7, 103.75m–106.8m

Bedded hyaloclastite sand. Several depositional events can be discerned in grain size variations.

Unit 8, 106.8m–107.9m

10cm finely bedded volcanogenic siltstone followed downwards by normal hyaloclastite with up to 2cm clasts.

Unit 9, 107.9m–108.6m

70cm of dark brown non-volcanic mudstone.

Unit 10, 108.6m–114.9m

Fairly homogeneous hyaloclastite sand with clasts <1cm. Strong carbonatisation. At 113.0m–114.9m scattered larger volcanic clasts up to 10cm are seen; they consist of plagioclase-microphyric basalt.

The boundary to the underlying non-volcanic mudstone is sharp.

In the sediments at 336.8m–346.9m there is a ca. 10m thick intrusive sheet of massive dolerite.

Preliminary correlation with surface exposures and with the Marraat-1 core

The volcanic rocks in GANE-1 belong to the Anaanaa Member, the lowest of the volcanic members in West Greenland which is exposed in a ca. 140km² area in western Nuussuaq east of the Itilli fault. More specifically, the rocks in GANE-1 must correlate with aphyric and plagioclase-phyric subaerial lava flows in the uppermost 89m of the Marraat-1 core located 9 km NW of GANE-1 (units 1–25, “the oil series”). The correlation may include lavas down to 130m (to unit 42) in Marraat-1; chemical analyses are required for determining this. The strongly plagioclase-phyric unit 1 in GANE-1 is lithologically similar to hyaloclastites found at ca. 35 m altitude in the river bed 1.5 km NE of GANE-1.

The volcanic rocks in GANK-1 either belong to the Anaanaa Member or, more probably, to the olivine microphyric lowermost part of the Naujánguit Member that overlies the Anaanaa Member. Chemical analyses are required for determining this.

Observations of hydrocarbons within the volcanic successions

GANK-1

The present logging confirmed the observations of Dahl *et al.* (1995) that scattered oil staining occurs within hyaloclastite units 4 and 5 in the depth interval 86m-98m.

GANE-1

The observations of Bate (1995) of bleeding and impregnating oil at intervals down to 345m were confirmed. In addition, oil impregnations were found throughout the lower part of the volcanic succession. Most of the oil below 345m is found within brown to honey-coloured calcite that fills vesicles in lava clasts in the hyaloclastites. A particular abundance was noted within unit 11 (456.5m–461.7m).

Two zones with bleeding oil are particularly noteworthy. One is just below the overburden at 3m–10m and the other is the interval 147.7m–158m. Within these two zones the hyaloclastites are completely saturated with oil, to an extent not observed in other cores or on surfaces in the field. These zones may represent true oil fields, albeit minor ones.

The interval 143.3m–158.2m (units 5–8) provides interesting details of two oil traps. Firstly, the 4.2m massive siltstone of unit 5 has acted as a seal for the oil that saturates the 2m thick reservoir of hyaloclastites in unit 6. Secondly, the 2.5m fine-grained massive hyaloclastite sand of unit 7, not itself containing much oil, forms a seal over the completely oil-saturated upper 6.2m of hyaloclastites in unit 8. Thus, it is the fine-grained sediments that form the seal and the coarse volcanics that form the reservoir rocks, a rather unusual situation. We suggest that porosities and other relevant physical parameters are established for units 5, 6, 7 and 8, and that more detailed organic geochemical analyses are carried out in order to test the homogeneity of the crude oil. This part of the core serves as a natural model for the characterization of the types of oil traps and reservoirs that may be present in the widespread volcanic and volcanic-sedimentary deposits in West Greenland.

Acknowledgements

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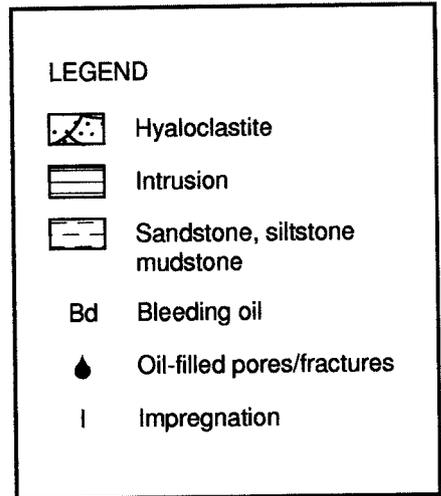
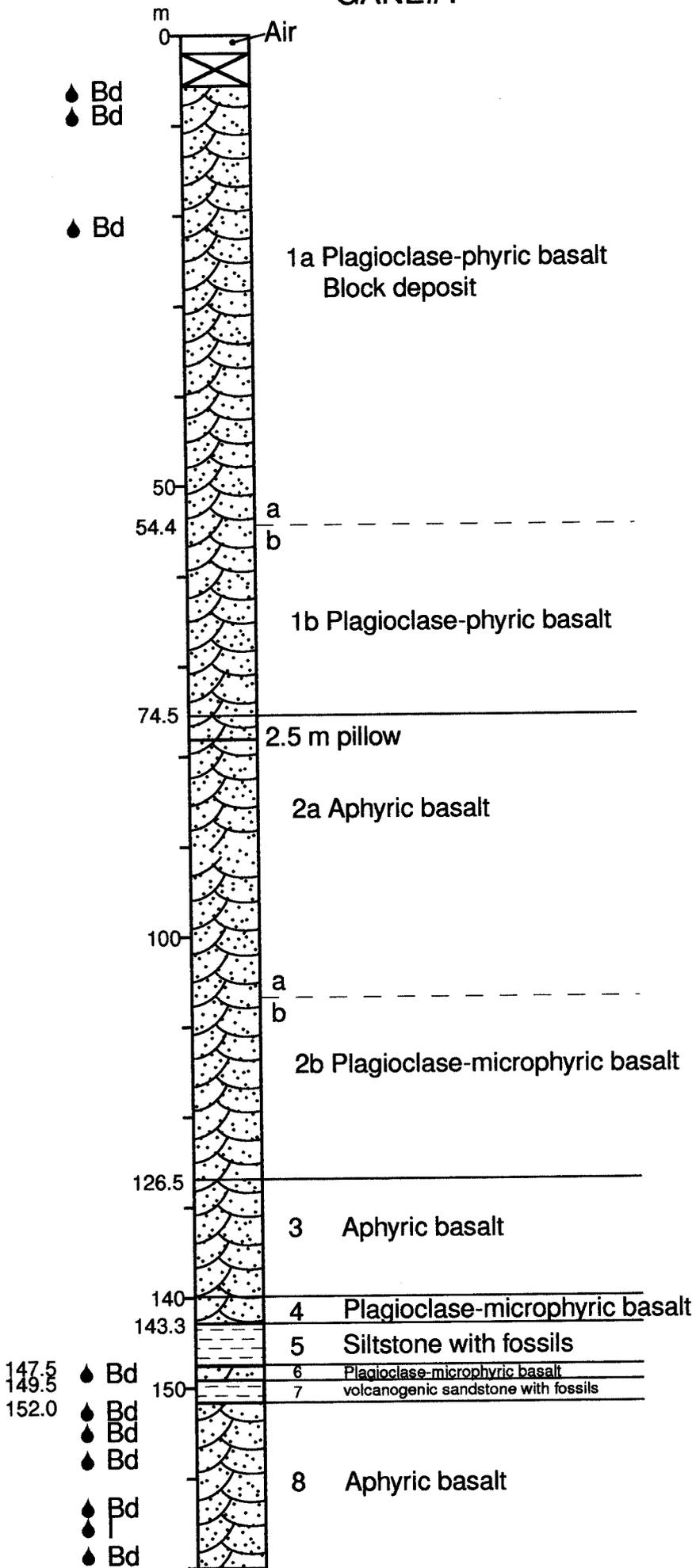
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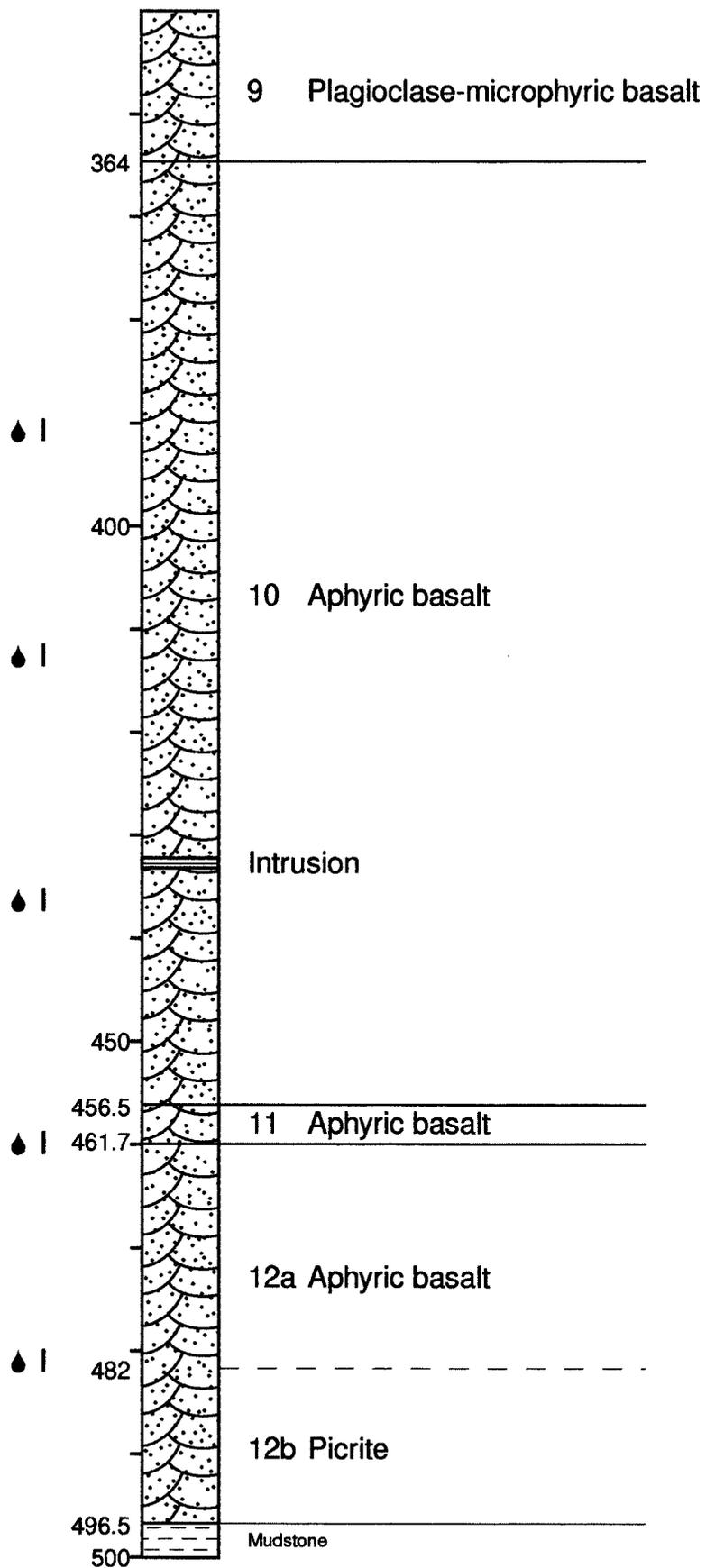
Figure 1. Log of the volcanic succession in GANE-1. Modified from Bate (1995).

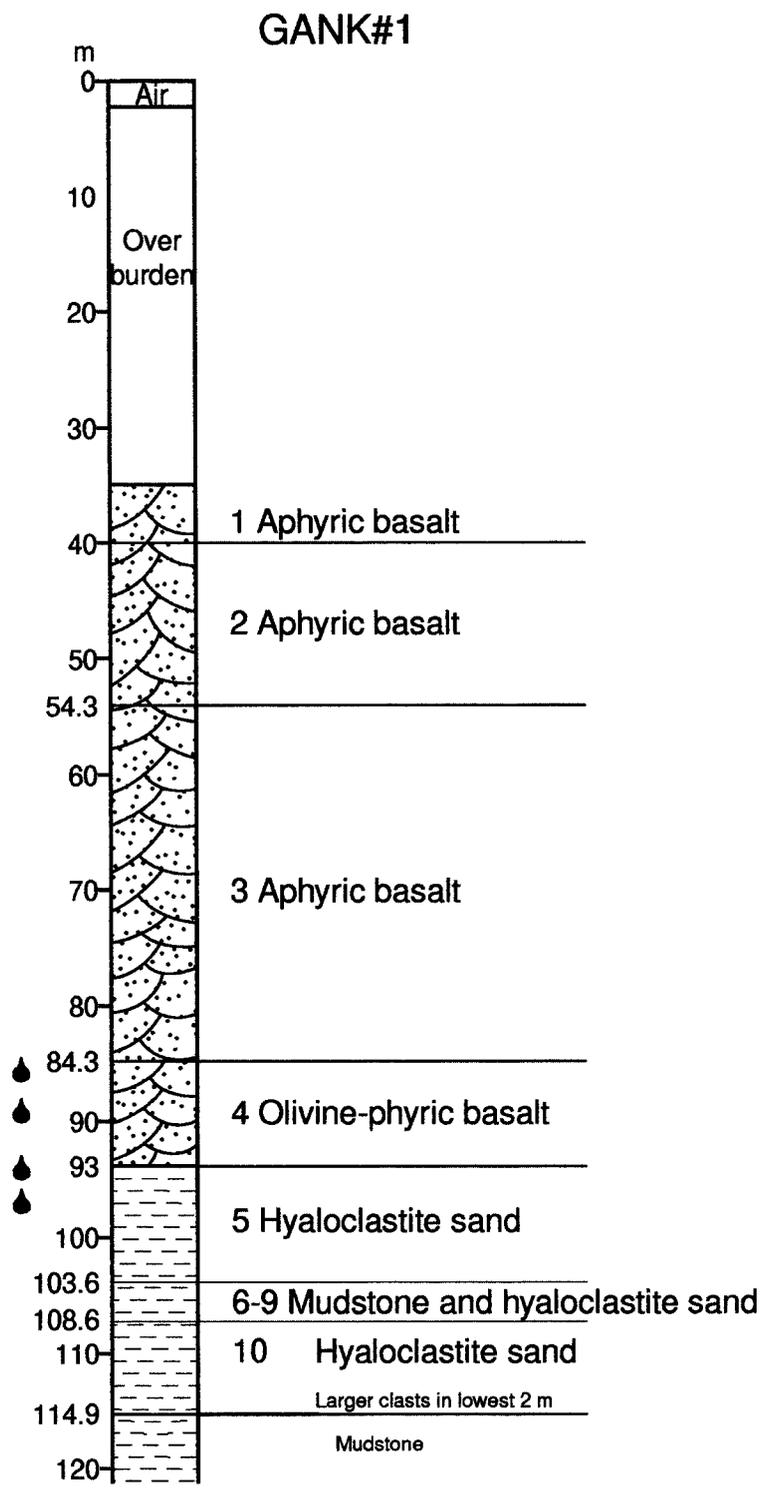
Figure 2. Log of the volcanic succession in GANK-1. Modified from Dahl *et al.* (1995).

Figure 3. Location of the drill holes in western Nuussuaq. From Bate (1995).

GAN#1







LEGEND

-  Hyaloclastite
-  Sandstone, siltstone, mudstone
-  Oil-filled pores/fractures

Figure 2

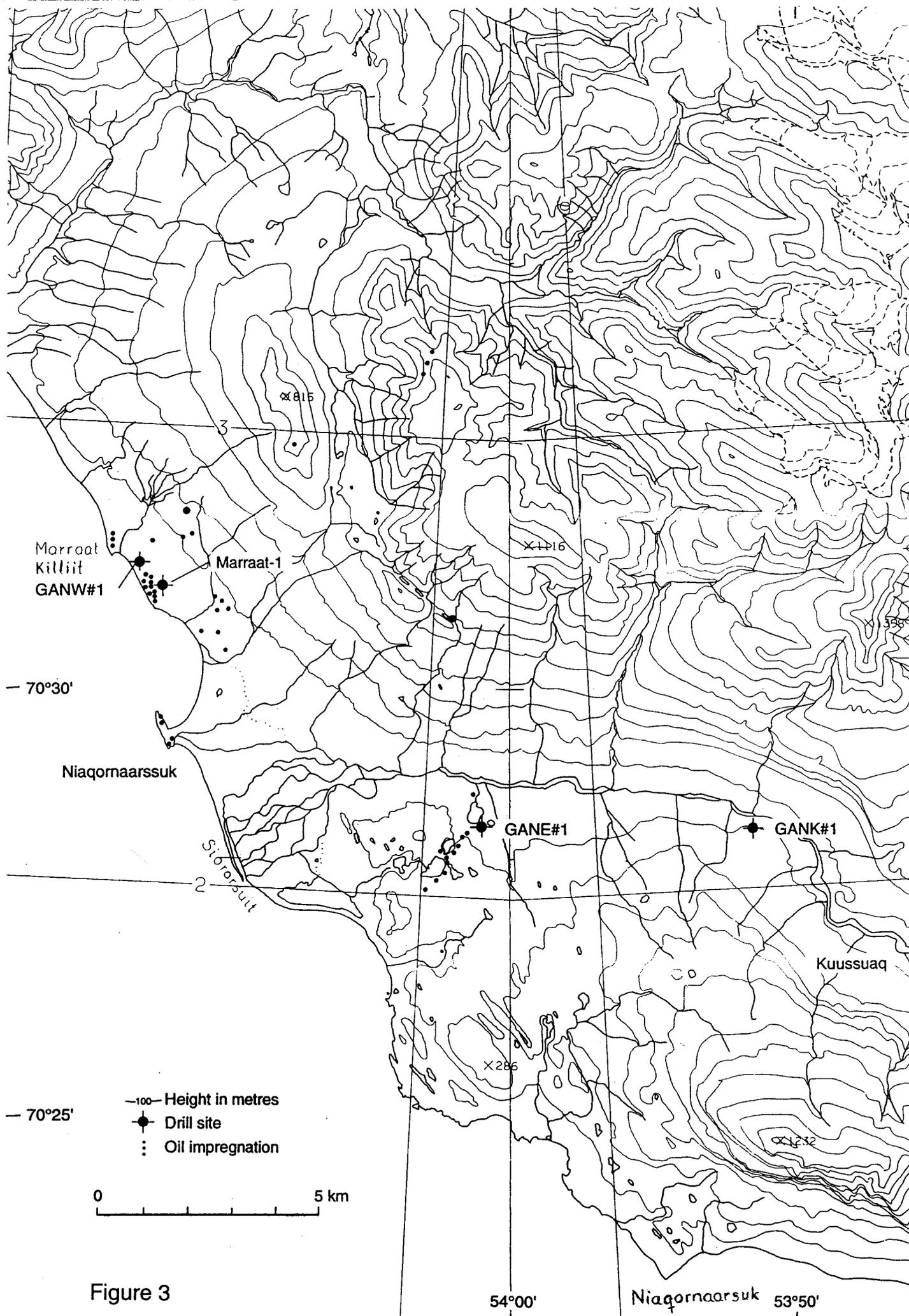


Figure 3