

Type section. The strata exposed on the south-facing slope of Nalluarissat between Aaffarsuaq and Kangersooq, just west of Itivnera, are designated as the type section (Figs 63, 64). The type section is located at 70°29.50'N, 53°08.87'W.

Distribution. The bed has only been recognised on the south-facing slope of Nalluarissat between Aaffarsuaq and Kangersooq (Fig. 82).

Thickness. The bed is up to 38 m thick and confined to lensoid bodies up to 100 m wide.

Lithology. The bed consists of cross-bedded coarse-grained sandstones, arranged in fining-upward successions form lensoid bodies arranged like pearls on a string (Figs 63, 64). Basement pebble conglomerates are locally present. The sediments between the cemented sandstone bodies are covered by scree (Dam *et al.* 2000).

Fossils. Macrofossils have not been found.

Depositional environment. The sandstones of the Itivnera Bed were deposited in fluvial channels (Dam *et al.* 2000).

Boundaries. The Itivnera Bed erosively overlies deltaic deposits of the Qilakitsoq Member (Atane Formation). In the type section, the fluvial sandstones are succeeded by turbiditic mudstones and sandstones of the Aaffarsuaq Member (Itilli Formation). The lower boundary is no longer interpreted as a sequence boundary because there is insufficient evidence that a sea-level fall preceded the rise in sea level that marks the transition to the deep-water deposits of the Aaffarsuaq Member.

Geological age. At Nalluarissat, just west of Itivnera, the Qilakitsoq Member is Late Santonian in age, and at Tunoqqu, immediately east of Itivnera, the Aaffarsuaq Member is of Early to Middle Campanian age (Nøhr-Hansen 1996). Deposition of the fluvial sandstone bodies at Itivnera is therefore well constrained to the Early Campanian.

Itilli Formation

new formation

History. The strata exposed in river sections in the Itilli valley on western Nuussuaq were informally assigned to the Itilli formation by J.M. Hansen (1980b). The Itilli

Formation is here extended to include the unnamed Upper Turonian to Campanian marine strata on Svartenhuk Halvø and Nuussuaq (cf. Birkelund 1965; Henderson *et al.* 1976; J.G. Larsen & Pulvertaft 2000). Furthermore, on northern Disko at Kussinerujuk and Asuk, outcrops previously correlated with the Paleocene Kangilia Formation (J.M. Hansen 1980b; Pulvertaft & Chalmers 1990) are here assigned to the Itilli Formation (see below). The Itivnera beds of the Itilli Formation (Dam *et al.* 2000) are, however, now redefined as the Itivnera Bed of the Qilakitsoq Member (Atane Formation).

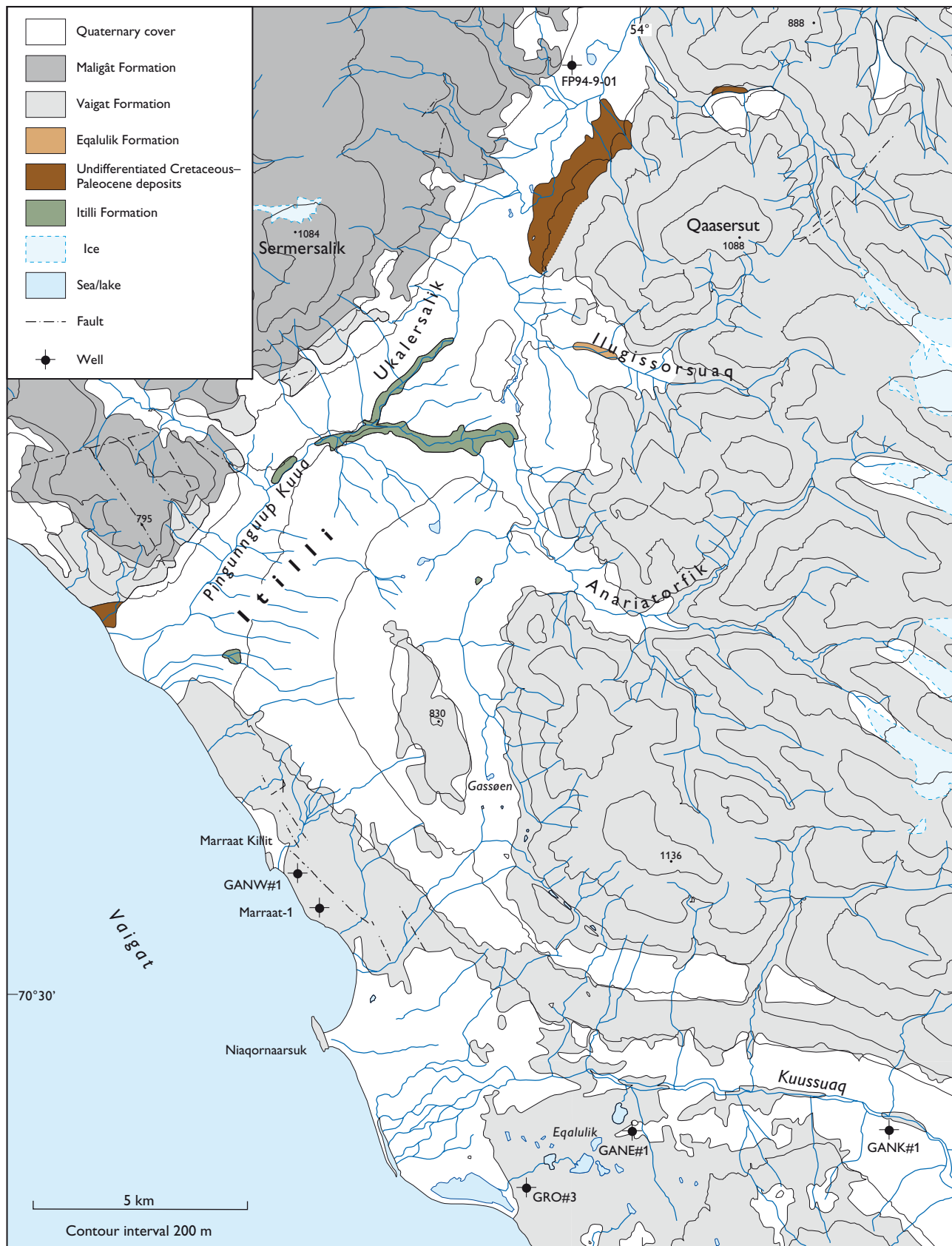
On Itsaku (Svartenhuk Halvø), the ?Upper Campanian/Maastrichtian to Paleocene succession has been suggested to be equivalent either to both the Itilli and Kangilia Formations (i.e. Campanian to Paleocene) or to the Kangilia Formation alone (i.e. upper Maastrichtian to Paleocene), based on correlation of two major conglomerate horizons with tectonic events recognised on Nuussuaq (J.G. Larsen & Pulvertaft 2000). Based on zircon provenance data, this succession is here assigned to the Kangilia Formation (see below).

Name. After Itilli, a major valley transecting Nuussuaq from north-west of Marraat on the south coast to west of Niaqornat on the north coast (Figs 2, 65).

Distribution. The Itilli Formation is exposed in the Itilli valley (Fig. 65) and on the north coast of Nuussuaq in the ravines between Ikorfat and Niaqornat (Fig. 74) where it has been drilled in the shallow wells GGU 400705, GGU 400706, and GGU 400407 (Christiansen *et al.* 1994a), and the formation is probably also present in the FP94-11-02, FP94-11-04 and FP94-11-05 wells (Dam & Nøhr-Hansen 1995). It is also well exposed on central Nuussuaq along the slopes of the valley of Aaffarsuaq between Qilakitsoq and Tunoqqu, along the slopes of the valley Kangersooq (Fig. 82), and in the valley of Agatdalen including the shallow well GGU 400702 (Fig. 113; Nøhr-Hansen 1996; Dam *et al.* 2000). On Disko, the formation is exposed at Asuk and Kussinerujuk.

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Fig. 65. Map of the southern part of the Itilli valley showing outcrops of the Itilli Formation (Anariartorfik Member) and the Eqlulilik Formation and location of the wells Marraat-1, GANW#1, GANE#1, GANK#1 GRO#3 and FP94-9-01. Based on Rosenkrantz *et al.* (1974) and Hald (1976). Contour interval 200 m. For location, see Fig. 2.



Kuugannguaq–Qunnilik Fault and is only 240 m thick along the northern slopes of the Aaffarsuaq valley between Qilakitsoq and Tunoqqu. At Kangilia, on the north coast of Nuussuaq, the formation is at least 250 m thick (Fig. 87), and the nearby GANT#1 well penetrated 645 m of the formation without reaching the base of the formation. On Svartenhuk Halvø, the drilled and cored part of the formation is 960 m thick (excluding twenty-two Paleocene dolerite intrusions with a total thickness of 240.2 m), but the base of the formation was not reached (Fig. 75). At Kussinerujuk on the north coast of Disko, the measured part of the formation is 42 m thick (Fig. 77; Pulvertaft & Chalmers 1990).

Lithology. In the type section, the Itilli Formation comprises mudstones, thinly interbedded sandstones and mudstones, chaotic beds, amalgamated beds of coarse-grained to very coarse-grained sandstone, and giant-scale cross-bedded sandstones (Figs 66, 68, 69, 70, Plate 2; Dam & Sønderholm 1994). These lithological contrasts are reflected in the blocky pattern in the petrophysical logs of the GRO#3 well (Fig. 67; Kristensen & Dam 1997).

In the Aaffarsuaq area, the Itilli Formation comprises mudstones, thinly interbedded sandstones and mudstones, and amalgamated sandstone and conglomerate units together with chaotic beds comparable to those in the Itilli valley (Dam *et al.* 2000). The main differences between the Itilli and Aaffarsuaq areas are that most of the channelled amalgamated sandstone and conglomerate units in Aaffarsuaq are separated from the underlying deposits by major erosional surfaces or minor angular unconformities and that they are generally coarser-grained than their Itilli counterparts. Furthermore, the chaotic beds in Aaffarsuaq occur at many levels in the section and are not restricted to a position immediately underlying a channelled sandstone unit, and the interbedded sandstone and mudstone units often show an overall thinning-upward trend.

The amalgamated sandstone and conglomerate units of the Aaffarsuaq area consist of very coarse- to medium-grained sandstone and conglomerate beds grading upward into thinly interbedded sandstones and mudstones. These coarse-grained units are up to 50 m thick, extend laterally beyond the extent of outcrop (several hundred metres)

Fig. 67. Lithological log of the GRO#3 well interpreted from petrophysical data. GR, Spectral gamma-ray log; DTC, Sonic log; Con., Coniacian; Maastricht., Maastrichtian; Strat., lithostratigraphy; T.D., total depth. Modified from Christiansen *et al.* (1999). For location, see Fig. 65.

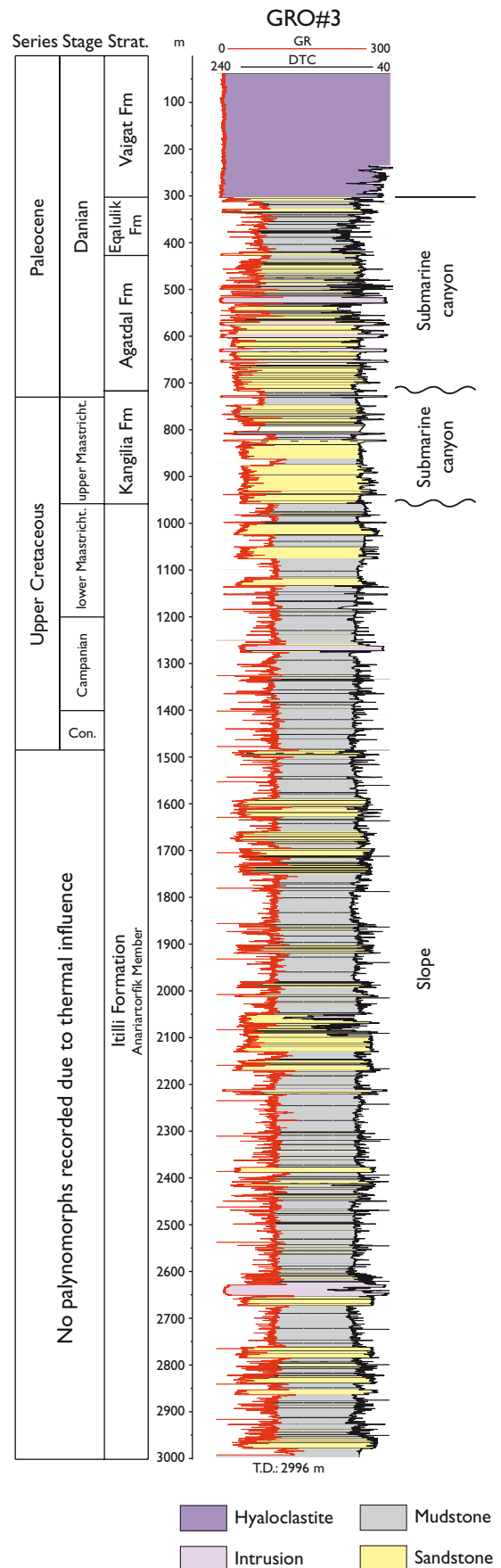




Fig. 68. Outcrop of the Itilli Formation in the type locality in the Anariartorfik gorge showing amalgamated sandstones and thinly interbedded sandstones and mudstones (prominent sandstone unit is approximately 30 m thick). Anariartorfik section 930–1010 m (Plate 2). For location, see Fig. 65.



Fig. 69. Thinly interbedded sandstones and mudstones of the Itilli Formation in the Anariartorfik section (1070–1150 m; Plate 2). For location, see Fig. 65.



Fig. 70. Amalgamated sandstones of the Itilli Formation (Anariartorfik Member) deposited from turbidity currents in slope channels overlying contorted mudstones (at river level). Pingunnguup Kuua section 460–510 m (Plate 2). The amalgamated sandstone unit is approximately 30 m thick and is cut by a dyke. For location, see Fig. 65.

and include clasts of intraformational mudstone, sandstone (probably derived from the underlying Atane Formation), redeposited concretions and basement lithologies.

On the north coast of Nuussuaq and on Svartenhuk Halvø, the formation is dominated by mudstones, thinly interbedded sandstones and mudstones, and bioturbated thinly interbedded sandstones and mudstones. These lithologies are arranged in coarsening-upward successions 10–50 m thick (Fig. 75).

At Kussinerujuk on the north coast of Disko, the formation consists of sandstones and conglomerates with angular cobbles and boulders of mudstone, sandstone, or interbedded sandstone and mudstone. Other clasts consist of rounded pebbles of quartz and clay ironstone (Fig. 77; Pulvertaft & Chalmers 1990, fig. 6). At Asuk, the formation consists of a basal sandstone or conglomerate bed succeeded by sand-streaked mudstones (Fig. 55).

Fossils. Ammonites, belemnites, inoceramid bivalves (Fig. 71) and rare crustaceans and corals are present in the formation at several localities on Nuussuaq and Svartenhuk Halvø (Birkelund 1965; Rosenkrantz 1970; Dam *et al.* 2000). However, most of these are not found *in situ* in the outcrops and may furthermore be reworked intraformationally or derived from older deposits. Dinocysts, spores and pollen occur throughout in small numbers but cannot be determined neither in the lower part of the Umiivik-1 and GRO#3 wells nor from the outcrops in the Itilli valley. Burrows are occasionally present at the top of sandstone beds. Details of fossil contents are presented under the description of individual members.

Depositional environment. The Itilli Formation was primarily deposited in slope and submarine fan environments. In the type area the amalgamated sandstones were deposited in slope channels initiated during sea level lowstands whereas the mudstones and the thinly interbedded sandstones and mudstones were deposited in inter-channel slope areas (Dam & Sønderholm 1994). Details on the depositional environment are presented under the description of individual members.

Boundaries. On the north coast of Nuussuaq, the Itilli Formation overlies the Atane Formation in a small and poorly exposed section at high altitude immediately east of the Ikorfat Fault (Fig. 22; A.K. Pedersen *et al.* 2006b). The boundary with the underlying Atane Formation is well exposed on central Nuussuaq along the northern slope of the Aaffarsuaq valley between Qilakitsoq and Tunoqu (Fig. 82; Nøhr-Hansen 1996; Dam *et al.* 2000) and on northern Disko at Kussinerujuk and Asuk (Fig. 2). In Aaffarsuaq, the lower boundary is placed at the unconformity between the Santonian deltaic deposits of the Atane Formation and the first turbidite sandstone or mudstone deposits of the Campanian Aaffarsuaq Member (Fig. 83). At Kussinerujuk and Asuk, the lower boundary is an erosional unconformity between the deltaic deposits of the Atane Formation and the slope deposits of the Itilli Formation (Figs 55, 77, 78, 79).

The upper boundary is well exposed on northern Nuussuaq where it is defined at a major unconformity with the upper Maastrichtian – Lower Paleocene Anner-tuneq Conglomerate Member of the Kangilia Formation (Figs 72, 76, 87). However, in areas outside the distribution of the Anner-tuneq Conglomerate Member, there



Fig. 71. Giant inoceramid bivalves on top of a turbidite sandstone bed of the Itilli Formation (Aaffarsuaq Member) in the second ravine east of Qilakitsoq. For location, see Fig. 82.



Fig. 72. Unconformity between the Itilli Formation (Umiivik Member) and the overlying Kangilia Formation with the resistant pale-weathering Annertuneq Conglomerate Member at the base. North coast of Nuussuaq, at Annertuneq. Base of conglomerate is at c. 300 m a.s.l. For location, see Fig. 74.

is no lithological contrast at the boundary between the Itilli and Kangilia Formations and in these areas biostratigraphic data may be essential for the distinction between the Turonian to lower Maastrichtian Itilli Formation and the mainly Danian Kangilia Formation. On Svartenhuk Halvø, the formation is overlain by hyaloclastite of the Vaigat Formation or, as observed on the east slope of Firefjeld, by a conglomeratic unit that may be correlated with either the Agatdal Formation or with the Quikavsak Formation. The upper boundary of the Itilli Formation is not exposed on northern Disko.

On the north coast of Nuussuaq and in the GANT#1 and GRO#3 wells, the Itilli Formation is unconformably overlain by the Kangilia Formation (Figs 67, 72, 87). Along the Aaffarsuaq valley, the upper boundary is ambiguous and can be difficult to identify. East of Qilakitsoq, however, Campanian deposits of the Itilli Formation are overlain by a Paleocene conglomerate/sandstone unit referred to the Eقالulik Formation (Fig. 83) thus indicating a major unconformity. At Nassaat, a tributary on the south-eastern side of Agatdalen, the presence of Upper Santonian mudstones with *Sphenocerasmus* was reported by Rosenkrantz (1970); this succession is now referred to the Itilli Formation. At this locality, the mudstones are overlain by pebbly sandstones and bituminous mudstones, a unit that referred to the Agatdal Formation by Rosenkrantz (1970 fig. 4c) but to the Upper Atanikerdluk Formation (Quikavsak Formation of this paper) by Koch (1959 fig. 37). No new data are available from this outcrop.

Geological age. A ?Late Turonian to early Maastrichtian age range for the formation is indicated by the ammonite

fauna (Fig. 16). Palynomorph data are generally in accordance with the ammonite data, but local discrepancies occur, probably due to redeposition of ammonites from the underlying deposits.

At Asuk and Kussinerujuk on northern Disko, the Itilli Formation is of Cenomanian–Turonian age (Fig. 16; Bojesen-Koefoed *et al.* 2007) whereas on Svartenhuk Halvø, the formation is of Turonian to Early Campanian age (Fig. 16; Nøhr-Hansen 1996, unpublished data; Dam *et al.* 1998b). Strata of Campanian age referred to the Hilli Formation are also exposed on Nuussuaq (Itilli, Aaffarsuaq, Agatdalen; Birkelund 1965; Sønderholm *et al.* 2003). The Maastrichtian part of the formation is only known from Kangilia and Aaffarsuaq (Birkelund 1965; Rosenkrantz 1970; Nøhr-Hansen 1996) and has been dated in the GRO#3 well (Sønderholm *et al.* 2003). Detailed information on the age of the various members is found in the description of the members below.

Correlation. The pre-Early Campanian part of the formation is coeval with the Atane and Upernivik Næs Formations (Fig. 16).

Subdivision. Four members are recognised, the Anariartorfik, Umiivik, Kussinerujuk, and Aaffarsuaq Members, of which the Anariartorfik Member is found only west of the Kuugannguaq–Qunnilik Fault. The Anariartorfik Member consists of interbedded turbidite channel sandstones and mudstones deposited in a fault-controlled slope environment. The Umiivik Member is the northernmost representative of the Itilli Formation. It is finer grained than the Anariartorfik Member, and dominated by major coarsening-upward successions

deposited in a base-of-slope and basin-floor fan environment. Both the Anariartorfik and Umiivik Members record deposition from probably the Cenomanian to the Maastrichtian. The Kussinerujuk Member is only exposed on northern Disko at Asuk and Kussinerujuk and represents a Cenomanian transgressive event on top of the Atane Formation. The Aaffarsuaq Member crops out east of the Kuuganguaq–Qunnilik Fault on central Nuussuaq and comprises a relatively thin wedge of Lower to Middle Campanian strata that are distinctly different from the Anariartorfik Member with regard to their large content of intraformational clasts, the overall lack of fine-grained mudstones and the lenticular shapes of the thinly interbedded sandstone and mudstone units. The sediments of the Aaffarsuaq Member were deposited in a deep marine, channelled footwall fan system.

Anariartorfik Member

new member

History. Strata referred here to the Anariartorfik Member were described informally as the Itilli Formation by J.M. Hansen (1980b). Detailed studies of strata assigned to the Anariartorfik Member were published by Dam & Sønderholm (1994) and Madsen (2000).

Name. The member is named after the Anariartorfik valley leading into the Itilli valley (Fig. 65).

Distribution. The Anariartorfik Member is exposed in the Itilli valley and is present in the subsurface west of the Kuuganguaq–Qunnilik Fault in the western part of Nuussuaq (Fig. 11).

Type section. The type section is the same as for the Itilli Formation in the southern part of the Itilli valley (Figs 65, 66, Plate 2). The base of the type section is located at 70°36.35'N, 54°13.79'W.

Reference sections. Well-exposed reference sections are located in the northern part of the Itilli valley and in the adjoining Tunorsuaq valley (Figs 2, 65, 74).

The member was cored in the FP94-9-01 borehole between 32 and 522 m in the central part of the Itilli valley (Fig. 65; Madsen 2000); the cores are stored at GEUS in Copenhagen. The member was drilled but not cored in the GRO#3 well between 959 m and 2996 m (Figs 65, 67; Kristensen & Dam 1997).

Thickness. The member has a thickness (including intrusions) of at least 2037 m in the GRO#3 well. Approximately 1400 m are exposed in two incomplete sections in the Itilli valley (Fig. 65, Plate 2).

Lithology. In the type section, the Anariartorfik Member is dominated by mudstones and thinly interbedded sandstones and mudstones, chaotic beds, amalgamated beds of coarse-grained to very coarse-grained sandstones, and giant-scale cross-bedded sandstones (Figs 66, 68, 69, 70, Plate 2; Dam & Sønderholm 1994). These lithological contrasts create a characteristic blocky pattern in the petrophysical log of the GRO#3 well (Fig. 67; Kristensen & Dam 1997).

The mudstones are dark grey to black, show parallel lamination and occur in intervals up to 15 m thick in the type section. Persistent layers of early diagenetic ankerite concretions occur in most mudstone intervals.

The thinly interbedded sandstone and mudstone units comprise laterally extensive graded laminae and beds of fine- to very coarse-grained sandstone capped by parallel-laminated mudstones; this facies forms successions several tens of metres in thickness (Plate 2). The sandstone beds range in thickness from less than 1 cm to 80 cm, have flat, locally scoured bases and show normal grading; the beds may be structureless near their base or may be parallel- or cross-laminated throughout. The sandstone beds are laterally persistent at outcrop scale (> 100 m) and there is generally no systematic variation in thickness. Convolute bedding and slump structures are common. Early diagenetic ankerite concretions are common in the mudstone units.

The chaotic beds are up to 30 m thick and consist of contorted, laminated mudstone, thinly interbedded sandstone and mudstone, and homogenised mudstone with scattered sand grains, reworked early diagenetic ankerite concretions, semi-indurated mudstone and sandstone clasts and occasional basement clasts. The chaotic beds invariably underlie a thick unit of amalgamated sandstone beds and are often associated with sandstone dykes (Fig. 66, Plate 2).

The amalgamated sandstone beds form up to 50 m thick channel-shaped bodies that can be followed for 1–2 km along strike (Figs 66, 68, 70, Plate 2). The sandstone units are erosionally based and locally show well-developed flute casts and channel-shaped scours at the base. The sandstone units may show a thinning-upward trend and have a gradational or sharp, but non-erosional contact to the overlying interbedded sandstone and mudstone units. Internally, the sandstone units are dominated by amalgamated, normally graded, medium-grained

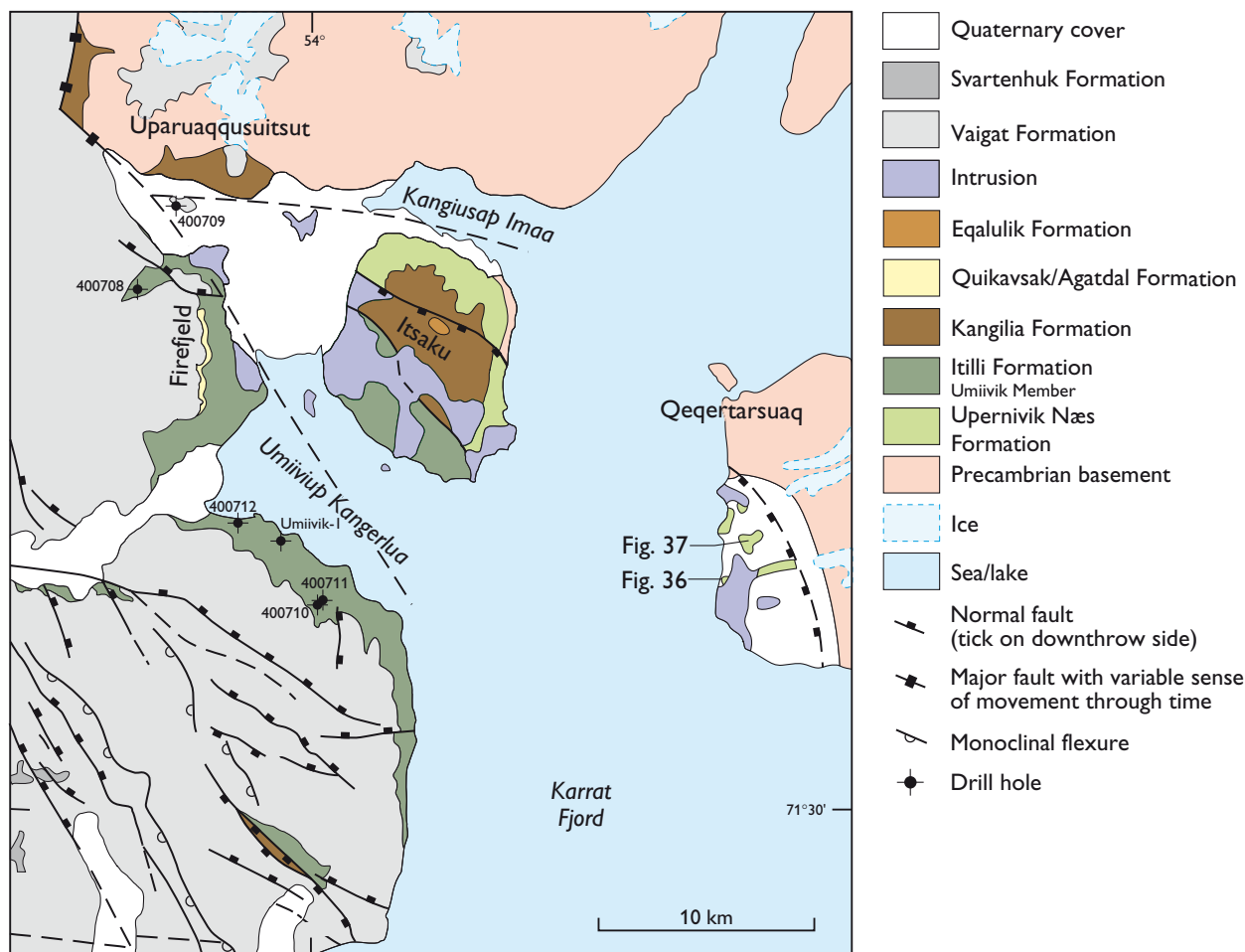


Fig. 73. Geological map of the south-eastern part of Svartehuk Halvø and the west coast of Qeqertarsuaq showing the location of the Umiivik-1 well (type section of the Umiivik Member of the Itilli Formation) and the position of shallow wells drilled by GGU in 1992 (GGU 400708–400712). Reference sections of the Upernivik Næs Formation on Qeqertarsuaq are indicated (see Figs 36, 37). For location, see Fig. 2. Modified from J.G. Larsen & Grocott (1991) and J.G. Larsen & Pulvertaft (2000).

to pebbly, very coarse-grained sandstone beds (0.1–3.5 m thick) or, less commonly, show planar and trough cross-bedding. The graded beds have planar, erosional bases and can be followed laterally for more than 140 m without major variations in thickness (Figs 66, 68, 70). Angular mudstone clasts, ranging from a few millimetres to 45 cm across and rounded basement pebbles up to 8 cm across are common in the graded beds. In some cases, the uppermost part of the graded sandstone beds show well-developed parallel lamination, with parting lamination and tool marks, trough cross-bedding, low-angle cross-bedding and climbing ripple lamination. The graded sandstone beds are commonly separated by thin mudstone beds or units of thinly interbedded mudstone and sandstone.

Giant-scale cross-bedded sandstone units occur as channel-shaped bodies at a few levels in the type section. The units comprise 7–15 m thick low-angle, cross-bedded sets dominated by coarse- to medium-grained sandstone; the sets can be followed for approximately 150 m in a dip direction. At one locality, a single set fills out a large channel-shaped erosional depression that is approximately 300 m wide (Plate 2 at 800 m; Dam & Sønderholm 1994).

Fossils. Macrofossils have not been found in this member, but burrows are locally present at the top of the sandstone beds. They include common *Ophiomorpha* sp., *Thalassinoides* sp., escape burrows, and rare *Helminthopsis* sp. (Dam & Sønderholm 1994). Identifiable palynomorphs are very rare in the area of the type sec-

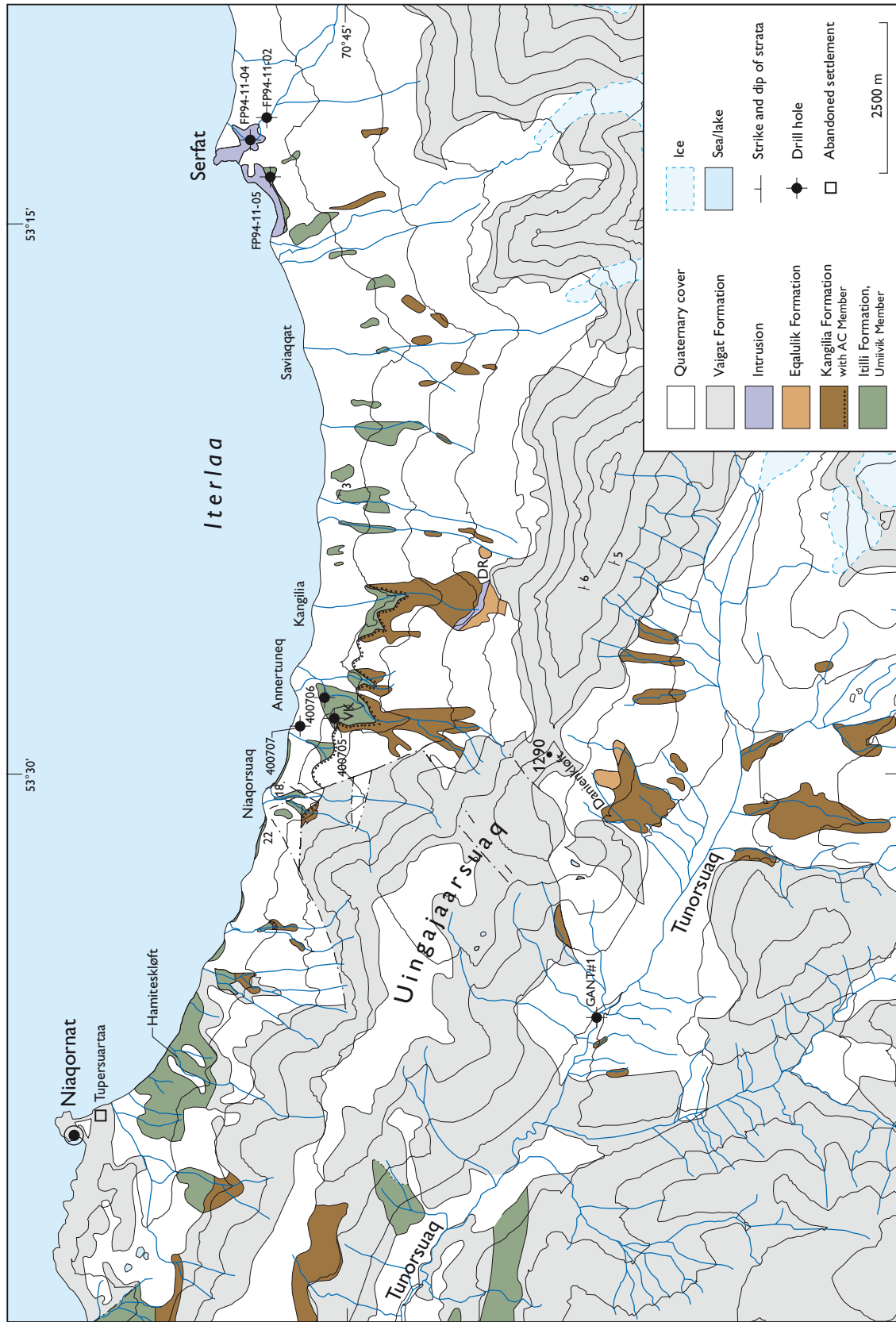


Fig. 74. Geological map of the north coast of Niuussuaq showing outcrops of the Itrilla and Kangilia Formations. The wells FP94-11-02, -04 and -05 are located near Serfat. The shallow wells drilled by GGU in 1992 (GGU 400705–400707) are located at Annerturneq. The GANT#1 well is in the Tunorsuaq valley. DR, Danierygge; AC, Annerturneq Conglomerate Member. Contour interval is 200 m. For location, see Fig. 2. Modified from Rosenkrantz *et al.* 1974.

tion, but are abundant in the cuttings from the middle and upper part of the GRO#3 well (Nøhr-Hansen 1997c).

Depositional environment. Deposition of the Anariartorfik Member took place in a fault-controlled slope environment (Dam & Sønderholm 1994). Most of the channelised amalgamated turbidite sandstone beds were deposited from high-density turbidity currents in confined low-sinuosity channels, although a few examples of giant-scale, cross-bedded sandstones are interpreted as the products of lateral accretion in meandering slope channels.

The thinly interbedded sandstones and mudstones are interpreted as having been deposited from traction currents and from fall-out processes associated with various sedimentation stages within waning low-density currents. The lateral continuity and the lack of systematic vertical thickness variations in the thinly interbedded sandstones and mudstones suggest that these deposits were not confined by channel-levee systems, but most likely represent interchannel slope deposits.

Where present, the chaotic beds always underlie undisturbed channel sandstones. This suggests that the channels were initially excavated by retrogressive slumping of unstable sediments on the slope followed by channel excavation by scouring (Dam & Sønderholm 1994).

Boundaries. The lower and upper boundaries of the Anariartorfik Member are not exposed. The upper boundary was drilled in the GRO#3 well but not cored (Fig. 67). An erosional unconformity between the Anariartorfik Member and the overlying Kangilia Formation was suggested by Kristensen & Dam (1997).

Geological age. Palynomorphs in the GRO#3 well indicate a ?Coniacian/Santonian – early Maastrichtian age for the uppermost *c.* 525 m of the Anariartorfik Member. In the lowermost 1510 m of the well, the organic material is degraded due to thermal maturation and this part of the formation cannot be dated (Nøhr-Hansen 1997c).

Umiivik Member

new member

History. Outcrops of marine Upper Cretaceous strata referred to the Umiivik Member on Svartenhuk Halvø and northern Nuussuaq have only been briefly described by earlier workers since their main focus was on the collection of fossils (Rosenkrantz *et al.* 1942; Birkelund

1956, 1965; Rosenkrantz 1970). Later studies in connection with mapping by the Geological Survey and drilling of stratigraphic wells in the Umiivik area of Svartenhuk Halvø have been reported by Christiansen (1993), Dam *et al.* (1998b), Christiansen *et al.* (2000) and J.G. Larsen & Pulvertaft (2000). On northern Nuussuaq, extensive stratigraphic studies have been carried out at Annertuneg and Kangilia (Christiansen *et al.* 1992; Christiansen 1993; Christiansen *et al.* 1994) and at Serfat in connection with drilling of mineral exploration wells (Dam & Nøhr-Hansen 1995).

Name. The member is named after the stretch of shore located south-east of Firefjeld in the inner part of the Umiivik Kangerlua bay, eastern Svartenhuk Halvø (Fig. 73).

Distribution. On Svartenhuk Halvø, the Umiivik Member is locally exposed in the north-western part of the peninsula (Fig. 2), and more extensively in the low-lying coastal outcrops around the bay of Umiivik Kangerlua, and *c.* 5 km north-west of the south-eastern corner of the peninsula (Fig. 73). On Nuussuaq, exposures are found along the north coast between Niaqornat and Ikorfat and in the Tunorsuaq valley (Figs 2, 74).

On Svartenhuk Halvø, the member has been cored in five shallow wells (GGU 400708–712; Christiansen 1993; Christiansen *et al.* 1994a) and in the deep Umiivik-1 well (Fig. 73; Christiansen *et al.* 1994; Nøhr-Hansen 1996; Christiansen *et al.* 1997; Dam 1997; Nøhr-Hansen 1997a; Dam *et al.* 1998b).

On the north coast of Nuussuaq the member has been penetrated in six shallow boreholes: GGU 400705–707 and FP4-11-02, FP94-11-04 and FP94-11-05 (Christiansen *et al.* 1994; Dam & Nøhr-Hansen 1995), and in the deep GANT#1 well (Fig. 74; Christiansen *et al.* 1996c; Dam 1996a; Dahl *et al.* 1997; Nøhr-Hansen 1997b; Kierkegaard 1998).

Type section. The most complete section of the member is available in the Umiivik-1 core drilled on the southern shore of Umiivik Kangerlua on Svartenhuk Halvø (GGU 439301; Figs 73, 75). Neither the base nor the top of the member is, however, seen in this well. The cores are stored at GEUS in Copenhagen. The Umiivik-1 well is located at 71°36.70'N, 54°02.52'W.

Reference sections. The best-exposed outcrops of the Umiivik Member are found below the Kangilia Formation (Annertuneg Conglomerate Member) at Annertuneg and Kangilia on the north coast of Nuussuaq (Figs 72,

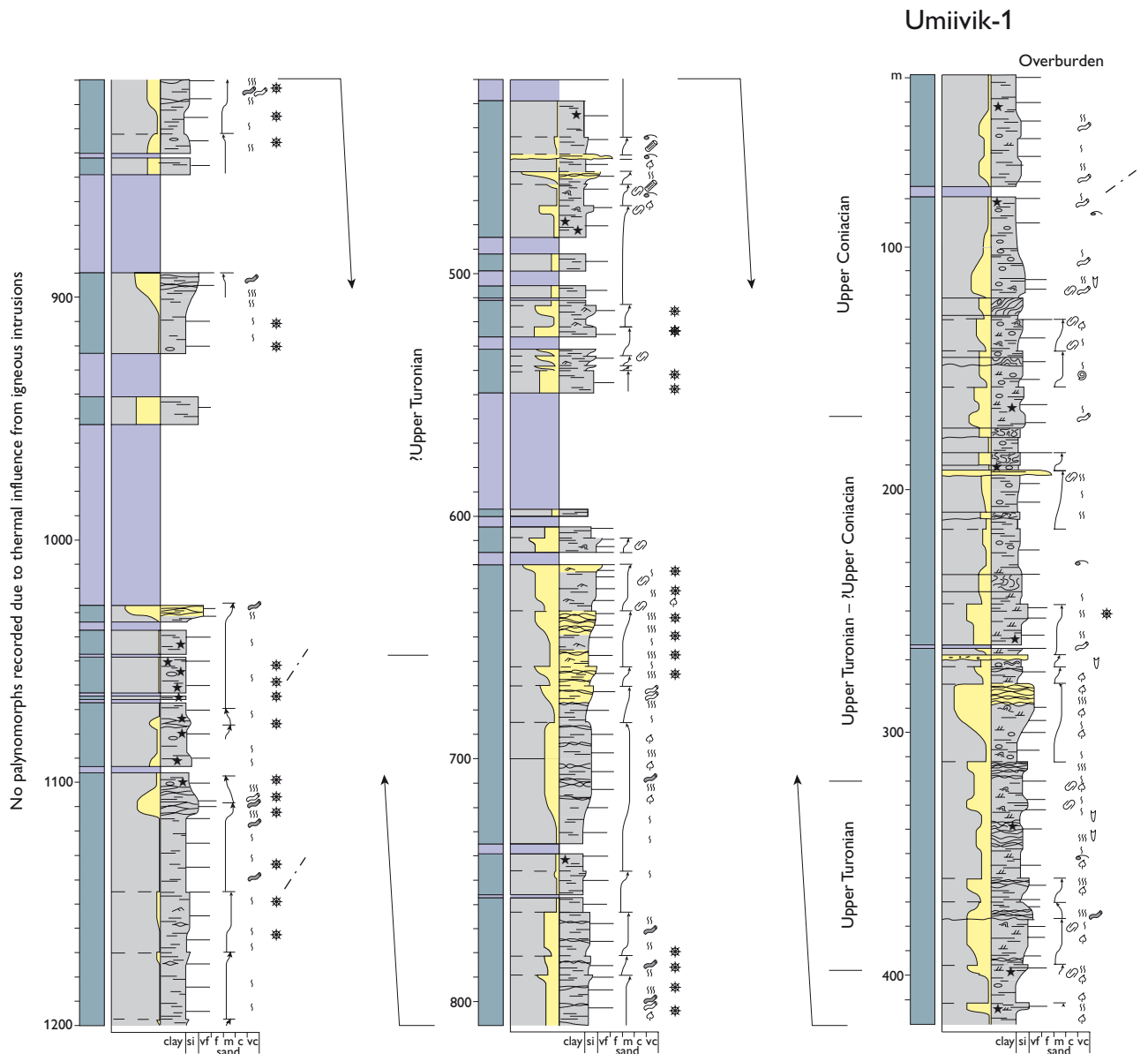


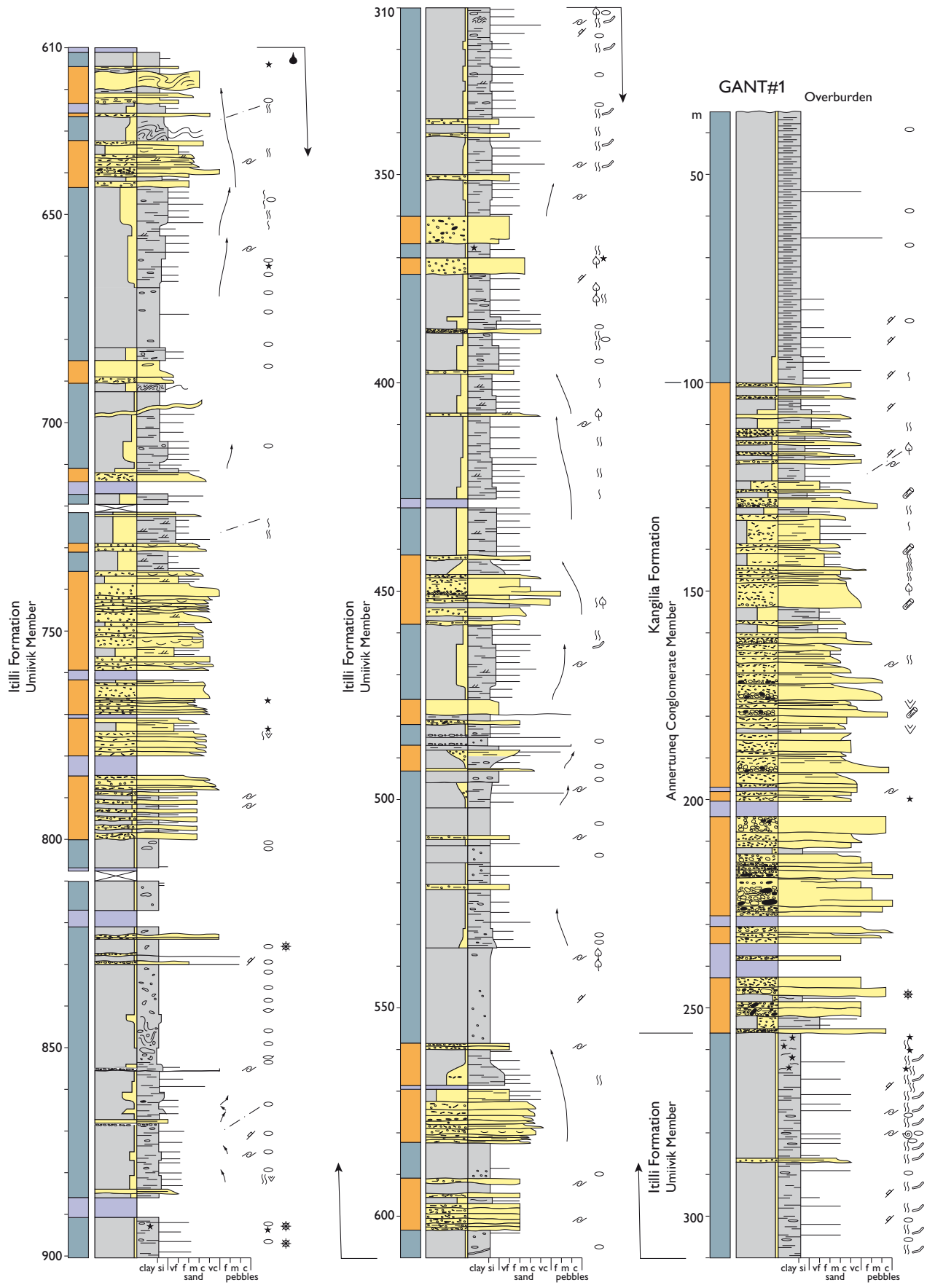
Fig. 75. Sedimentological log showing type section of the Umiivik Member (Itilli Formation) in the Umiivik-1 well. For location, see Fig. 73; for legend, see Plate 1. Modified from Dam *et al.* (1998b).

87). At Annertuneq, the GGU cores 400705–707 were drilled to supplement the outcrop studies (Fig. 74; Christiansen *et al.* 1994). In the GANT#1 well, the interval from 255.8 m to 900.6 m (Fig. 76) is assigned to the Umiivik Member (Dam 1996a). The cores are stored at GEUS in Copenhagen.

Thickness. The total thickness of the Umiivik Member is unknown, but in the Umiivik-1 well on Svartenhuk Halvø it is at least 960 m thick (excluding a total of 22 dolerite intrusions with a cumulative thickness of 240.2

m). In the slopes behind the Umiivik-1 drill site, approximately 185 m of poorly exposed mudstone is present below the base of the hyaloclastic volcanic rocks of the Vaigat Formation – this part of the succession is partly penetrated by the cores 400710–711 (Fig. 73; Christiansen *et al.* 1994). In the GANT#1 well, on northern Nuussuaq, 620 m have been cored (excluding intrusions).

Lithology. The Umiivik Member is dominated by black mudstones intercalated with laminae and thin beds of sandstone; carbonate concretions are common (Figs 75,



76). Heavily bioturbated interbedded sandstones and mudstones, chaotic beds, and structureless, muddy sandstones also occur. Indistinct thickening- and coarsening-upward cycles, 2–85 m thick, can be seen in the Umiivik-1, FP94-11-02 and FP94-11-04 wells (Fig. 75; Dam & Nøhr-Hansen 1995). A cobble conglomerate composed of lithified sandstone clasts in a mudstone matrix is exposed in stream gullies on the south side of Uparuaqqusuitsut on north-eastern Svartenhuk Halvø (Fig. 73; Christiansen *et al.* 2000).

In the GANT#1 core, chaotic beds, muddy sandstones and sandy mudstones alternate with thick, sharp-based fining-upward successions (Fig. 76; Dam 1996a). The fining-upward successions consist of amalgamated sandstone beds grading upward into thinly interbedded sandstones and mudstones. Thin coarsening-upward successions also occur. The amalgamated sandstones consist of normally graded, medium- to coarse-grained sandstone beds with scattered basement pebbles and mudstone intraclasts. The sandstone beds are generally structureless, but parallel and cross-lamination occurs towards the top of some beds. A thin mudstone layer usually caps the sandstone beds.

The thinly interbedded sandstones and mudstones consist of sharp-based, graded laminae and beds of fine-grained to very coarse-grained sandstone alternating with black parallel-laminated mudstones. The sandstones are well-sorted and may show parallel and cross-lamination; small mudstone rip-up clasts frequently occur throughout the sandstone beds.

Fossils. Ammonites from the Umiivik Member have been described from several localities on Svartenhuk Halvø and include *Scaphites mariasensis umiivikensis* (Birkelund), *Scaphites preventricosus svartenhukensis* (Birkelund), *Clioscapites* sp. aff. *saxitonianus* (McLearn), *Scaphites cobbani* (Birkelund), *Scaphites rosenkrantzi* (Birkelund), *Scaphites* cf. *corvensis* (Cobban), *Clioscapites saxitonianus septentrionalis* (Birkelund), ammonites of the genus *Haresiceras* and inoceramids of the steenstrupi group (Birkelund 1965). Belemnites from Svartenhuk Halvø

include *Actinocamax* cf. *primus* (Arkhangelsky) and *Actinocamax* sp. (Birkelund 1956). Unidentified teleost fish remains have also been found in strata yielding Coniacian ammonites (Bendix-Almgreen 1969).

Ammonites occur at several localities along the north coast of Nuussuaq in the Umiivik Member, including *Pseudophyllites skoui* (Birkelund), *Scaphites* (*Hoploscapites*), *S. (H.) greenlandicus* (Donovan), *S. (H.) ravni* (Birkelund), and *S. (H.) ikorfatensis* (Birkelund). The belemnites *Actinocamax groenlandicus* (Birkelund) and *Actinocamax* aff. *groenlandicus* (Birkelund), and an indeterminate solitary corallum have also been collected (Birkelund 1956, 1965; Floris 1972).

Dinocysts are abundant in the Umiivik Member (Dam & Nøhr-Hansen 1995; Nøhr-Hansen 1996, 1997a; Dam *et al.* 1998b).

Depositional environment. The Umiivik Member records deposition from low-density and high-density turbidity currents, debris flows, slumping and fall-out from suspension. Deposition of the mudstones and intercalated mudstones and sandstones took place in a base-of-slope and basin-floor fan environment. The succession in the GANT#1 well, which is situated close to the Kuuganguaq–Qunnilik Fault, reflects a fault-controlled base-of-slope environment with major and minor tributary feeder channels, small turbidite lobes and interdistributary channel areas.

Boundaries. The Umiivik Member unconformably overlies the Atane Formation on the north coast of Nuussuaq in a small and poorly exposed section at high altitude immediately east of the Ikorfat Fault (Fig. 22; A.K. Pedersen *et al.* 2006b).

West of the Ikorfat Fault, the lower boundary of the Umiivik Member is not exposed and has not been drilled. On northern Nuussuaq, the member is unconformably overlain by the Kangilia Formation (Figs 72, 74, 87). At most localities on Svartenhuk Halvø, it is unconformably overlain by Paleocene hyaloclastic rocks of the Vaigat Formation (Fig. 73). At Firefjeld, however, a thin Paleocene conglomeratic unit that may be correlated with either the Agatdal Formation or the Quikavsak Formation is present between the Umiivik Member and the volcanic succession.

Geological age. The age of the Umiivik Member is based on dinocyst and ammonite data (Birkelund 1965; Nøhr-Hansen 1996, 1997a). The ammonites from Svartenhuk Halvø indicate a ?Late Turonian – Early Campanian age for the Umiivik Member in this area (Fig. 16). Dinocysts

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Fig. 76. Sedimentological log of the Umiivik Member (Itilli Formation) and the Annertuneq Conglomerate Member (Kangilia Formation) in the GANT#1 well. For location, see Fig. 74; for legend, see Plate 1. Modified from Dam (1996a).

from the Umiivik-1 well indicate a ?Late Turonian – Late Coniacian age for the uppermost 659 m of the well; below this palynomorphs are not preserved due to severe alteration of the mudstones by the Paleocene dolerite intrusions. It is likely, however, that the core includes Cenomanian–Turonian strata (Nøhr-Hansen 1997a; Dam *et al.* 1998b). Dinocysts from outcrops and from the three shallow wells (GGU 400710, 400711, 400712) along the southern shore of Umiiviup Kangerlua on Svartenhuk Halvø indicate a Santonian to Early Campanian age (Nøhr-Hansen 1996).

On the north coast of Nuussuaq, the ammonites indicate the presence of Upper Campanian and Maastrichtian strata which is in accordance with palynostratigraphic dating (Birkelund 1965; Nøhr-Hansen 1996).

Kussinerujuk Member

new member

History. On northern Disko at Kussinerujuk and Asuk, local outcrops of conglomerate, sandstone and mudstone unconformably overlying the Atane Formation have previously been correlated with the Paleocene Kangilia Formation (J.M. Hansen 1980b; Pulvertaft & Chalmers 1990). Later, these beds were included in the Asuup Innartaa Member of the Danian Quikavsak Formation (Dam 2002). On the basis of new biostratigraphic data, however, these are here assigned to the Kussinerujuk Member of Cenomanian–Turonian age (Bojesen-Koefoed *et al.* 2007).

Name. The member is named after Kussinerujuk on the north coast of Disko, where it is exposed in narrow gorges (Fig. 2).

Distribution. The member is only known from the north coast of Disko around Kussinerujuk and Asuk.

Type section. The type section of the member is in the ravines at Kussinerujuk (Figs 2, 77, 78). The type section is located at 70°13.10'N, 53°27.68'W.

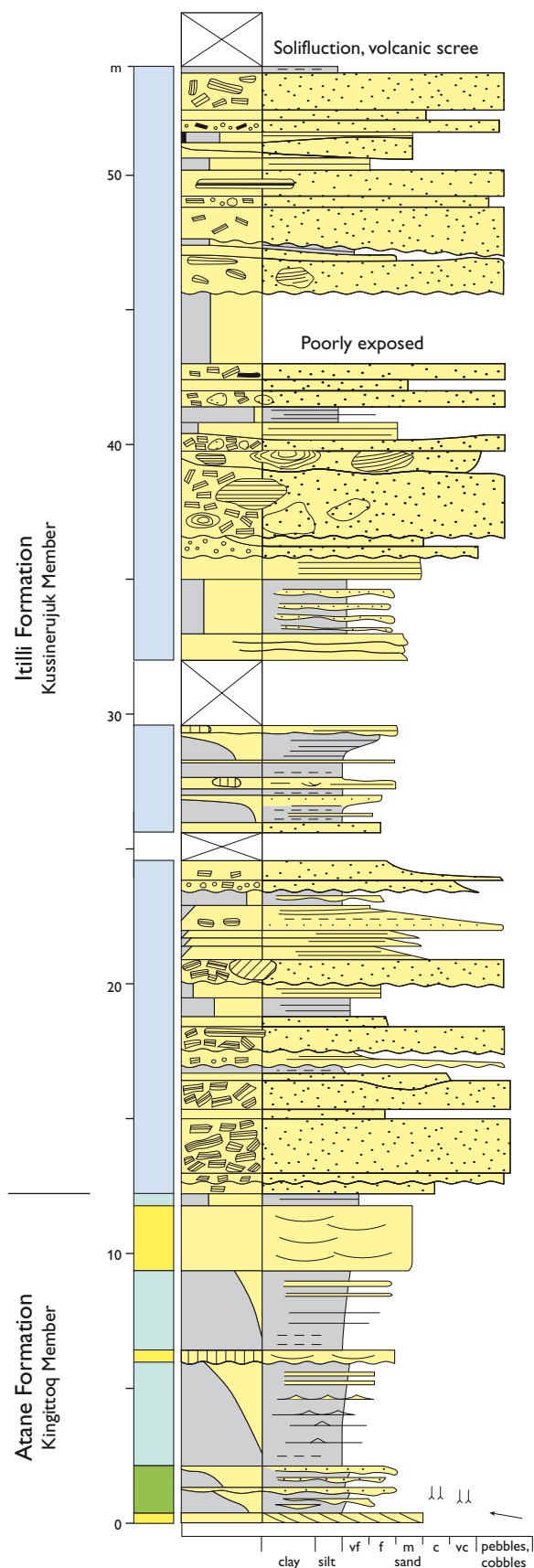
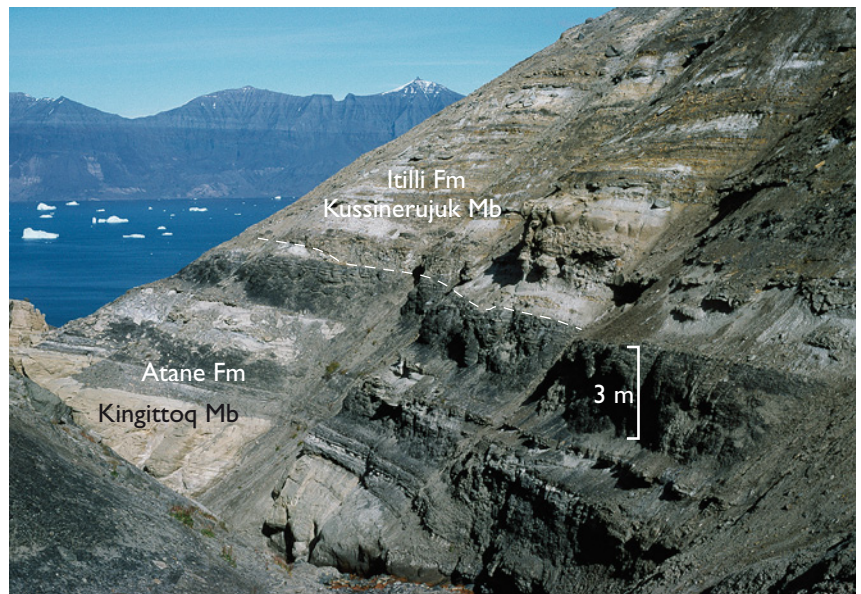


Fig. 77. Type section of the Kussinerujuk Member (Itilli Formation) at Kussinerujuk, north coast of Disko. For location, see Fig. 2; for legend, see Plate 1. Base of section is *c.* 450 m a.s.l.

Fig. 78. Type locality of the Kussinerujuk Member (Itilli Formation) at Kussinerujuk. Note the basal erosional boundary with the Atane Formation beneath; the uppermost depositional unit underlying the Kingittoq Member is a dark grey, delta front mudstone. The Kussinerujuk Member is dominated by mud-clast conglomerates with a matrix of sand (see Fig. 77). For location, see Fig. 2.



Reference sections. Reference sections are found in the coastal cliffs east of Asuk (Figs 55, 79). The lithologies here differ from those of the type section but are locally affected by complicated deformation resulting from landslides obscuring the stratigraphic relationships (Bojesen-Koefoed *et al.* 2007).

Thickness. At Kussinerujuk the measured part of the formation is at least 42 m thick (Fig. 77; see also Pulvertaft & Chalmers 1990) but the member may be up to a couple of hundred metres thick.

Lithology. The Kussinerujuk Member comprises thinly interbedded mudstones and sandstones, and mudstone clast conglomerates, first described by Pulvertaft & Chalmers (1990 fig. 6).

At Kussinerujuk the member consists of mud-clast conglomerates of varying thicknesses, with angular clasts of cobble to boulder size, interbedded with medium- to coarse-grained sandstone (Fig. 77). In some conglomerate beds, the clasts are imbricated whereas other conglomerates appear to be disorganised. Pebble-sized clasts consist of rounded quartz and clay ironstone while angular cobbles and boulders consist of mudstone, sandstone, or interbedded sandstone and mudstone.

At Asuk, the Atane Formation is overlain by mudstones and sandstones that are referred to the Kussinerujuk Member. These sediments occur in three separate outcrops. The westernmost of these is seen in Fig. 79, the central outcrop is seen in Fig. 80, and the eastern is seen in the coastal cliff adjacent to the huge alluvial fan at

Qorlortorsuaq. The western outcrop is overlain by volcanic breccias and lavas of the Asuk Member (lower part of the Vaigat Formation; Bojesen-Koefoed *et al.* 2007). The volcanic rocks are part of a major landslide, and the complicated relationships seen in Fig. 79 suggest that the sediments at this locality are also affected by sliding; their stratigraphic relationships with the central and eastern outcrops are thus uncertain.

A simplified sedimentological log from the central outcrop is shown in Fig. 55. Here a basal conglomerate of mudstone and sandstone clasts in a matrix of coarse-grained sand erosionally overlies the Atane Formation and is succeeded by parallel-laminated sandstones interbedded with sand-streaked mudstones (Figs 55, 80).

The western, landslipped outcrops comprise a unit of parallel-laminated, sand-streaked mudstone, locally with small-scale load structures (Fig. 81A). Other units consist of strongly erosional, channellised sandstones that cut into mudstones (Fig. 81 B); thicker sandstone beds are fine- to medium-grained and show parallel lamination and ripple cross-lamination. Other sandstone beds are structureless and have erosional bases with sole-marks.

Fossils. Brackish to marine dinocysts occur in the member and are relatively abundant at Asuk (McIntyre 1994a, b) noted that rich pollen and spore assemblages dominated by bisaccate conifer pollen are present in the type section whereas dinocysts are very rare.

Depositional environment. The Kussinerujuk Member records a transgressive event on top of a variably incised



Fig. 79. Outcrops of the Itilli Formation at the western end of the coastal cliff section at Asuk. Outcrops of the Atane Formation are seen farthest to the east (left); for detail, see Fig. 57. The pale sandstones (centre-left) are impregnated with hydrocarbons (see Bojesen-Koefoed *et al.* 2007). The dark grey mudstones in the centre of the photograph are referred to the Kussinerujuk Member as are the sandstones to the west. The dark-weathering rocks cropping out above these sandstones are referred to the volcanic Asuk Member (Vaigat Formation). These volcanic rocks are part of a major landslide, and the complicated structural relationships between the pale sandstones and the mudstones of the Itilli Formation suggest that the coastal exposures may be affected by landslides. The height of the cliff is *c.* 30 m. For location, see Fig. 2.

surface capping the Atane Formation east of the Kuuganguaq–Qunnilik Fault. The genetic relationships between the two outcrop areas of the member are, however, poorly understood. The conglomerates at the type locality at Kussinerujuk were deposited from channelised sediment gravity flows at unknown water depths possibly generated by slope failure in a deeply incised channel. Farther east, at Asuk and Qorlortorsuaq, the mudstone-dominated succession is tentatively interpreted to be deposited in a marine environment during transgression. Deposition occurred below storm wave base on a gently sloping sea floor from low-energy unconfined turbidity currents or distal storm-generated flows.

Boundaries. The lower boundary, as exposed at Kussinerujuk, Asuk and Qorlortorsuaq (Fig. 2), is an erosional unconformity where mudstones or mud-clast conglomerates sharply overlie deltaic sandstones of the Atane Formation (Kingittoq Member; Figs 16, 55, 77). The upper boundary is not exposed, but is probably an erosional unconformity overlain by Paleocene hyaloclastite breccias of the Vaigat Formation.

Geological age. Spores, pollen and dinocysts indicate a Cenomanian to Late Turonian age for the member at Kussinerujuk (McIntyre 1994a, b; this study). Dinocysts indicate a Cenomanian age at Asuk (Fig. 16; Bojesen-Koefoed *et al.* 2007).

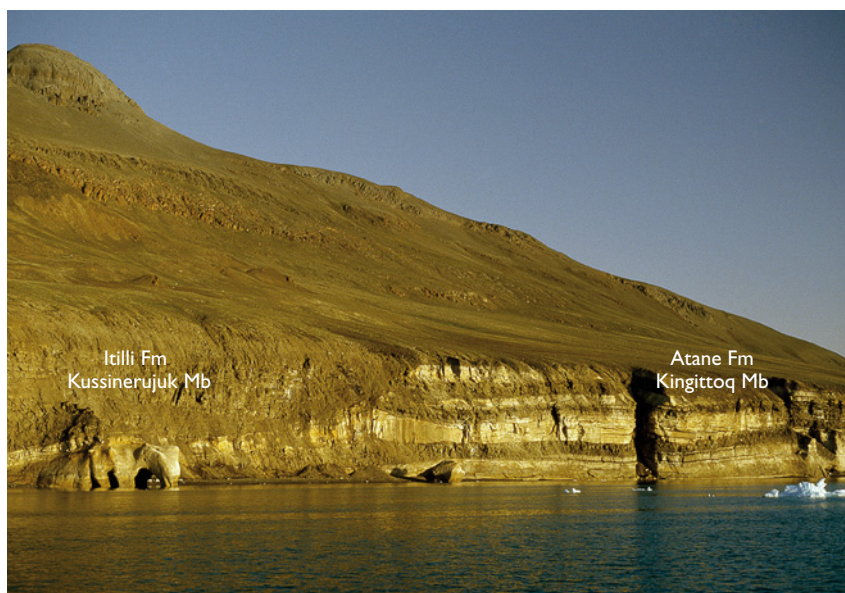


Fig. 80. Erosional unconformity between the Atane Formation and the Itilli Formation (see Fig. 55) in the coastal cliff east of Asuk. The coastal cliff is *c.* 30 high. For location, see Fig. 2.

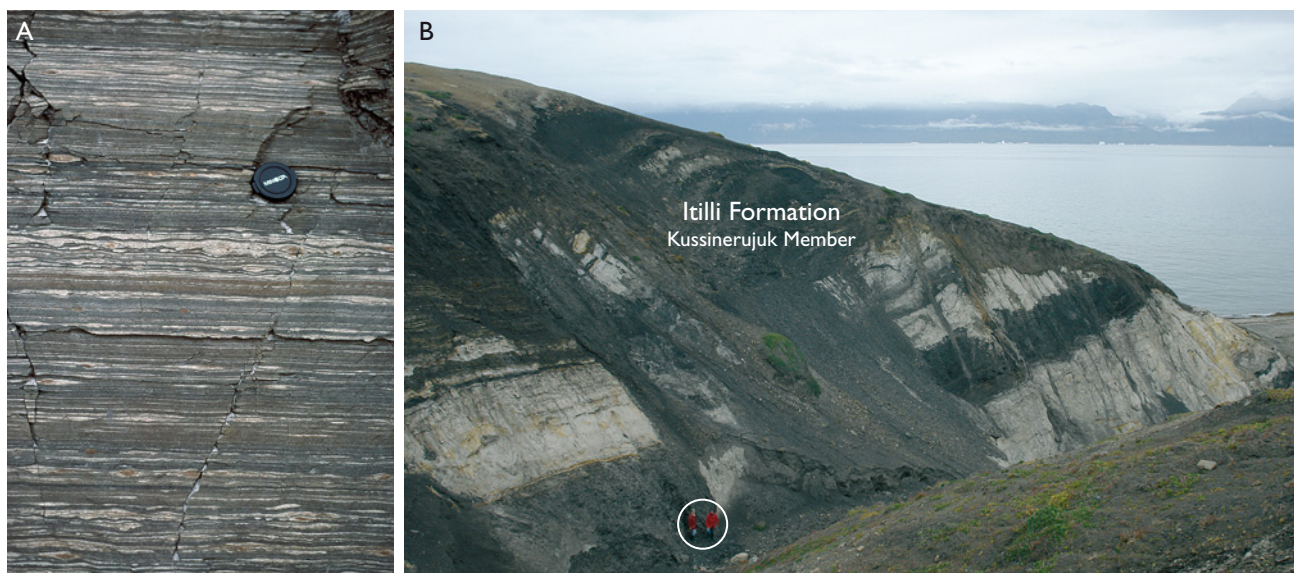


Fig. 81. A: Silt-streaked mudstone with small-scale load structures in the Kussinerujuk Member (Itilli Formation) at Asuk. Lens cap for scale. B: Land-slipped deposits of erosionally based sandstones interbedded with mudstones at Asuk are assigned to the Kussinerujuk Member of the Itilli Formation. Encircled persons for scale; for location, see Fig. 2.

Correlation. The Kussinerujuk Member is coeval with parts of the Umiivik and Anariartorfik Members of the Itilli Formation.

Aaffarsuaq Member

new member

History. The un-named Upper Cretaceous marine sandstones and shales exposed on central Nuussuaq that were informally referred to the Aaffarsuaq member by Dam *et al.* (2000), are mainly known for the remarkable discoveries in 1952 of huge specimens of Upper Santonian – Lower Campanian inoceramid (*Sphenoceramus*) bivalve shells (Fig. 71; Rosenkrantz 1970).

Name. The member is named after the Aaffarsuaq valley on central Nuussuaq (Fig. 82).

Distribution. The member is found on central Nuussuaq where it is well exposed along the south-facing slopes of Aaffarsuaq between Qilakitsoq and Tunoqqu. Minor exposures are present in a stream section on the north-facing slope of Aaffarsuaq, south of Nalluarissat, in Kangersooq (Fig. 82) and in Turritelladal at Scaphitesnæsen, and in Agatdalen where the Teltbæk fault crosses the Agatdalen river (Figs 82, 113; Dam *et al.* 2000).

Type section. The type section is located in the second ravine east of Qilakitsoq on the northern slopes of Aaffarsuaq (Figs 82, 83). The base of the type section is located at 70°28.70'N, 53°21.97'W.

Reference sections. Well-exposed reference sections occur in ravines on the northern side of Aaffarsuaq along Nalluarissat, between Qilakitsoq and Tunoqqu (Fig. 82).

Thickness. In the main outcrop area, the thickness of the member decreases eastward from *c.* 250 m in the type section to 65 m at Tunoqqu.

Lithology. The Aaffarsuaq Member is characterised by amalgamated sandstone and rip-up mudstone and sandstone clast conglomerate units alternating with thinly interbedded sandstones and mudstones, dark, sand-streaked mudstones, and chaotic beds of homogeneous mudstone commonly cut by sandstone dykes and syn-sedimentary faults (Figs 83, 84, 85, 86; Dam *et al.* 2000).

The amalgamated sandstone and conglomerate units of the Aaffarsuaq Member consist of very coarse- to medium-grained sandstone and conglomerate beds grading upwards into thinly interbedded sandstones and mudstones. These coarse-grained units are up to 50 m thick and extend laterally beyond the extent of outcrop (several hundred metres) or occasionally form lenticular bodies. Individual beds have planar erosional bases and internally show normal grading. Beds are from <25 cm

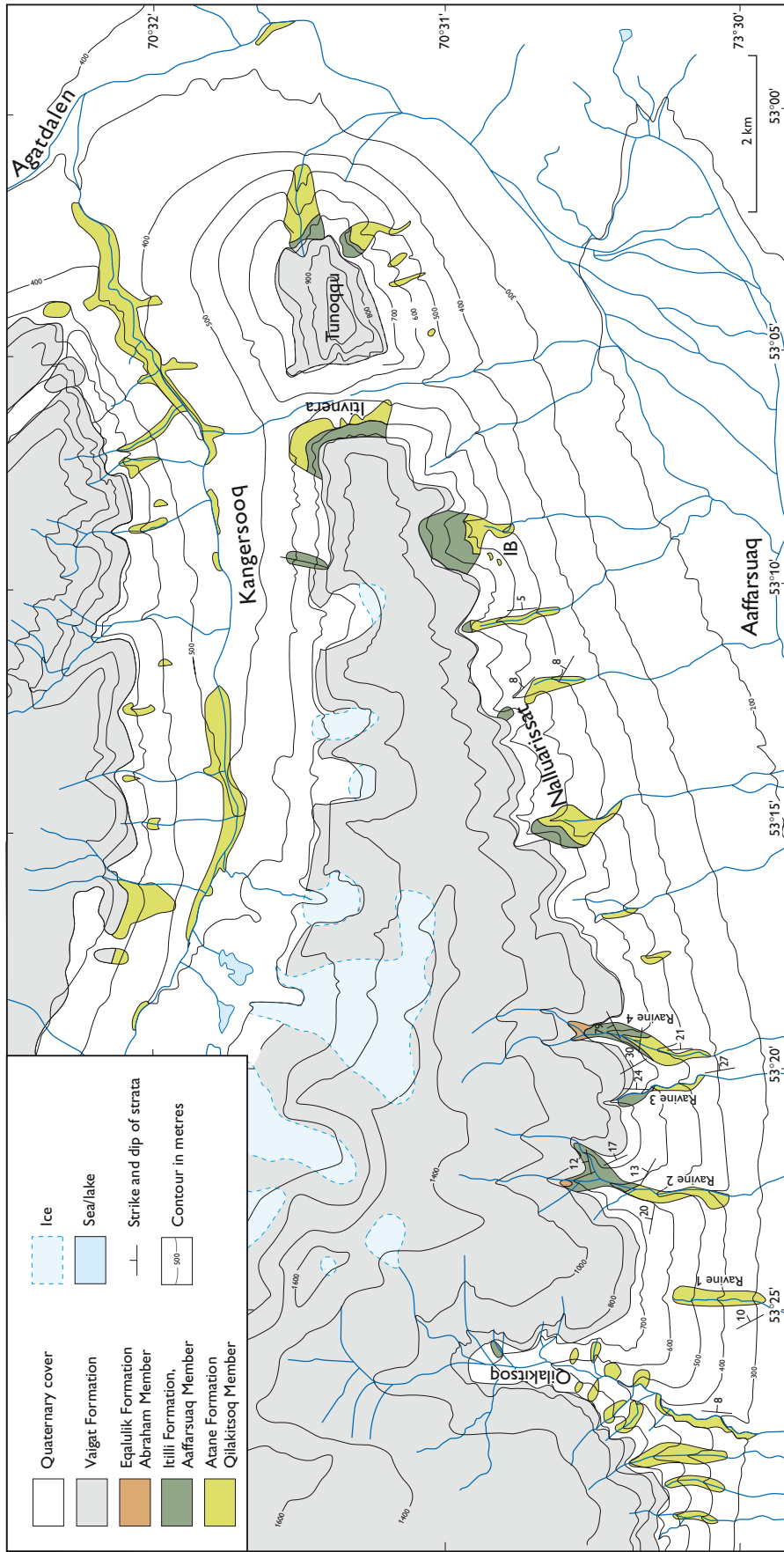


Fig. 82. Geological map of the north side of the Aaffarsuaq valley between Qilakitsoq and Agatdalen. The type section of the Qilakitsoq Member (Atane Formation) is located along Qilakitsoq, and the type section of the Aaffarsuaq Member (Itilli Formation) is located in Ravine 2. IB, type section of the Iivnera Bed. Contour interval is 100 m in the sedimentary outcrops, 200 m in the Vaigat Formation. Modified from Rosenkrantz *et al.* (1974).

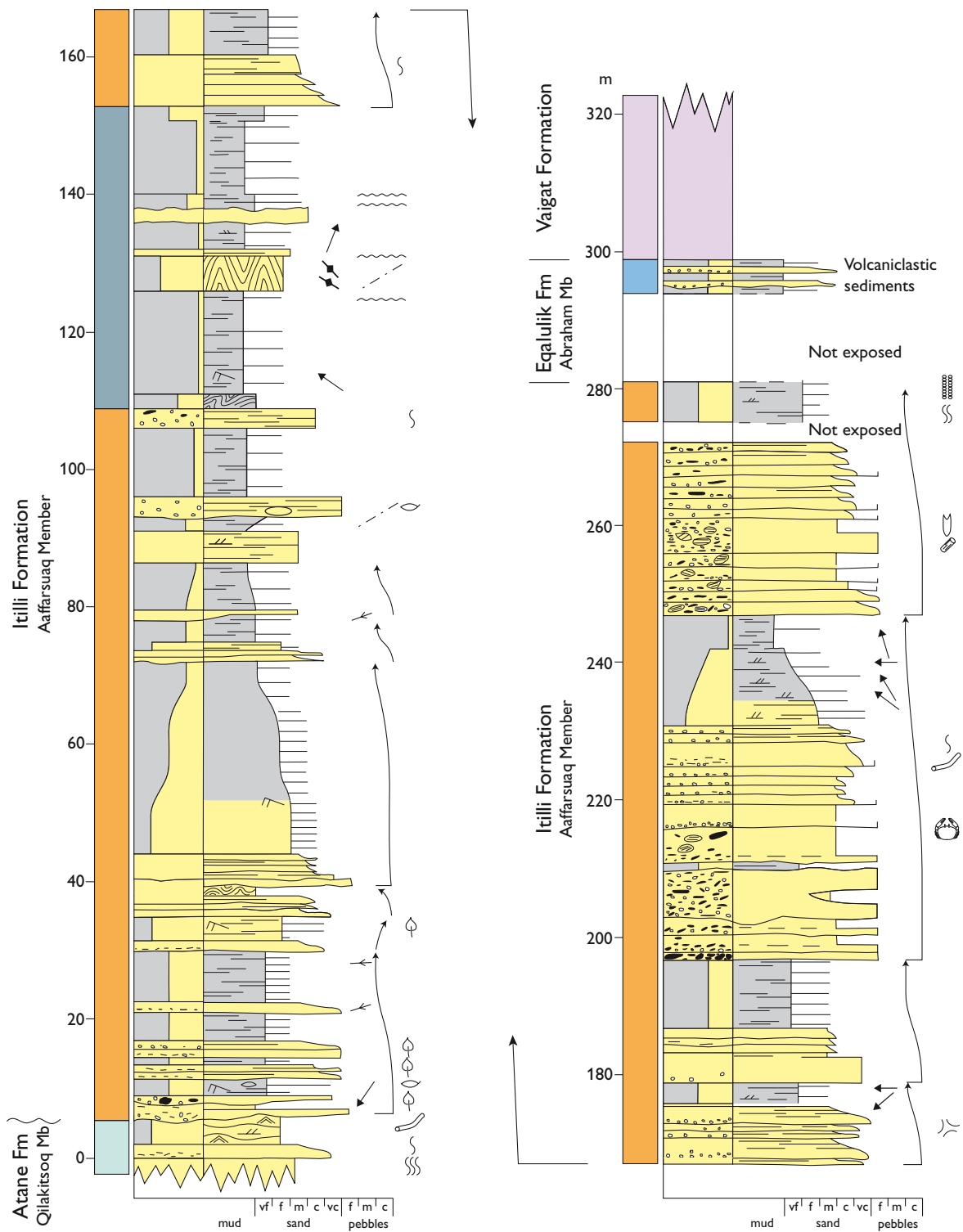


Fig. 83. Type section of the Aaffarsuaq Member (Itilli Formation), second ravine east of Qilakitsog, compare with Fig. 85. For location, see Fig. 82; for legend, see Plate 1. Modified from Dam *et al.* (2000).



Fig. 84. Unconformity between Santonian deltaic deposits of the Atane Formation (Qilakitsoq Member) and Campanian turbidite sandstones and conglomerates of the Aaffarsuaq Member (Itilli Formation). East-side of Tunoqqu. For location, see Fig. 82.

to more than 5 m thick and are commonly separated by thin mudstone beds (Figs 83, 85). The sandstones are mostly structureless, whereas the conglomerates show considerable lateral variation, are poorly sorted, and always have a coarse-grained sandy matrix. Both matrix- and clast-supported conglomerates occur. The clasts consist of intraformational mudstone, sandstone (probably derived from the underlying Atane Formation), concretions and basement lithologies (Dam *et al.* 2000).

The amalgamated sandstone and conglomerate units are overlain by thinly interbedded sandstone and mudstone units with either a gradational or a sharp contact. These units are up to 30 m thick and show a general thinning- and fining-upward trend (Figs 83, 85). They consist of laterally persistent, normally-graded, <1–40 cm thick beds of fine- to medium-grained sandstone capped by parallel-laminated mudstone.

Mudstones with thin (<2 cm), laterally persistent sandstone streaks form monotonous successions 10–30 m thick. The mudstones are finely laminated and laminae are usually normally graded. The sandstone laminae are normally graded, parallel- or cross-laminated throughout and constitute less than 25% of the succession.

Up to 15 m thick units of strongly contorted, thinly interbedded sandstones and mudstones and chaotic beds of homogeneous mudstone with evenly scattered coarse sand grains, mudstone intraclasts, transported early diagenetic concretions and basement clasts occur both within the mudstone-dominated successions and directly beneath the thick units of amalgamated sandstones and conglomerate.

Fossils. Ammonites have been found at Scaphitesnæsen in Turrittelakløft and include *Pseudophyllites skoui* (Birkelund), *Baculites obtusus* (Meek), *Baculites cf. haresi* (Reeside), *Scaphites cobbani* (Birkelund) and *Scaphites rosenkrantzi* (Birkelund) (Birkelund 1965). Reworked ammonites including *Scaphites cf. svartenhukensis* (Birkelund 1965) have been found at Tunoqqu (Dam *et al.* 2000).

Well-preserved inoceramids are commonly found at the top of turbidite sandstone beds, suggesting only little transportation (Fig. 71). Bryozoans fixed to inoceramid bivalve shells have been reported. A single, nearly complete capitulum of the cirripid *Eskimolepas gregersi* Rosenkrantz (Rosenkrantz 1970) has also been found. Dinocysts and pollen belonging to the *Aquilapollenites* interval have been reported from Scaphitesnæsen and Tunoqqu (Nøhr-Hansen 1996; Dam *et al.* 2000).

Depositional environment. The Aaffarsuaq Member exhibits a characteristic suite of thick units of amalgamated sandstone and conglomerate beds, interpreted to represent deposition mainly from gravity flows in a channellised, footwall fan system. Deposition of the amalgamated sands was confined to major turbidite channels. The intervening thinly interbedded sandstone and mudstone units were deposited mainly from low-density turbidity currents confined to minor channels. The sand-streaked, mudstone-dominated units were deposited by waning low-density turbidity currents in an interchannel slope setting. The contorted, thinly interbedded sandstones and mudstones probably formed by downslope displacement of semi-consolidated sediment (Dam *et al.* 2000).

In the Aaffarsuaq Member, the chaotic beds are not invariably associated with turbidite channel deposits, as



Fig. 85. Mudstones and conglomeratic sandstones of the upper part of the Aaffarsuaq Member (Itilli Formation) in the type section in the second ravine east of Qilakitsoq, see Fig. 83, *c.* 175–300 m. For location, see Fig. 82.

observed in the Anariartorfik Member, suggesting that downslope failure could also be associated with seismic activity (Dam *et al.* 2000).

Geological age. The ammonites at Scaphitesnæsen indicate an Early Campanian age (*Baculites obtusus* Zone) for the Aaffarsuaq Member. The mudstones are generally almost barren of palynomorphs but a rich flora is locally



Fig. 86. Conglomerate at the top of the type section of the Aaffarsuaq Member (Itilli Formation); note the predominance of sedimentary clasts. Ruler is 120 cm long. For location, see Fig. 82.

present that suggest an Early–Middle Campanian age for the member (Nøhr-Hansen 1996; Dam *et al.* 2000).

Boundaries. The lower boundary is an angular unconformity. Tilted strata of the deltaic Qilakitsoq Member (Atane Formation) were truncated during the transgression recorded by the Aaffarsuaq Member (Dam *et al.* 2000). Along the Aaffarsuaq valley, the Aaffarsuaq Member is unconformably overlain by Paleocene hyaloclastites of the Vaigat Formation (A.K. Pedersen *et al.* 2002). However, in two ravines along Aaffarsuaq, it is overlain by Paleocene mudstones and volcanoclastic sandstones referred to the Eقالulik Formation (Figs 82, 83, see below).

Kangilia Formation

revised formation

History. The Kangilia Formation was established by Rosenkrantz (1970) to encompass the Danian (Lower Paleocene) conglomerate-based, marine mudstone-dominated succession that overlies Upper Cretaceous mudstones (Itilli Formation of this paper) with an angular unconformity on northern and central Nuussuaq. Based largely on the content of fossils, he divided the formation into four members, from base to top: the Conglomerate Member, a conspicuous coarse-grained, clast-supported conglomerate unit, *c.* 50 m thick, the Fossil Wood Member, comprising black mudstones with a sandstone unit in the lower part, *c.* 425 m thick, the *Thyasira* Member consisting of sandstones and black mudstones with tuff beds, *c.* 35 m thick and the *Propeamussium* Member made up of black mudstones, locally with intercalated sandstones, *c.* 100 m thick.

Without providing details, Rosenkrantz (*in* Henderson 1969 fig. 4) included the entire 300 m thick mudstone-dominated succession at Ataata Kuua (near Atâ) in the Kangilia Formation. Furthermore, the distribution of the Kangilia Formation was shown in a schematic section through the Nuussuaq Basin that was presented by Henderson *et al.* (1976 fig. 303). The two upper members of the formation were also reported from Alianaatsunnguaq, Tupaasat and Ataa on the south coast of Nuussuaq (Rosenkrantz 1970).

The Kangilia Formation including the basal conglomeratic member (Annertuneq Conglomerate Member) is formally defined here. The ‘Oyster–Ammonite Conglomerate’ (Birkelund 1965) is formally defined as the Oyster–Ammonite Conglomerate Bed. The Fossil Wood,

Thyasira and *Propeamussium* Members are abandoned. The strata previously assigned to the latter two are now included in the new Eقالulik Formation (see below). On central Nuussuaq, Dam *et al.* (2000) mapped a unit in the Kangilia Formation that was informally termed the Danienrygge member; this unit is not formally recognised here.

On Itsaku, Svartenhuk Halvø, J.G. Larsen & Pulvertaft (2000) suggested that the poorly dated ?Upper Campanian/Maastrichtian to Paleocene succession may be equivalent either to both the Itilli and Kangilia Formations (i.e. Campanian to Paleocene) or to the Kangilia Formation alone (i.e. upper Maastrichtian to Paleocene), on account of a tentative correlation of two major conglomerate horizons with two discrete tectonic events recognised on Nuussuaq. Zircon provenance data show that the detrital zircon population of this succession has a distinct and narrow age range peaking at 1870 Ma whereas ages of zircons in the underlying sediments of the Upernivik Næs Formation show a greater spread with a distinct peak at 2750 Ma (Scherstén & Sønderholm 2007). Since there was only one major change in zircon provenance in the section involving a shift to a unique, single point source at the boundary between the Upernivik Næs and the overlying deposits, the suggestion is that only one tectonic event is recorded in the section. The entire ?Upper Campanian/Maastrichtian to Paleocene succession on Itsaku may thus be assigned to the Kangilia Formation.

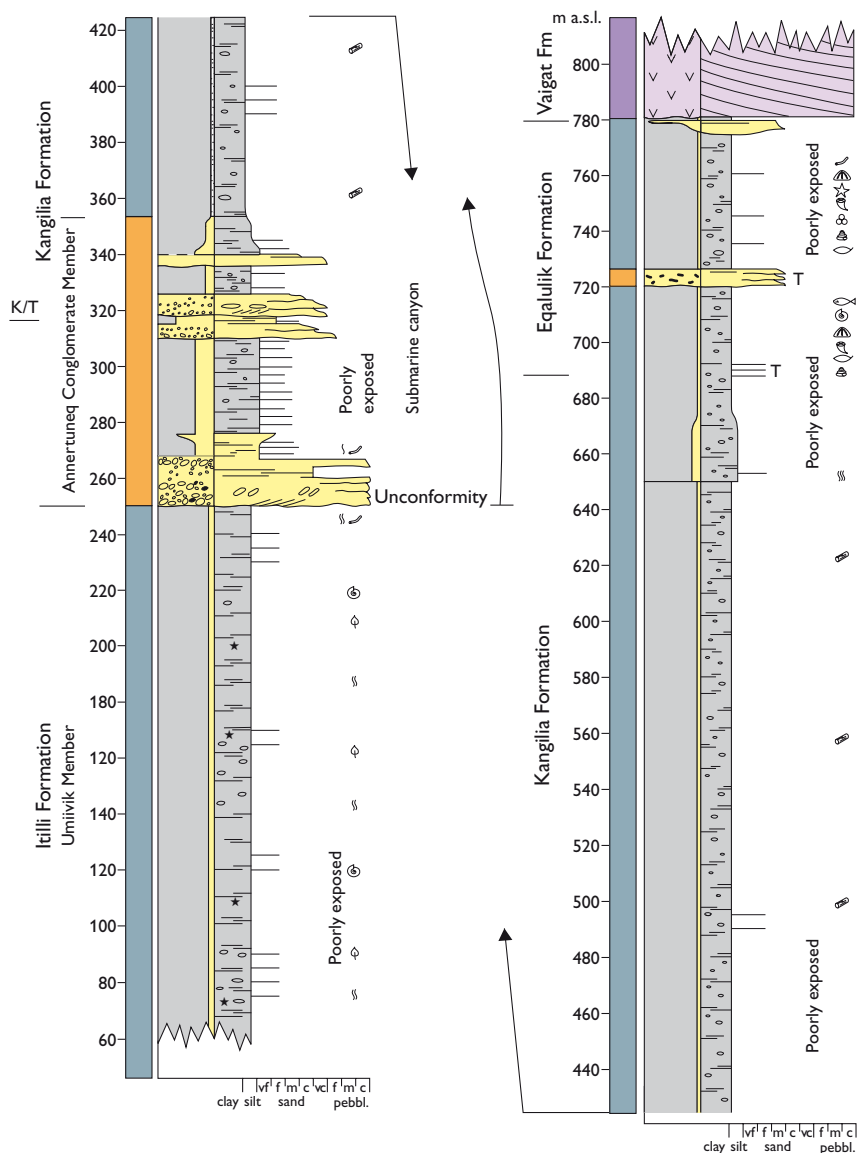
Name. After the headland of Kangilia on the north coast of Nuussuaq (Fig. 74).

Distribution. The formation is exposed at Ataata Kuua, Ivisaannguit, Tupaasat, Nuuk Killeq and Alianaatsunnguaq on the south coast of Nuussuaq (Figs 2, 6, 40; A.K. Pedersen *et al.* 1993), in the northern part of Agatdalen on central Nuussuaq (Fig. 113), in the Tunorsuaq valley on western Nuussuaq (where it has also been drilled in the GANT#1 well) and along the north coast of Nuussuaq (Fig. 74), and on Itsaku on eastern Svartenhuk Halvø (Fig. 73). The formation has been drilled on western Nuussuaq in the GRO#3 well (Fig. 65).

Type section. The exposures at Kangilia on the north coast of Nuussuaq are designated as the type section (Figs 87, 88). The base of the type section is located at 70°44.90′N, 53°25.33′W.

Reference sections. Well-exposed reference sections occur at Annertuneq (Fig. 72; Nøhr-Hansen & Dam 1997),

Fig. 87. Type section of the Kangilia Formation at Kangilia on the north coast of Nuussuaq. The log is generalised due to intermittent exposures of the mudstone intervals. Top of section is at Danienrygge; for location, see Fig. 74. K/T, Cretaceous–Palaeogene boundary. See also Figs 88 and 118. For legend, see Plate 1.



Ataata Kuua (Figs 14, 89; Dam & Nøhr-Hansen 2001) and at Ivisaanguit west of Ataata Kuua. The formation was drilled and cored in the GANT#1 well in Tunorsuaq between 35 m and 256 m (Fig. 76) and drilled in the GRO#3 well between 728 m and 959 m (Fig. 67).

Thickness. The Kangilia Formation varies in thickness from 440 m at Kangilia (Fig. 87) to *c.* 400 m at Ataata Kuua (Fig. 15), 230 m in the GRO#3 well (Fig. 67), to just 75 m on central Nuussuaq (H.J. Hansen 1970).

Lithology. On northern Nuussuaq the Kangilia Formation comprises a basal approximately 85–140 m thick conglomeratic unit overlain by a mudstone-dominated succession. The conglomeratic unit is here formally

established as the Annertuneq Conglomerate Member. In the lower part it is composed of amalgamated conglomerate beds that towards the top become finer-grained and separated by mudstone intervals (Figs 72, 76, 87; for detailed description, see below).

The succession overlying the basal conglomerate unit consists mainly of dark mudstones with thin beds of fine- to coarse-grained sandstone (Figs 76, 87, 88). The mudstones are weakly laminated; locally some of the laminae are graded. The sandstone beds have sharp bases and are usually normally graded. The sandstones are structureless or parallel-laminated. Ferroan carbonate concretions and fragments of fossil wood are common at various levels.



Fig. 88. Outcrop of the Itilli, Kangilia and Eqalulik Formations at Kangilia. The snowline at *c.* 800 m corresponds roughly to the base of the volcanic Vaigat Formation. For location, see Fig. 74.

At Ataata Kuua on the south coast of Nuussuaq, a basal sandstone unit with scattered mudstone clasts and transported concretions up to 1.5 m in diameter rests on a deeply eroded surface above lowest Campanian and older Atane Formation (Figs 14, 15). The unit forms the base of a 107 m thick fining-upward succession; the sandstone unit grades up into thinly interbedded sandstones and mudstones that are capped by mudstones with scattered basement pebbles interbedded with sandstone lenses and layers (Fig. 89; Pulvertaft & Chalmers 1990; Dam & Nøhr-Hansen 2001). The sandstones are largely structureless, but may grade into parallel- and cross-laminated sandstone. Convolute bedding is developed locally.

The sandstones occur as sheets in composite bedsets in the basal 11 m of the succession, or as single beds that fill wide shallow scours in the middle and upper part (Fig. 89). The composite sandstone bedsets are succeeded by approximately 50 m of interbedded sandstones and mudstones consisting of sharply based laminae and beds

that grade upwards from coarse-grained to fine-grained sandstone capped by silty mudstone (Fig. 89). These lithologies may form sharply based fining-upward units up to 1.5 m thick, restricted to lenticular bodies a few tens of metres wide (Fig. 89). Erosional discordances are common within the lenticular bodies and internally they are made up of small amalgamated fining-upward successions.

The interbedded sandstones and mudstones are succeeded by a 56 m thick unit dominated by massive mudstone containing scattered sand grains and few pebble- and cobble-sized basement clasts (Fig. 89). The mudstone beds are interbedded with laminated mudstones with sand streaks (Fig. 90). Conglomerates and sandstones form an up to 40 m thick unit in the middle of the Ataata Kuua exposure (Figs 14, 15, 89), with sedimentary facies very similar to that seen in the prominent conglomerate unit on the north coast of Nuussuaq. This unit is overlain by approximately 250 m of generally poorly exposed mudstone (Fig. 14).

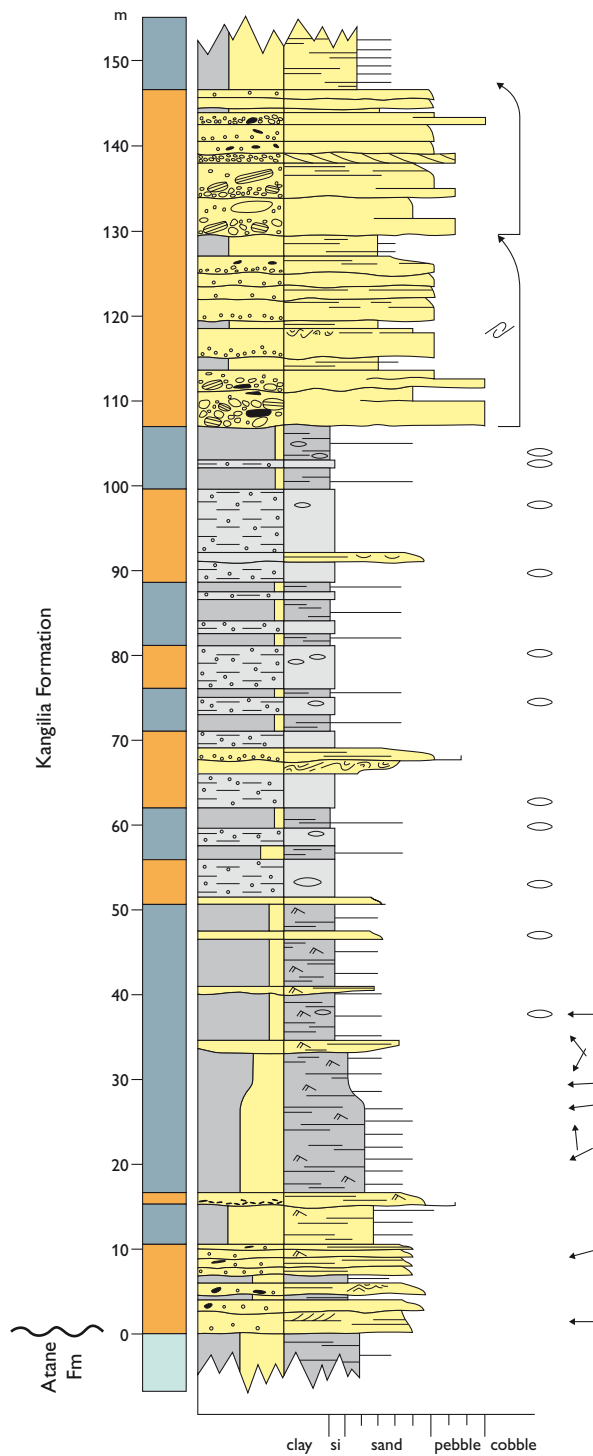


Fig. 89. Sedimentological log showing the lower part of the Kangilia Formation at Ataata Kuua. Slightly modified from Dam & Nøhr-Hansen (2001), see also Fig. 15. For location of section, see Fig. 40; for legend, see Plate 1.



Fig. 90. Dark grey mudstones interbedded with thin sandstone beds of the Kangilia Formation at Ataata (for location, see Fig. 40). The illustrated section is *c.* 5 m thick.

Just west of Ataata Kuua, several levels of coarse-grained sandstones and conglomerates are present within the upper mudstone succession (Fig. 91). Larger clasts include sandstone and mudstone intraclasts, clay ironstone concretions and kaolinised gneiss clasts. Dykes of injected sand are also seen. Farther west these coarse-grained levels disappear.

In Agatdalen on central Nuussuaq, the formation is generally poorly exposed and dominated by mudstones. A Paleocene conglomerate unit about 5 m thick was described as the Oyster-Ammonite Conglomerate by Birkelund (1965) and Rosenkrantz (1970). It is mainly composed of derived, highly fossiliferous concretions and is here formally established as the Oyster-Ammonite Conglomerate Bed.

Fossils. Along the north coast of Nuussuaq, fossils are rare in the Kangilia Formation apart from *Teredo*-bored fossil wood (Mathiesen 1961; Rosenkrantz 1970). A very



Fig. 91. Mudstones interbedded with sandstone and channellised conglomerates (arrows point to base of conglomerate-filled channels). The Kangilia Formation at Ataa; for location, see Fig. 40. Height of the section is c. 50 m.

small number of *in situ* ammonites (*Hoploscaphites* aff. *H. angmartussutensis*) and echinoderms have been found in a sandstone bed in the lower part of the formation and in scattered concretions (Nøhr-Hansen & Dam 1997; Kennedy *et al.* 1999). Palynomorphs are common and are referred to five zones from the *Wodehouseia spinata* Zone to the *Palaeocystodinium bulliforme* Zone (Nøhr-Hansen 1997b; Nøhr-Hansen *et al.* 2002).

The Oyster–Ammonite Conglomerate Bed in Agatdalen is made up of highly fossiliferous concretions containing a mainly Maastrichtian fauna of ammonites although concretions with Campanian and Danian species are also present. The matrix of the conglomerate contains Danian oysters and other bivalves, gastropods, crus-

taceans and rare specimens of other fossils (Birkelund 1965; Rosenkrantz 1970).

On the south coast of Nuussuaq, fossils are very scarce in the Kangilia Formation and only indeterminate thin-shelled bivalves and gastropods have been found in the mudstones at Ivisaannguit. The trace fossil *Planolites* isp. and escape burrows occur locally in the sandstone beds.

Depositional environment. The presence of dinocysts, echinoderms and ammonites indicates a marine depositional environment and the mudstones and sandstones dominating the formation are interpreted to have been deposited from waning, low-density turbidity currents whereas the conglomeratic units were deposited from

channellised, high-density currents. Some of the mudstones may also have been deposited from suspension.

The conglomerates and sandstones at the base of the Kangilia Formation exhibit a characteristic suite of facies that indicate deposition from catastrophic flows related to high-density, turbidity currents and debris flows. On the north coast of Nuussuaq deposition took place in a slope environment, probably in a major submarine canyon setting (Figs 76, 87).

At Ataata Kuua, the lower part of the formation was deposited in a submarine canyon (Figs 15, 92) whereas the mudstones in the upper part were deposited by dilute turbidity currents in an unconfined slope setting. The basal erosional unconformity represents a transverse section through the submarine canyon (Figs 15, 92; Dam & Nøhr-Hansen 2001). The thin lenticular fining-upward successions are interpreted as minor turbidite channel deposits. Dinocysts and macrofossils suggest general marine conditions during deposition. Along the south coast of Nuussuaq, at Ataata Kuua and Ivisaannguit, no marine palynomorphs have been recorded (McIntyre 1993), suggesting a dominant terrestrial input.

Boundaries. The lower boundary is an erosional unconformity that separates the Kangilia Formation from the underlying Atane Formation on southern Nuussuaq (Fig. 15) and from the Itilli Formation on western, central and northern Nuussuaq (Figs 14, 87, 88). Along the north coast of Nuussuaq, in the GANT#1 and GRO#3 wells and at Ataata Kuua, the lower boundary is picked at the base of a thick conglomerate unit that cuts down into the underlying deposits of the Itilli and Atane Formations. At all these localities, the lower boundary marks the base of a major submarine canyon system (Fig. 92; Dam & Nøhr-Hansen 2001). Where the basal conglomerate is absent, the unconformity between the Itilli and Atane Formations is difficult to locate using lithological criteria (mudstone overlying mudstone) and has to be picked on the basis of biostratigraphic data.

On Itsaku (Svartenhuk Halvø), there is an angular unconformity between the Kangilia Formation and the underlying sediments of the Upernivik Næs Formation. At this locality, a thick conglomerate unit occurs at the base of the formation. Elsewhere on Svartenhuk Halvø, the formation locally onlaps the basement or is in faulted contact with the Umiivik Member of the Itilli Formation (Fig. 73; J.G. Larsen & Pulvertaft 2000).

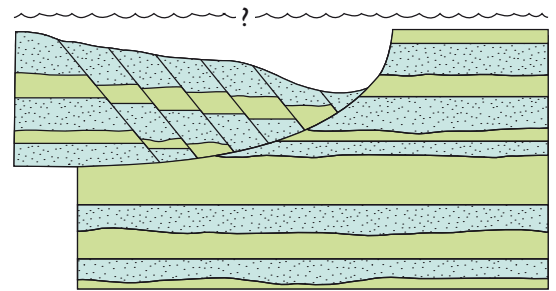
The Kangilia Formation is overlain by the Eqaalik Formation on northern and western Nuussuaq (Figs 87, 118), the Agatdal Formation on central Nuussuaq and

possibly on Itsaku (Fig. 113), and by the Quikavsak Formation on southern Nuussuaq (Fig. 99A).

Geological age. The dinocyst flora suggest a late Maastrichtian to Danian age for the Kangilia Formation on the north coast of Nuussuaq and a Danian age in the central part of Nuussuaq (Fig. 16; J.M. Hansen 1970; Nøhr-Hansen 1996, Nøhr-Hansen & Dam 1997; Nøhr-Hansen *et al.* 2002).

The type section of the Kangilia Formation provides a well-exposed section across the Cretaceous–Tertiary (K/T) boundary in a clastic, deep-water setting (Fig. 87; Nøhr-Hansen & Dam 1997). Ammonites in the lowermost part of the formation indicate a late Maastrichtian age (Kennedy *et al.* 1999) and coccoliths indicate that most of the section above the K/T boundary has a nanofossil NP3–4 Zone age and consequently that NP2 and

A Submarine canyon incision



B Submarine canyon filling

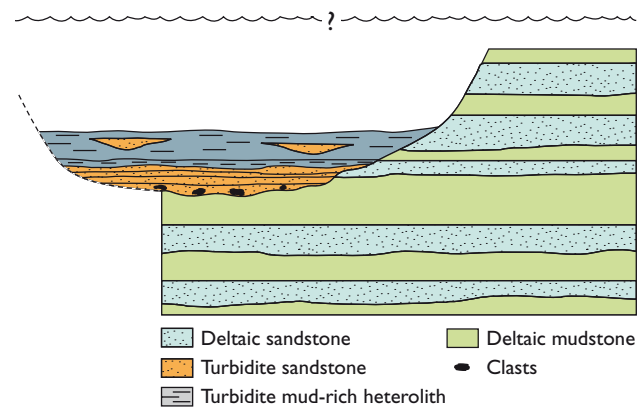


Fig. 92. Conceptual model for the formation of the submarine canyon fill of the Kangilia Formation at Ataata Kuua. From Dam & Nøhr-Hansen (2001 fig. 4). The canyon formed in response to listric faulting, detachment and collapse of the hanging wall (A). The steeply dipping part of the detachment surface of the footwall acted as the canyon wall and seems not to have been eroded to an appreciable extent. During a subsequent transgression, the canyon was filled with turbidite deposits (B). Colours reflect interpreted depositional environments (see Plate 1).

part of the NP1 zone are probably missing or very condensed (Nøhr-Hansen *et al.* 2002). The K/T boundary was also cored by the GANT#1 well (Fig. 76).

On central Nuussuaq, Danian bivalves and gastropods in the matrix of the Oyster–Ammonite Conglomerate Member indicate that this part of the formation cannot be older than Danian.

On the south coast of Nuussuaq at Ataata Kuua, palynomorphs (mainly spores and pollen) suggest a late Maastrichtian – Early Paleocene age for the formation (McIntyre 1993).

Correlation. The upper, Paleocene part of the Kangilia Formation is coeval with the Agatdal and Quikavsak Formations (Fig. 16).

Subdivision. At the type locality of the Kangilia Formation, the Annertuneq Conglomerate Member forms the basal unit of the formation (Figs 76, 87). In Agatdalen, a conglomerate unit containing abundant, derived concretions, the so-called ‘Oyster–Ammonite Conglomerate’ of Birkelund (1965), is now formally established as the Oyster–Ammonite Conglomerate Bed.

Annertuneq Conglomerate Member

redescribed member

History. This coarse-grained unit was established by Rosenkrantz (1970) as the Conglomerate Member – the basal member of the Danian Kangilia Formation in the type section on the north coast of Nuussuaq (Figs 72,

93, 94). Rosenkrantz (1970) correlated it with his basal Danian conglomerate in Agatdalen, a unit also referred to as the Oyster–Ammonite Conglomerate by Birkelund (1965) and H.J. Hansen (1970). Based on new data from the north coast of Nuussuaq and subsurface data from the GANT#1 well, a more thorough and formal description is presented here. The member is retained for the sake of continuity and also because this impressive unit is distinctive as one of the relatively few conglomerates in the Nuussuaq Basin.

Name. The name is derived partly from the reference locality close to the type section and partly from its historical name based on the lithology of the unit.

Distribution. The Annertuneq Conglomerate Member forms a conspicuous unit along the north coast of Nuussuaq between Niaqorsuaq and Kangilia. It has been drilled in the GANT#1 well in the Tunorsuaq valley (Figs 74, 76), and is assumed to be present locally in the subsurface at the base of the Kangilia Formation.

Type section. The type section of the Annertuneq Conglomerate Member is the same as for the Kangilia Formation (Figs 74, 87, 88). The base of the member is located at 70°44.54′N, 53°25.11′W.

Reference sections. A well-exposed section of the lower part of the member is accessible in the western gully leading to Annertuneq, a few kilometres west of Kangilia (Figs 72, 93, 94). The member was cored in the GANT#1 well, from 256.0 m to 100.0 m (Fig. 76).

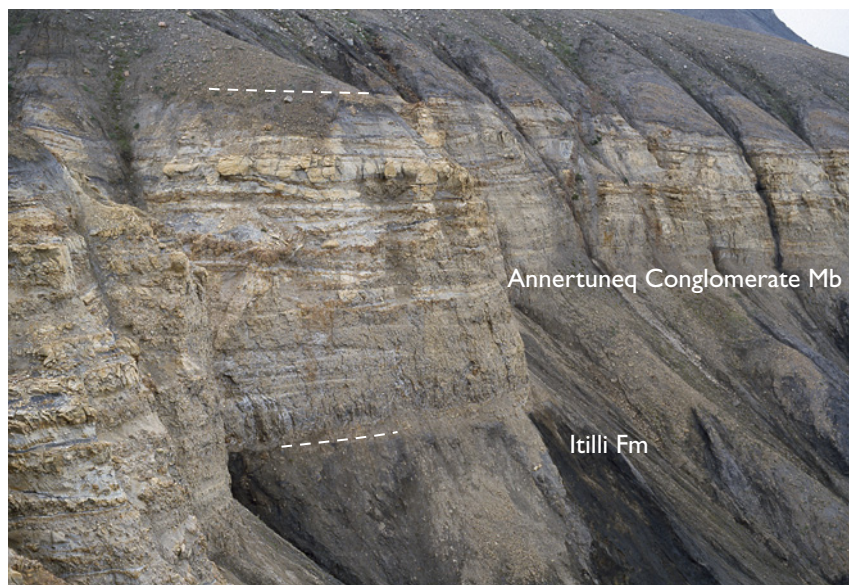


Fig. 93. The Annertuneq Conglomerate Member (c. 40 m thick) of the Kangilia Formation at Annertuneq. For location, see Fig. 74.

Thickness. The Annertuneq Conglomerate Member varies in thickness from *c.* 85 m on the north coast of Nuussuaq (Fig. 87) to 140 m (excluding igneous intrusions) in the GANT#1 well (Fig. 76; see also A.K. Pedersen *et al.* 2006b).

Lithology. At the reference section at Annertuneq, the lower part of the conglomerate unit is composed of amalgamated up to 8 m thick lenticular beds containing pebble- to boulder-sized clasts up to 2 m in diameter (Fig. 94). Clasts include quartz (40%), quartzitic grey sandstones (35%), intraformational mudstones and concretions (10%), quartzitic red sandstones (7%), chert (3%) and others (5%); 'others' include Precambrian gneiss and granite clasts, and clasts of silicified limestone that may be pisolitic or contain Ordovician gastropods. The conglomerates also include coalified wood fragments and poorly preserved marine bivalves and gastropods. Individual conglomerate beds can be divided into structureless, structureless to normally graded, or inversely graded, clast-supported conglomerate facies. The conglomerates are poorly sorted and always contain a matrix of medium to very coarse-grained sandstone or sandy mudstone. The sandstones are predominantly structureless, but in some cases the uppermost parts of the beds show well-developed parallel lamination and cross-lamination. Dish structures and escape burrows are common.

In the type section at Kangilia, the lower part of the member consists of a 20 m thick unit of amalgamated conglomerate beds comprising pebble- to boulder-sized clasts in a poorly sorted medium- to very coarse-grained sandstone matrix. The conglomerate units fine upwards and sandstone becomes the dominant lithology towards the top (Fig. 87, 95).

Fossils. Scarce, strongly worn bivalves and gastropods and occasional, coalified wood fragments are present in the member.

Depositional environment. Both at the type section and in the GANT#1 well, the conglomerates were deposited from debris flows and high density turbidite currents and sandstones from high- and low-density turbidity currents. It has previously been suggested that deposition took place in a fluvial environment (H.J. Hansen 1970), but the depositional facies and inferred processes, the upward transition into fully marine deposits and the presence of marine dinocysts in the interbedded mudstones (Nøhr-Hansen 1997b) indicate a marine depositional environment. The considerable increase in the thickness of the member in the GANT#1 well compared

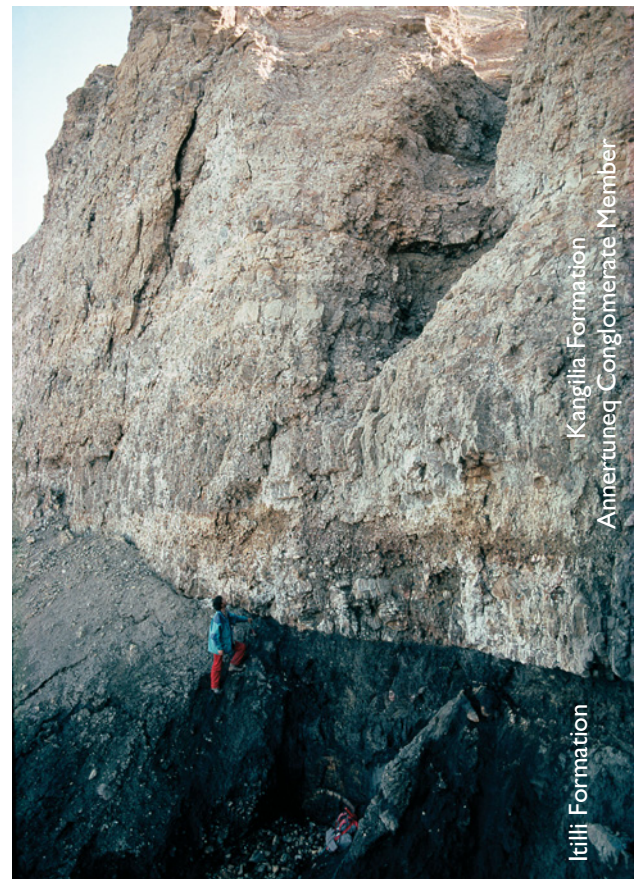
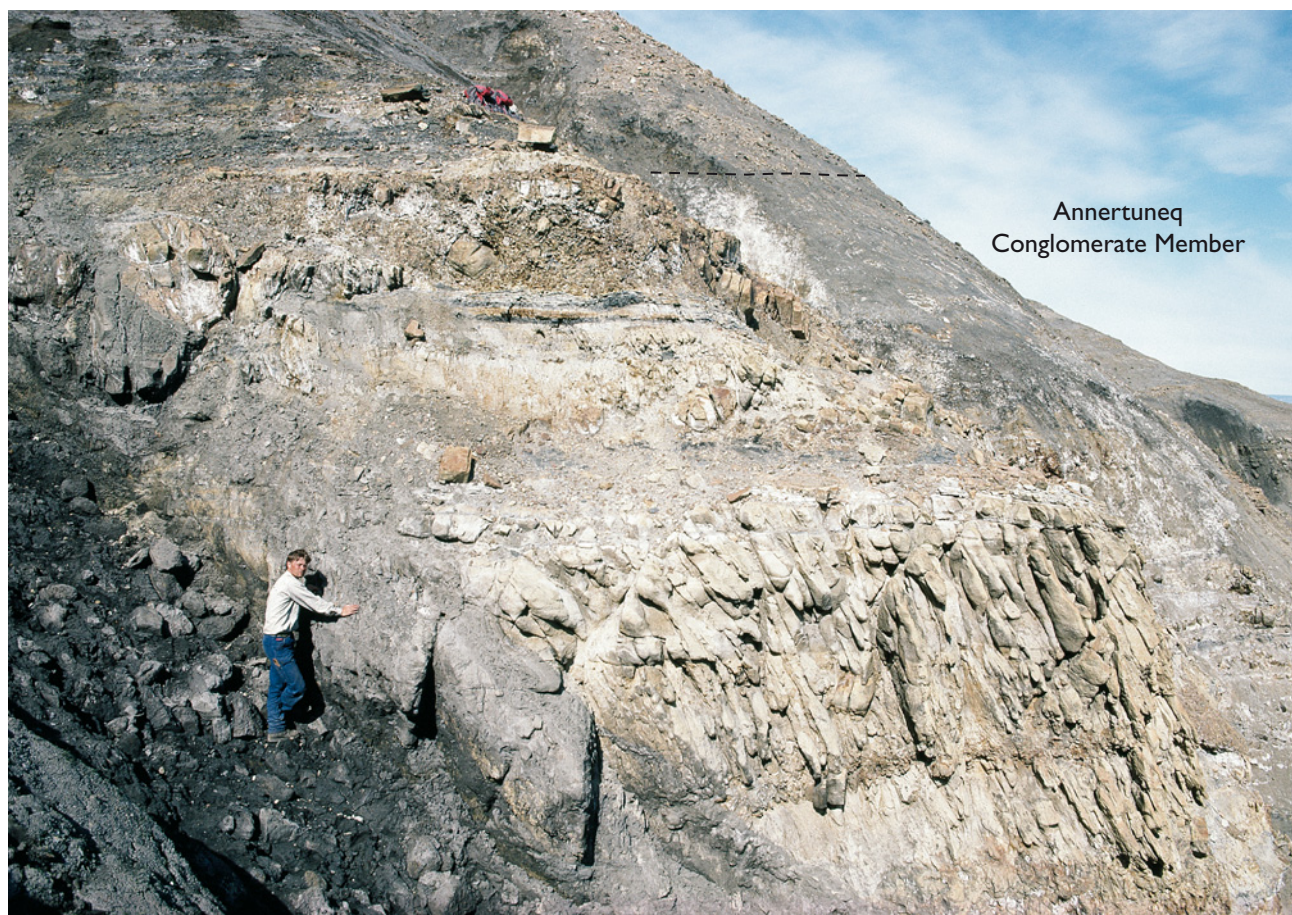


Fig. 94. Close-up of the sharp, erosional base of the Annertuneq Conglomerate Member at Annertuneq. Person for scale. For location, see Fig. 74.

to the exposures situated at Annertuneq and Kangilia, *c.* 6 km to the north, suggests that deposition took place in a major submarine canyon and that the GANT#1 well is situated in a more axial position than the north coast exposures.

Boundaries. The lower boundary of the Annertuneq Conglomerate Member is developed as a major erosional unconformity. On the north coast of Nuussuaq, this separates mudstones of the Itilli Formation below from the conglomerates of the Annertuneq Conglomerate Member above (Fig. 72). The upper boundary is gradational at all localities and is placed at the top of the uppermost, very coarse-grained sandstone bed (Figs 76, 87, 93, 95).

Geological age. The Annertuneq Conglomerate Member does not contain fossils of biostratigraphic significance. The age of the member is, however, constrained by its position between marine mudstones. The Umiivik Member of the Itilli Formation (below) has a Late Campanian



Annertuneg
Conglomerate Member

Fig. 95. Upper boundary (dashed line) of the Annertuneg Conglomerate Member of the Kangilia Formation at Kangilia showing a gradual transition from conglomerates and sandstones to mudstones. For location, see Fig. 74; person for scale.

age (J.M. Hansen 1980b; Nøhr-Hansen 1996, 1997b; Dam *et al.* 1998c; Nøhr-Hansen *et al.* 2002). The mudstones of the remaining Kangilia Formation (above) are of late Maastrichtian – Paleocene age. The position of the Maastrichtian–Paleocene boundary within the Kangilia Formation varies between localities, from 210 m above the base of the Annertuneg Conglomerate Member (Nøhr-Hansen & Dam 1997), *c.* 70 m above the base of the member at Kangilia (Fig. 87), to a position close to the top of the member in the GANT#1 well (Nøhr-Hansen 1997b). This suggests an ?early to late Maastrichtian age for the member.

Oyster–Ammonite Conglomerate Bed

new bed

History. In Agatdalen on central Nuussuaq, a conglomerate of Danian age containing a huge number of derived concretions has been referred to as the Oyster-Ammonite

Conglomerate (e.g. Birkelund 1965). H.J. Hansen (1970) referred this conglomerate to the *Thyasira* Member of Rosenkrantz (1970). For historical reasons and in order to distinguish this fossiliferous conglomerate unit from the Annertuneg Conglomerate Member, it is now formally established as a bed and named the Oyster–Ammonite Conglomerate Bed.

Name. The bed is named after the rich occurrence of reworked oysters and ammonites in the conglomerate.

Distribution. The bed has only been described from three localities in Agatdalen (Fig. 113).

Type locality. The bed is best exposed in the western river bank of the Agatdalen river, south-east of Sill Sø (Figs 96, 113). The type locality is located at 70°34.62'N, 53°04.50'W.

Thickness. The bed is approximately 5 m thick (Rosenkrantz 1970).

Fig. 96. A: Type locality of the Oyster–Ammonite Conglomerate Bed on the western bank of the Agatdalen river. For location, see Fig. 113. B: Clast in the poly-modal, matrix-supported conglomerate (paraconglomerate) in the Oyster–Ammonite Conglomerate Bed. Hammer (encircled) for scale.



Lithology. The Oyster–Ammonite Conglomerate Bed is a clast-supported conglomerate dominated by numerous, calcareous concretions and dark mudstone boulders eroded from Maastrichtian and Campanian deposits (Fig. 96; H.J. Hansen 1970). The matrix consists of sandy mudstone containing Danian oysters and bivalves (see below). In places, calcareous concretions have been formed within the conglomerate (Floris 1972).

Fossils. The fossils in the concretions are reworked and include ammonites, oysters and other bivalves, gastropods, crustaceans and corals (Birkelund 1965; Rosenkrantz 1970; Floris 1972). They show that the concretions were eroded from Maastrichtian deposits and represent a rich fauna including *Hypophylloceras* (*Neophylloceras*) *greenlandicum* Birkelund 1965, *Saghalinites wrighti* Birkelund 1965, *Baculites* cf. *B. meeki* Elias 1933, *Scaphites* (*Disco-scaphites*) *waagei* Birkelund 1965, and *S. (D.) angmar-tussutensis* Birkelund 1965 (*Hoploscaphites* Nowak 1911 according to Kennedy *et al.* 1999). In addition *Scaphites*

(*Hoploscaphites*) cf. *S. (H.) ravni* Birkelund 1965, *S. (H.)* cf. *S. (H.) greenlandicus* Donovan 1953, *S. cobbani* Birkelund 1965 and *S. rosenkrantzi* Birkelund 1965 occur very occasionally and indicate that some concretions were derived from the Campanian (Kennedy *et al.* 1999). Corals include *Stephanocyathus* sp. and *Caryophyllia agat-dalensis* (Floris 1972). The mudstone matrix includes oysters and other bivalves that have also been described from the lower part of the overlying Eqaalulik Formation on the north coast of Nuussuaq (*Thyasira* Member of Rosenkrantz (1970)). Dinocysts are present in both the reworked concretions and the matrix of the conglomerate.

Depositional environment. Deposition took place from debris flow(s) in a marine environment.

Boundaries. The lower and upper boundaries of the bed are not well exposed. The lower boundary is inferred to be an erosional unconformity separating the conglomerate from underlying mudstones of the Campanian Itilli

Formation. The conglomerate is overlain by black bituminous mudstones of the Kangilia Formation (Fig. 113).

Geological age. The oysters and other bivalves in the matrix of the conglomerate indicate a Danian age (Birke-lund 1965). The fauna has species in common with the *Thyasira* Member of the Kangilia Formation of Rosenkrantz (1970), here defined as the Eqalulik Formation, and the conglomerate was referred to the Lower to Middle Danian by Rosenkrantz (1970). Dinocysts from the mudstone matrix also suggest a Danian age. Kennedy *et al.* (1999) referred the ammonites to the early Maastrichtian. The age of the Oyster–Ammonite Conglomerate Bed is constrained by its Danian fossils and the early Late Danian age of the Agatdal Formation, which overlies the Kangilia Formation.

Correlation. The bed is referred to the Kangilia Formation based on the general Danian age and the lack of volcanoclastic material (the presence of which characterises the Eqalulik Formation) in both the conglomerate and the overlying mudstone.

Quikavsak Formation

new formation

History. The strata comprising the Quikavsak Formation as defined here were briefly described by Steenstrup (1874 p. 79) and later in detail by Koch (1959) who included them in his Quikavsak Member of the Tertiary

Upper Atanikerdluk Formation. The strata are now established as a separate formation. A major, fluvial channelised sandstone unit that Koch (1959 fig. 5) previously included in the top of the Atane Formation at Quikassaap Kuua is now tentatively also included in the Quikavsak Formation. At Nassaat, a tributary on the south-eastern side of Agatdalen, a poorly exposed conglomerate unit that had been assigned to the Sonja member (Agatdal Formation) by Rosenkrantz (1970) and to the Quikavsak Member by Koch (1959) is here re-assigned to the Quikavsak Formation.

Dam (2002) suggested a division of the Quikavsak Formation into four members reflecting various depositional stages during infill and drowning of the incised valley system. Dam's three lower members – the Tupaasat, Nuuk Qiterleq and Paatuutkløften Members – are defined formally below. The Asuup Innartaa Member is no longer recognised, and the deposits on Nuussuaq are now included in either the Eqalulik or the Atanikerluk Formations whereas the deposits on Disko are now referred to the Kussinerujuk Member of the Itilli Formation (see below).

Name. The member is named after the stream of Quikavsauk kûa (now spelled Quikassaap Kuua) near Atanikerluk (Fig. 40). The spelling of the name is taken from Koch (1959).

Distribution. The formation is exposed along the south coast of Nuussuaq, from Nuuk Killeq in the west to Saqqaqdalen in the east. On central Nuussuaq, the formation is exposed at Nassaat (Fig. 2).

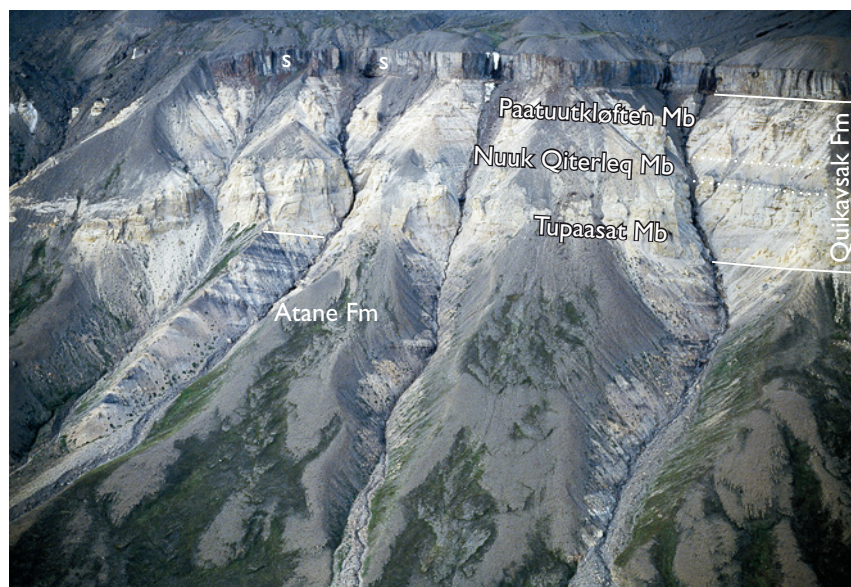


Fig. 97. The type locality of the Quikavsak Formation, east of Nuuk Qiterleq on the south coast of Nuussuaq (for location, see Figs 2, 40). The Quikavsak Formation overlies the Atane Formation and is overlain by a very thin Eqalulik Formation and hyaloclastite breccias of the Vaigat Formation. A volcanic sill (S) has been intruded between the Quikavsak and the Eqalulik Formations. The thickness of the Quikavsak Formation in this outcrop is *c.* 180 m.