Early Tertiary volcanic rocks from eastern Disko and south-eastern Nûgssuaq

Asger Ken Pedersen and Lotte Melchior Larsen

As part of an integrated study of the interaction between sedimentary and volcanic facies in the Cretaceous–Tertiary West Greenland basin, early Tertiary extrusive and intrusive basic igneous rocks have been investigated in eastern Disko and south-eastern Nûgssuaq (fig. 1).

The volcanic activity started in the early Tertiary. It was centred in the western regions of Disko and Nûgssuaq and west of the present land areas, and consequently western Disko and western Nûgssuaq have a thick and complete volcanic succession, the Vaigat and Maligât Formations (Hald & Pedersen, 1975; Pedersen, 1975a, 1985). The coeval deposits in the eastern part of the basin are clastic sediments of the Upper Atanikerdluk Formation (Koch, 1959). With time, the volcanic deposits prograded eastwards, and eventually the whole area was covered by a coherent basalt plateau. The present study attempts to extend the established volcanic stratigraphy from western Disko and the geological map sheets 1:100 000 Qutdligssat (published in 1976) and Mellemfjord (published in 1987) into eastern Disko and eastern Nûgssuaq where volcanic rocks and sediments interfinger.

The igneous rocks encountered this summer are grouped into five categories, numbered with increasing stratigraphic height:

(1) Lower sill complex and dykes,
(2) Air fall tuffs,
(3) Upper sill complex,
(4) Entablature lavas and hyaloclastites,
(5) Subaerial plateau lavas.

Lower sill complex and dykes

These intrusives crop out in the Cretaceous and Tertiary sediments, and their age relations to the overlying lavas are not yet clear. A few dykes are observed cutting the lavas, and we consider that most of the dykes are younger than the lavas.

A major sill complex occurs on Nûgssuaq from Atanikerdluk to Sarqaqdalen (fig. 1), and was described by Munck (1945). A similar large sill at Nûgârssuk on Disko probably belongs to the same system. Cross-cutting relations indicate that the lower sill complex is younger than the vertical dykes, and the sills may therefore be the youngest igneous rocks present in the area, despite their low stratigraphic position.

Systematic sampling of dykes and sills has been carried out. The dykes encountered are all basalts, dominantly feldsparphyric although a few are nearly aphyric. Geochemical investigations are intended to clarify the position of these intrusives in the volcanic history of the region.

Near Atanikerdluk a dyke (dyke II of Koch & Pedersen, 1960) was found to contain abundant rounded pillow-like inclusions, from head to fist size, of a black, almost glassy igneous

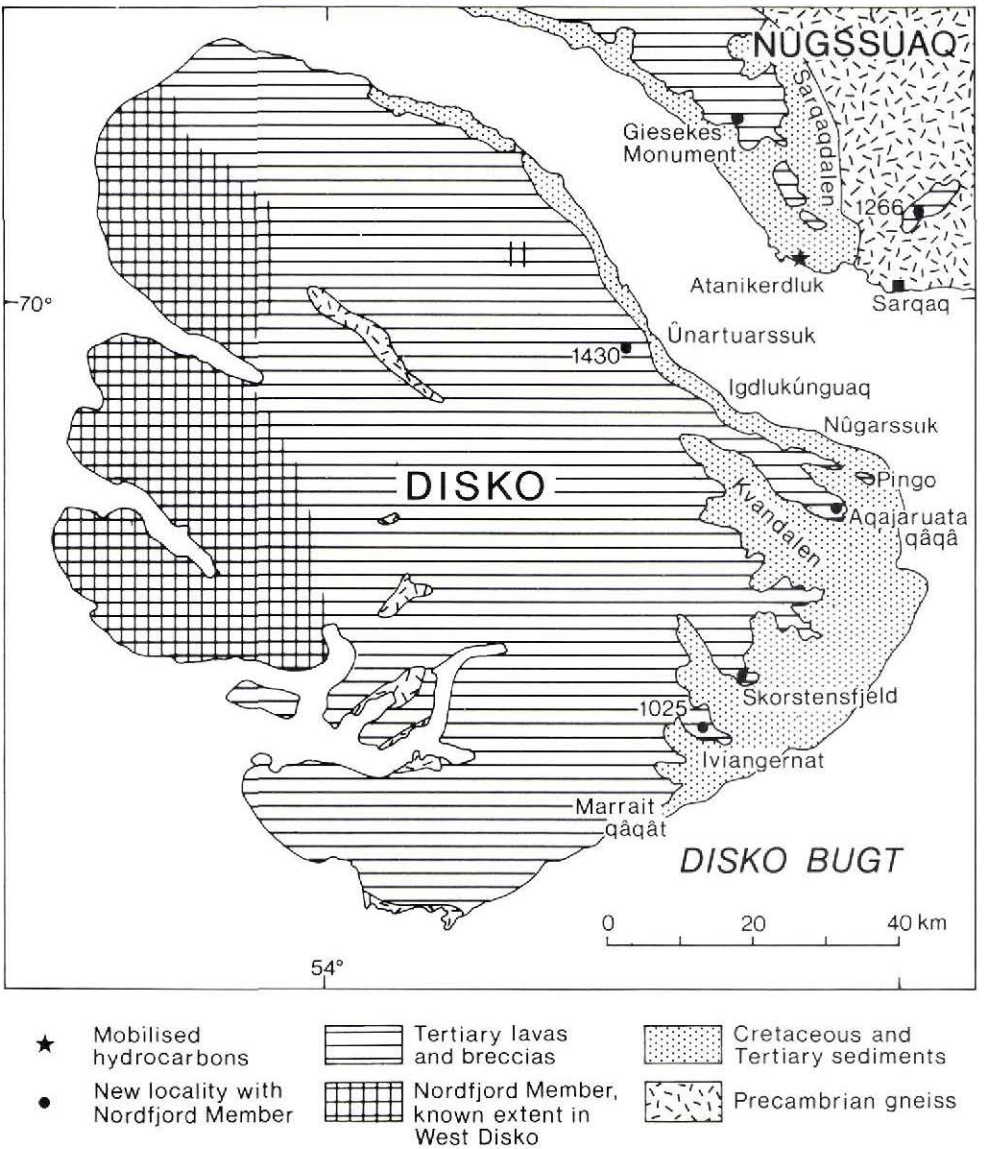

Fig. 1. Generalized geological map of Disko and part of southern Nûgssuaq.

rock. The same dyke has in places a white carbonate-rich breccia zone at the irregular marginal contact, and in this zone droplets up to 0.7 cm in size, and veins, of a black tar-like substance which burns with a smoky flame were discovered. On a small scale this occurrence demonstrates that basaltic intrusives can mobilize hydrocarbons in a region with otherwise thermally immature sediments (Schiener & Leythaeuser, 1978).

Air fall tuffs

Altered tuffs were noted by Koch (1959) in mudstones from the Naujât Member in the otherwise sandstone-dominated Upper Atanikerdluk Formation on Nûgssuaq. Similar tuffs occur in eastern Disko in mudstones correlated with the Naujât Member. The tuffs have been measured and sampled by G. K. Pedersen (this report), and detailed investigation of the tuffs is intended to establish a correlation between the sediments in the east and the coeval volcanic rocks of the Vaigat and lower part of the Maligât Formation in the west.

Upper sill complex

Within 200 to 300 m below the coherent overlying plateau basalt cover a varying number of sill intrusions are observed, emplaced into Tertiary sediments. Where intruded into mudstones, the intrusions often form irregular pillowed sills, as first noted at Nûgssuaq by Pedersen (1975b). At some localities scoriaceous oxidized zones and decimetre-sized vesicles in the sills indicate emplacement into poorly consolidated mudstone close to the earth's surface. Often the sills have developed prominent entablature zones in their upper or central parts, indicative of emplacement in a humid environment. At one locality at Marrait qáqât a sill intruded into sandstone is associated with an overlying subaerial pseudocrater field formed when magma from the sill penetrated to the surface through unconsolidated sandstones. The upper sill complex has been sampled in order to establish a chemical stratigraphy. This is intended to verify field observations which indicate that some sills were emplaced over large areas close to the palaeosurface, and that some sills may even be reintruded subaerial or subaquous lava flows.

Entablature lavas and hyaloclastites

Above the upper sill complex occur the lowermost indisputable lava units. Their thicknesses vary due to local topography, and ponded flows reaching 100 m in thickness are among the thickest basaltic lava flows found in the Tertiary of West Greenland. The lavas rest on mudstones or sandstones, and local hyaloclastite tongues and pillow lobes may extend a few metres down into the sediments. The flows have somewhat irregular colonnades and one or several prominent entablature zones. Some flows may grade upwards into hyaloclastite or into oxidized subaerial lava tops, depending on whether the lava tops were below or above shallow water. The latter type exemplifies the inundation of shallow humid basins by lava flows sufficiently thick to have their tops above the water level.

Subaerial plateau lavas

Where lavas have overflowed relatively dry sand plains, development of entablature zones is either inconspicuous or absent, and typical subaerial plateau lavas are formed. Between eruptions the lavas were covered by several metres of sandstone, sometimes with basalt pebble conglomerate. A gradual easterly progression of the lava flows at one stage pushed the deposition of clastic sediments far east and south of Disko. A lava plateau built up of basaltic lava flows from the Maligât Formation then extended into the present Disko Bugt.

On south-eastern Nûgssuaq the easterly progressing lavas lapped onto the high-lying basement gneiss at the eastern basin margin. Lavas resting on basement are now preserved only in scattered erosion remnants on the highest peaks east of Sarqaqdalen. The lavas are all subaerial, with oxidized flow tops, and are typically covered by lateritic soil up to a few decimetres thick.

A detailed sampling and geochemical analysis programme of the lavas aims at establishing the extent of individual lavas and eruption volumes over large areas.

Nordfjord Member

The recognition of one very distinctive unit in the plateau lavas, the Nordfjord Member of the Maligât Formation (Pedersen, 1975a), is important because it allows us to outline syn- and post-volcanic tectonic movements in the region from field work alone. The Nordfjord Member was found to be present throughout the investigated area, and its known extent is thereby considerably enlarged (fig. 1).

The Nordfjord Member was established in north-west Disko where it contains sediment-contaminated volcanic rocks ranging from basalt to rhyolite in composition, and from this area several conglomerate and sandstone beds are known as well as the largest occurrences of air fall tuffs on Disko. A characteristic feature of the member is the occurrence of strongly feldsparphyric basaltic pahoehoe lavas, and of basalts with particularly large plagioclase phenocrysts up to 1 cm in size.

Table 1. Nordfjord Member on eastern Disko and eastern Nûgssuaq

	Locality, fig.1	Characteristic and distinctive field lithologies
1	Point 1266 N of Sarqaq, Nûgssuaq	A silicic basalt lava with 1 cm feldspar phenocrysts. Lava rests on reddish grey claystone (altered tuffs ?).
2	Gieseckes Monument, Nûgssuaq	A light brown ?claystone at the base of a rusty-weathering lava flow on an inaccessible mountain peak.
3	Aqajaruata qáqâ, Disko	A composite lava flow with native iron: an andesite with xenoliths of modified shale and sandstone overlies a bottom zone of aphyric basalt.
4	Point 1240, Disko	The same composite lava as at loc. 3. Basaltic lava, with >1 cm plagioclase glomerocrysts.
5	SE of point 1430, Disko	14 m thick river deposit of silt to conglomerate beds of altered rhyolite pumice, rhyolitic pitchstone, andesite and feldsparphyric basalt.
6	Skorstensfjeld, Disko	Silicic basalt lava flow. A number of pahoehoe lava flows of strongly feldsparphyric basalt with 0.5 to 0.8 cm plagioclase phenocrysts.
7	Point 1025 NW of Iviangernat, Disko	Basalt lava with abundant 6 to 7 mm plagioclase phenocrysts.

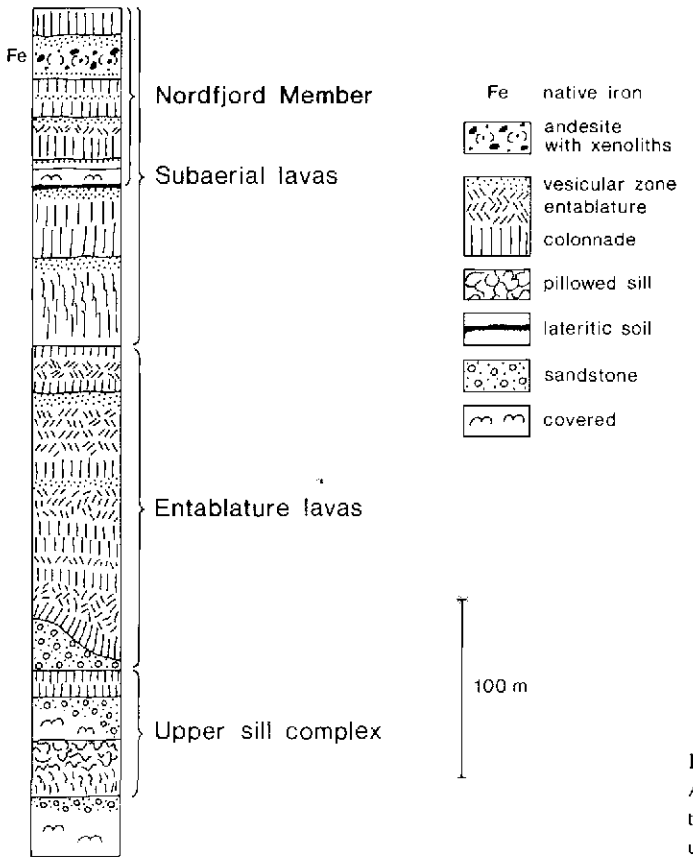

Fig. 2. Profile measured at Aqajâruata qâqâ showing a typical section through the upper sill complex and lavas.

Table 1 summarizes the Nordfjord Member lithologies at the new localities and at one found in 1985. Three localities of particular importance are described below.

Point 1266 north of Sarqaq, Nûgssuaq (loc. 1). Five lava flows with a total thickness of about 80 m rest on Precambrian gneiss. The two uppermost lavas belong to the Nordfjord Member. Lava no. 4 rests on reddish-grey claystone (altered tuff ?) and is a typical Nordfjord Member lava with up to 1 cm large plagioclase phenocrysts. It is more than 40 m thick.

Point 1430 west of Ûnartuarssuk, eastern Disko (loc. 5). This locality, discovered in 1985, contains a 14 m thick river deposit of conglomerate, gravel, tuffaceous sandstone and claystone. The sandstone and conglomerate are light grey to white, with a matrix of altered rhyolite pumice and clasts of rhyolitic pitchstone, andesite and feldsparphyric basalt. The rhyolitic material is almost certainly transported by a river from the productive rhyolite centres located somewhere in north-western Disko or west of the present coast (Pedersen, 1975a, 1977). This indicates that the palaeo-watershed was at that time located west of the present coast of Disko, and definitely west of the Disko gneiss ridge. The river deposit is covered by lavas of feldsparphyric basalt, while more evolved lavas are absent.

Aqajaruata qáqâ, eastern Disko (loc. 3–4). The measured profile contains around 400 m of basalt lavas and underlying sills (fig. 2). The uppermost 100 m, constituting four lava flows, belong to the Nordfjord Member. The lowest of the four flows rests on a red lateritic horizon several decimetres thick, and has up to 1 cm large plagioclase phenocrysts. The next highest lava flow is strongly sediment-contaminated and contains native iron. It is 25 m thick and composite, with a base of 2 m of aphyric basalt, while the rest is a strongly vesicular andesitic rock with abundant sediment xenoliths and weathered rusty spots from native iron and sulphides. This flow can be observed for 25 km towards the west but is missing at point 1430, 38 km towards the west-north-west. It is the most eastern occurrence of iron-bearing lava yet known from the province; however, there is a dyke at Igdlukúnguaq which is known for its nickeliferous pyrrhotite (Pauly, 1958; Ulff-Møller, 1983). This dyke may belong to the same volcanic system as the composite lava.

Economic geology

Our study has confirmed the potential of basic intrusions as local heat sources capable of generating hydrocarbons from carbonaceous sediments in this region. The discovery of a voluminous native iron bearing composite lava flow in the poorly investigated Kvandalen region of east Disko offers the possibility of locating the feeder system which might contain accumulations of economically interesting siderophile elements partitioned into iron and sulphide cumulates.

Acknowledgements. AKP acknowledges field support from GGU, the Arctic Station in Godhavn and the Danish Natural Science Research Council.

References

Hald, N. & Pedersen, A. K. 1975: Lithostratigraphy of the early Tertiary volcanic rocks of central West Greenland. *Rapp. Grønlands geol. Unders.* **69,** 17–24.

Koch, B. E. 1959: Contribution to the stratigraphy of the nonmarine Tertiary deposits on the south coast of Nûgssuaq peninsula, northwest Greenland, with remarks on the fossil flora. *Bull. Grønlands geol. Unders.* **22** (also *Meddr Grønland* **161**, 1), 100 pp.

Koch, B. E. & Pedersen, K. R. 1960: Geological map of Atanikerdluk and environs 1:10 000. *Bull. Grønlands geol. Unders.* **23** (also *Meddr Grønland* **162**, 4), 38 pp.

Munck, S. 1945: On the geology and petrography of the West Greenland basalt province. V. Two major dolerite intrusions of the Nûgssuaq peninsula. *Meddr Grønland* **137**(5), 61 pp.

Pauly, H. 1958: Igdlukúnguaq nickeliferous pyrrhotite. *Bull. Grønlands geol. Unders.* **17** (also *Meddr Grønland* **157**, 3), 169 pp.

Pedersen, A. K. 1975a: New mapping in north-western Disko 1972. *Rapp. Grønlands geol. Unders.* **69,** 33–34.

Pedersen, A. K. 1975b: A pillowed sill from the Atanikerdluk area, Nûgssuaq. *Rapp. Grønlands geol. Unders.* **81,** 5–14.

Pedersen, A. K. 1977: Iron-bearing and related volcanic rocks in the area between Gieseckes Dal and Hammers Dal, north-west Disko. *Rapp. Grønlands geol. Unders.* **81,** 5–14.

Pedersen, A. K. 1985: Lithostratigraphy of the Tertiary Vaigat Formation on Disko, central West Greenland. *Rapp. Grønlands geol. Unders.* **124,** 30 pp.

Schiener, E. J. & Leythaeuser, D. 1978: Petroleum potential off West Greenland. *Oil Gas J.* **76**(40), 223–234.

Ulff-Møller, F. 1983: Tellurisk jern fra subvulkanske intrusioner på Disko, Grønland. En petrografisk og kemisk undersøgelse. Unpubl. thesis, University of Copenhagen, 131 pp.

A. K. P.,
Geologisk Museum,
Øster Voldgade 5–7,AS) DK-1350 Copenhagen K,
Denmark.

New sedimentological data on Lower Tertiary shales from Disko and Nûgssuaq, West Greenland

Gunver Krarup Pedersen

The sedimentological data described and discussed below were collected during a period of 47 days in the summer of 1986. The field work was carried out over 23 days from four camps: Tartunaq, Akúneq, Skansen and Tuapait (fig. 1). The main objective was investigation of the Naujât Member, through which a number of sections were measured, but in addition the under- and overlying, predominantly sandy facies associations were also studied.

Introduction

Cretaceous to Tertiary sediments are exposed in up to 1000 m thick sequences on Disko and Nûgssuaq in West Greenland. The sediments were deposited in a major delta with sediment transport from south to north (Henderson *et al.,* 1976). The area studied is located within the fluvial-dominated parts of the delta where the main lithology is whitish, slightly consolidated sand.

The sand is interbedded with heteroliths as well as with dark grey to black shales among which an early Tertiary sequence is prominent due to its thickness (up to 100 m), its lateral continuity, and its lack of marine fossils. On Nûgssuaq this shale was erected as the Naujât Member of the Upper Atanikerdluk Formation by Koch (1959).

Geochemical data from the Naujât Member show that the total organic content is unusually high, partly liptinitic, and the shale is thus transitional to an oil shale (Schiener & Leythaeuser, 1978). These authors interpreted the Naujât Member as lacustrine, deposited in a body of fresh water dammed up behind a barrier of contemporaneous volcanic rocks.

This study of the sedimentology of the Naujât Member was undertaken to record vertical and lateral facies relationships; to interpret depositional processes of clastic as well as organic material; and finally to relate the sedimentary environment of the shale to the geological development of the delta. The interpretation presented below is necessarily of a preliminary character, and emphasis is therefore placed on descriptions of the sedimentary facies with comments on their spatial distribution.