Middle Jurassic near-shore sediments at Kap Hope, East Greenland

KRZYSZTOF BIRKENMAJER

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The Bathonian near-shore arenaceous sediments at Kap Hope were formed along the eastern border of the Middle Jurassic marine basin of East Greenland. Palaeocurrent measurements indicate an easterly supply of clastics with a source located within or to the east of Liverpool Land. https://doi.org/10.37570/bgsd-1976-25-13

Krzysztof Birkenmajer, Institute of Historical Geology and Palaeontology, University of Copenhagen, Øster Voldgade 10, 1350 København K., Denmark, June 20th, 1976. (Present address: Institute of Geology, Polish Academy of Sciences, ul. Senacka 3, 31–002 Kraków, Poland).

The Kap Hope locality is a small downfaulted area of Triassic and Lower to Middle Jurassic sediments within crystalline rocks of the Caledonian fold belt of Liverpool Land, East Greenland (fig. 1). The Jurassic sediments crop out along the northern shore of Scoresby Sund from Kap Hope settlement to the mouths of Jætteelv, and at Gulfjelde (Gule Fjælde in older papers), namely at Bjerring Pedersens Fjeld and Aage Nielsens Fjeld (fig. 2).

The Mesozoic rocks of Kap Hope discovered by Bjerring Pedersen in 1924 were investigated in detail by Rosenkrantz (1934, 1942) who had mapped the area and established the stratigraphy of Mesozoic sediments based, with respect to the Lower Jurassic rocks, on good faunal evidence. The present author visited the Kap Hope area in 1971 and concentrated his work on sedimentological problems of both the Triassic and Jurassic deposits. The latter are the only sediments of Jurassic age in Liverpool Land, and are also the easternmost known deposits of the Jurassic-Cretaceous Jameson Land basin in East Greenland.

The Mesozoic sequence

Lithostratigraphic subdivision of the Triassic and Jurassic sequences at Kap Hope adopted here (fig. 2, table 1) follows the recent standards established by Perch-Nielsen et al. (1974) and Surlyk et al. (1973) for the Jameson Land and Scoresby Land regions of East Greenland. The Triassic sequence at Kap Hope is incomplete, and consists only of two units: the Klitdal Member (Pingo Dal Formation) at the base, and the Ørsted Dal Member (Fleming Fjord Formation) at the top, separated from one another by a break in sedimentation, possibly an erosional unconformity. The Klitdal Member, resting directly upon weathered crystalline rocks (mostly gneiss) of the Caledonian fold belt, consists of red or pink arkosic conglomerate and coarse to medium grained arkose and arkosic sandstone with well developed large-scale cross-bedding. The Ørsted Dal Member is poorly exposed east of the Kap Hope settement, and slightly better in Bruddal where it wedges out toward the north between the Klitdal Member and the Kap Stewart Formation. It consists of red clay with red or white limestone-marl concretions, sometimes with green clay and green micaceous sandstone intercalations.

The Kap Stewart Formation rests unconformably either upon the Ørsted Dal Member or directly upon the Klitdal Member. The transition from the Ørsted Dal Member to the Kap Stewart Formation, as suggested by Rosenkrantz (1942) has not been confirmed. The lower part of Rosenkrantz's "transitional beds"

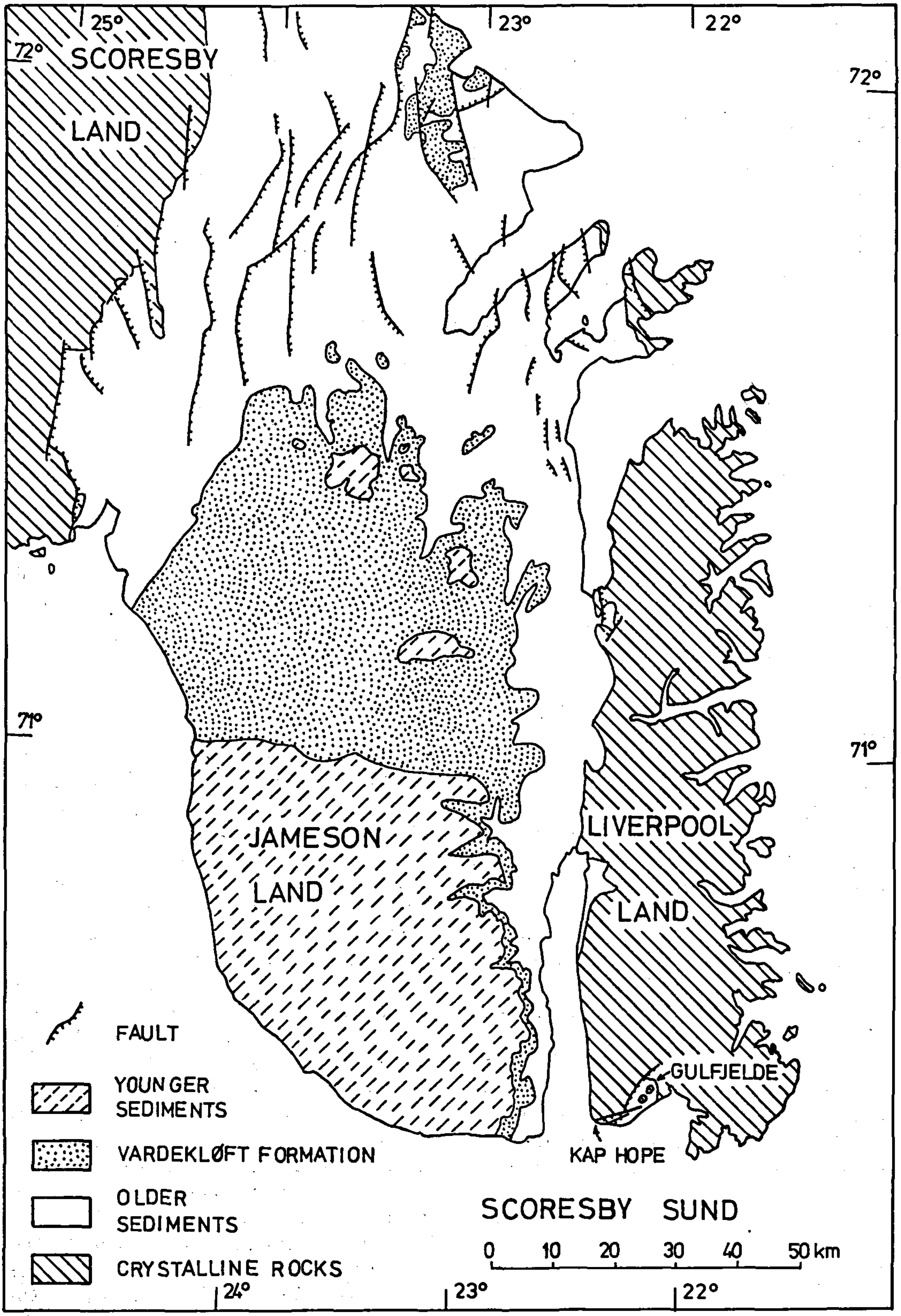

Fig. 1. Distribution of the Vardekløft Formation (Middle Jurassic) in Jameson Land and Scoresby Land, East Greenland. After Surlyk et al. (1973), simplified.

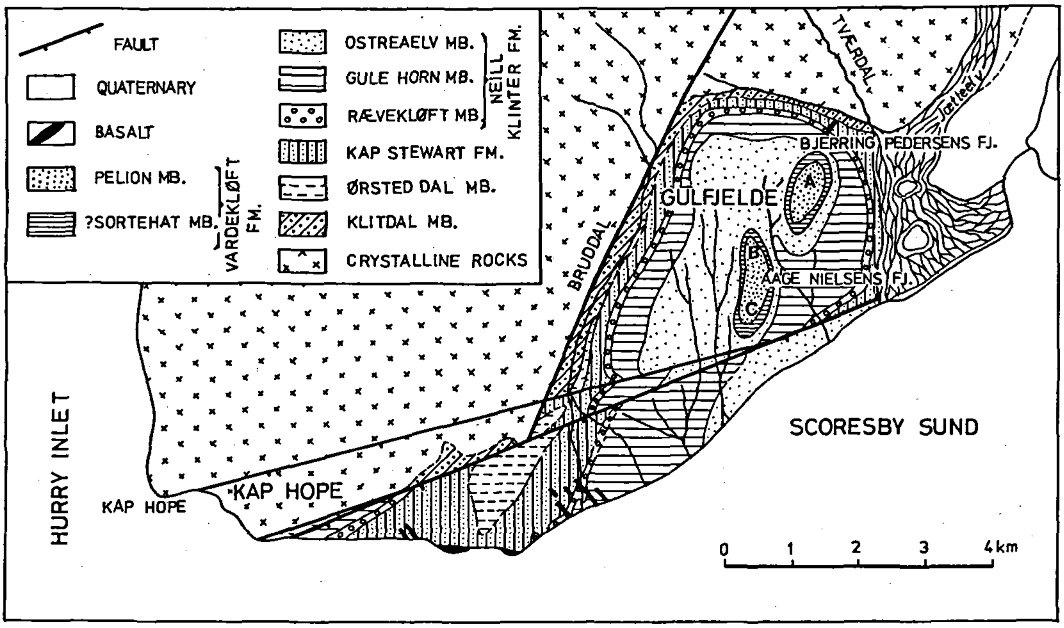

Fig. 2. Geological sketch-map of Mesozoic rocks at Kap Hope. After Rosenkrantz (1942), supplemented and modified by the present author. A, B, C — — localities illustrated in figs. 3, 5.

belongs to the Ørsted Dal Member and the upper part, starting with thin grey conglomerate followed by green glauconitic sandstone, to the Kap Stewart Formation.

The Kap Stewart Formation consists of white, quartzitic, often arkosic sandstone with some conglomerate, plant-bearing dark shale and fine-grained sandstone beds, with one coal seam. Large-scale cross-bedding occurs especially at the bottom and in the middle part of the succession. The plant remains identified by Harris (1937) indicate the presence of the *Lepidopteris* Zone (Rhaetian) in the lower part and the *Thaumatopteris* Zone (Lower Lias, resp. Hettangian, see Surlyk et al. 1971) in the upper part of the Formation (Rosenkrantz 1942).

According to Sykes (1974a) the Kap Stewart Formation on the nearby eastern coast of Hurry Inlet accumulated in a fluviatile environment with a southerly clastic source. Sykes did not find any indications of marine environment in the succession. However, at Kap Hope, the presence of glauconitic sandstone both near the base and near the top of the Kap Stewart Formation indicates that the fluviatile sediments were formed close to the sea shore and were invaded from time to time by the sea.

The marine Neill Klinter Formation at Kap Hope is separated from the Kap Stewart Formation by a break in sedimentation and unconformity. Its lower Ræveklφft Member begins with a 5–30 cm thick basal conglomerate succeeded by highly fossiliferous grey or green often arkosic or glauconitic sandstones with brown weathering hue, with calcareous sandstone ("limestone" of Rosenkrantz 1942) bands which yielded an index fauna of the Pliensbachian *Uptonia jamesoni* Zone (Rosenkrantz 1942; Donovan 1957). In Hurry Inlet there are also indications of a higher Pliensbachian *Prodactylioceras davoei* Zone (Rosenkrantz 1934; Surlyk et al. 1973).

The Gule Horn Member ("Domerian" of Rosenkrantz 1942; Upper Pliensbachian = Domerian to Lower Toarcian according to Surlyk et al. 1973) is represented by green or grey friable, often calcareous sandstone medium to fine grained, shaly sandstone and sandy or silty shale, often with brownish or rusty weathering hue. Small-scale ripple-drift cross-lamination and lenticular bedding occur

FORMATION	MEMBER	THICKNESS m	STAGE
VARDEKLØFT	PELION	35+	BATHONIAN
	?SORTEHAT	5–10	?U. BAJOCIAN
NEILL KLINTER	OSTREAELV	ca 80	TOARCIAN
	GULE HORN	100+	"DOMERIAN"
	RÆVEKLØFT	20+	PLIENSBACHIAN
KAP STEWART		20?	HETTANGIAN RHAETIAN
FLEMING FJORD	ØRSTED DAL	40–50	?NORIAN
PINGO DAL	KLITDAL	20–30	?DIENERIAN
CALEDONIAN CRYSTALLINE ROCKS			

Table 1. Triassic and Jurassic successions at Kap Hope, East Greenland. Wavy lines denote unconformities.

within the sandstones. Few thin flake conglomerate intercalations (20–30 cm thick) consisting of shale and clay-ironstone fragments have been found. Bivalve burrows and other trace fossils occur in some sandstone layers, especially close to flake-conglomerate intercalations. Plant remains have been found in the upper part of the Member by Rosenkrantz (1942).

The Ostreaelv Member (Toarcian of Rosenkrantz 1942) consists of grey or green platy glauconitic sandstone and silty shale with some whitish, fine-grained arkosic sandstone intercalations. Brown-rusty weathering colours are frequent. Large (20–30 cm in diameter) very hard limonite-cemented sandstone concretions may be found. Ammonite finds by Rosenkrantz (1942) indicate the presence of late *Hildoceras bifrons* or early *Lytoceras jurense* Zone (Donovan 1957).

The sedimentary features of the Gule Horn Member and the Ostreaelv Member in the nearby Hurry Inlet indicate, according to Sykes (1974b) an offshore-estuarine sequence formed under tidal conditions.

The Vardekløft Formation is present only at the top of Gulfjelde (Bjerring Pedersens Fjeld and Aage Nielsens Fjeld). Its basal unit consists of poorly exposed dark-grey or greenish, silty, often micaceous shale. According to Rosenkrantz (1942, pp. 48–49, fig. 26) the shale contains some dark-brown, oolitic, impure limestone concretions with a few grains of glauconite and with scarce and poorly preserved marine bivalves, of which *Nuculana aequilatera* (Dunker et Koch) indicates a Middle Jurassic (Bathonian ?) age of the sediment. The shale with concretions could represent either the Sortehat Member (?Upper Bajocian) or the basal part of the Pelion Member (Bathonian). The lack of suitable exposures did not allow the relationship between the Vardekløft Formation and the Neill Klinter Formation to be studied. In Jameson Land and Scoresby Land there is a break in sedimentation and unconformity between these two formations corresponding to Upper Toarcian, Aalenian and a part of the Bajocian (Surlyk et al. 1973).

The Pelion Member proper (Bathonian according to Surlyk et al. 1973) consists of light-coloured sandstone, either massive, or platy, or with large-scale cross-bedding, with one dark shale intercalation. Due to the lack of suitable exposures, it was not possible to study the contact of this Member and the underlying shale. If we considered the shale to be equivalent to the Sortehat Member, its small thickness (5–10 m at Kap Hope) as compared with Jameson Land and Scoresby Land where it amounts to 60–120 m (see Surlyk et al. 1973) could suggest an erosional unconformity at the base of the Pelion Member at Kap Hope. The upper surface of the Pelion Member is erosional. No fossils have been found from this Member at Gulfjelde.

Pelion Member: Facies decription

Very good, though small exposures of the Pelion Member at the top of Gulfjelde permit study of its facial development in considerable detail. Four principal facies may be distinguished: (1) Massive sandstone, (2) Cross-bedded sandstone (with one sub-facies), (3) Platy sandstone and (4) Shale (fig. 3).

Facies 1. Massive sandstone

Sandstone, light-grey or yellowish, usually massive, sometimes with faint low-angle large-scale cross-lamination or with faint horizontal lamination. The sandstone is mainly fine-grained, sometimes medium grained, with well-rounded quartz grains, with an admixture of weathered felspar and fine muscovite flakes. The rock is poorly cemented and easily disintegrates to yellow sand. It forms units up to 2 m thick in the upper part of the section, and a band 15 m thick at the base of the Pelion Member at Bjerring Pedersens Fjeld. Calcite-cemented spheroidal concretions 5–25 cm in diameter occur commonly.

Facies 2. Cross-bedded sandstone

Sandstone, white, greyish or yellow, in large-scale cross-bedded units 5–50 cm thick, bounded by planar erosional surfaces (fig. 4).

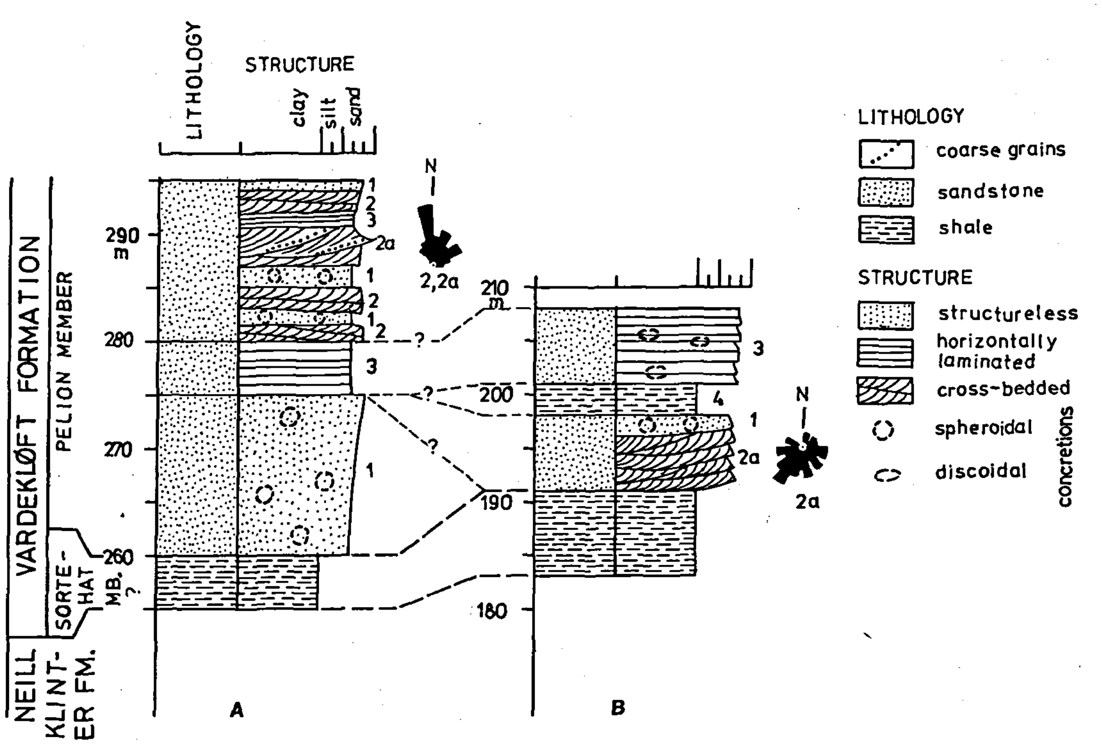

Fig. 3. Facies relations in the Pelion Member (Bathonian) at Gu'fjelde. A – Bjerring Pedersens Fje'd; B – northern part of Aage Nielsens Fjeld (see fig. 2).

Fig. 4. Planar cross-bedded sandstone (facies 2), Pelion Member (Bathonian), Bjerring Pedersens Fjeld (Kap Hope area).

Foreset lamination is well developed, individual foresets are 1–5 cm thick, bottomsets are present, topsets usually eroded. Maximum dip of foresets with respect to the bounding erosional surfaces amounts to 30°. The sandstone is medium-grained, with subrounded or rounded quartz grains. Fine streaks of coarser quartz and feldspar grains (1–3 mm in diameter) may occur between the laminae. No parting lineation has been observed. The upper surfaces of cross-bedded units often display irregular patterns resembling desiccation cracks. The facies occurs at Bjerring Pedersens Fjeld and in the southern part of Aage Nielsens Fjeld.

A variety of the above facies (facies 2a) is represented by arkosic, medium to fine-grained loosely-cemented sandstone with large-scale cross-bedded units 0.5–1 m thick, rather wedge-shaped and with foresets less regular than those of facies 2. This variety appears at the base of the Pelion Member in the northern part of Aage Nielsens Fjeld.

Facies 3. Platy sandstone

Platy sandstone, dark-grey, greenish, micaceous, fine-grained, grading to sandy shale, with horizontal lamination. Sometimes there occur discoidal cementation concretions 10–30 cm in diameter.

Facies 4. Shale

Soft shale, greenish or grey.

Interpretation

The facies 1, 2, 2a and 3 are represented by generally fine-grade, mature clastic quartz sediments with high degree of roundness, highest in the massive sandstones (facies 1). A small admixture of mica flakes and/or clastic feldspar may sometimes be found, while the silt-clay grade matrix is either absent (facies 1, 2, 2a) or present in varying amount (facies 3). The facies 2 and 2a are large-scale cross-bedded units bounded by erosion surfaces (either planar or wedge-shaped), indicating a high energy enviroment. Unimodal arrangement of foresets in planar cross-bedded units of facies 2 (fig. 5A, C) suggests deposition of sand dunes from traction currents flowing in one direction, presumably in wide flat channels. More scattered results were obtained from wedge-shaped cross-units (facies 2a), but even here a dominant direction is still apparent (fig. 5B).

There is no indication as to whether the cross-bedded units originated in a fresh-water or marine environment. The presence of irregular patterns resembling desiccation cracks at the top of some of the cross-bedded sets (facies 2) may be indicative of a very shallow environment subject to changing water level.

The high degree of roundness and generally fine grades of quartz grains in massive sandstones, with sporadic occurrence of faint large-scale cross-lamination and horizontal lamination (facies 1) may be indicative of an environment subject to wind action, e.g. beach dunes. Poor cementation of quartz grains in the sandstones which easily disintegrate to loose sand would agree with this assumption. Spheroidal cementation concretions in massive sandstones, if formed at an early stage of diagenesis, would probably indicate that the sediment underwent little compaction.

The platy sandstone with horizontal lamination (facies 3) grading to sandy shale contains clay-silt matrix and is closer connected with the shale facies (4) than with the remaining sandstones. This is a water-laid deposit formed either at the bottom or on a gentle slope of a basin, possibly without influence either of wave or current action, as is evidenced by the lack of related structures. The presence of discoidal cementation concretions may possibly indicate greater compaction of the sediment due to expulsion of water at an early diagenetic stage than was the case with the massive sandstone (facies 1) where the concretions are spheroidal.

In the absence of biogenic facies indicators it is difficult, if possible at all, to decide whether the Pelion Member at Gulfjelde is of marine or fluvial origin. A hypothesis presented here (fig. 6) assumes that the sediment is a mixed one containing units formed under the influence of wind (facies 1) and tentatively interpreted as beach dunes, the units formed in slightly meandering channels by high-energy unidirectional currents, comparable to braided river or shallow, wide intertidal channels (facies 2 and 2a), and the sediments formed in a restricted basin: platy sandstone grading to sandy shale (facies 3) and shale (facies 4). The highly changing pattern of palaeocurrent

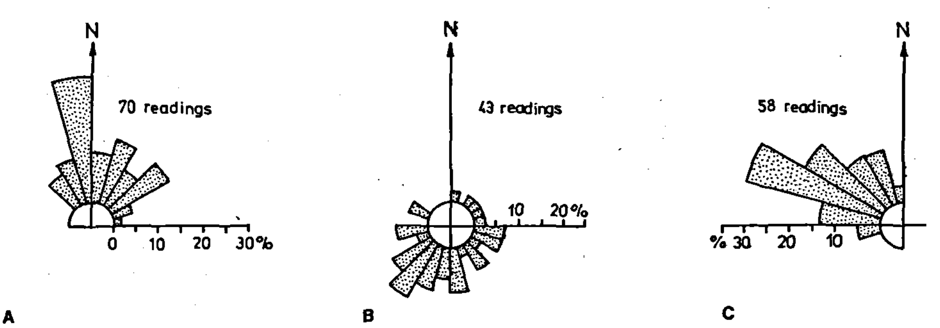

Fig. 5. Pelion Member (Bathonian): Palaeocurrent measurements of large-scale cross-bedding. A, B, C – – as in fig. 2.

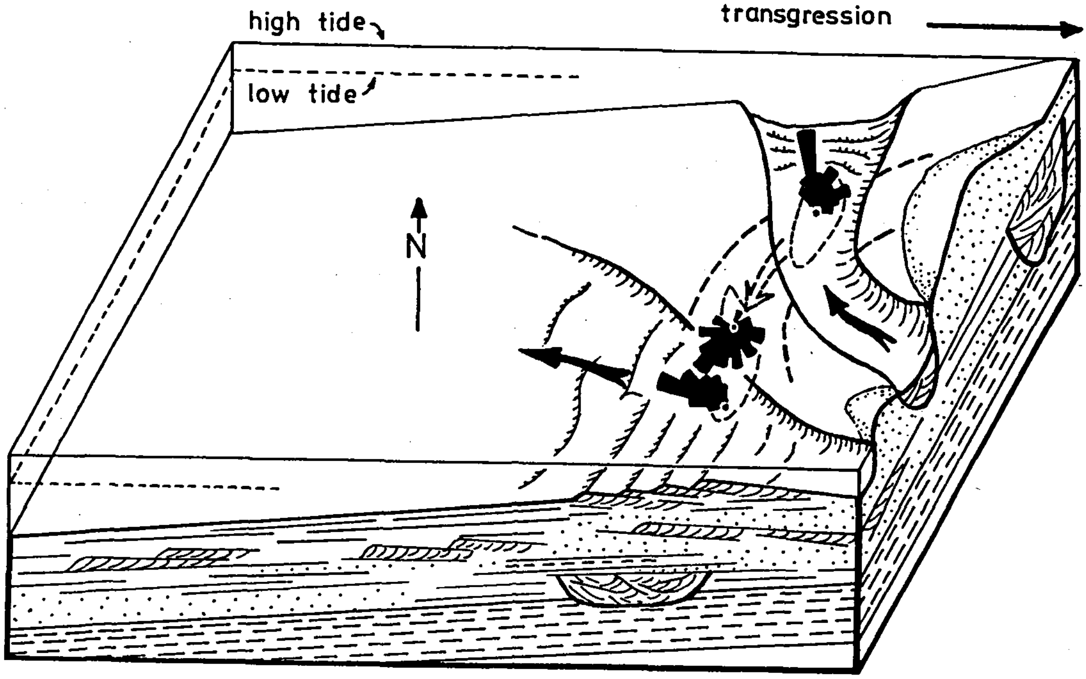

Fig. 6. Sedimentological model for the Pelion Member (Bathonian) at Gulfjelde (Kap Hope area). Vertical scale exaggerated.

direction between the examined exposures (figs. 5, 6) would point to migration of slightly sinuous channels cutting through a shallow part of the shelf at an outlet of a river (with the main clastic source area lying to the east), possibly within the range of tides and very close to the shore where beach sand dunes could develop.

Such an unstable near-shore environment of interfingering shallow-marine (littoral) and non-marine facies would have been preserved in the geological record as a result of continuous transgression of the Bathonian sea, as is accepted for the Pelion Member of the nearby Jameson Land and Scoresby Land areas (see Surlyk et al. 1973; Birkelund et al. 1974; Birkelund 1975; Clemmensen & Surlyk 1976).

Palaeogeographical implications

The results of the above study, though not conclusive as to the environmental character of some of the facies, indicate that the clastic material of the Pelion Member of Kap Hope was supplied from a low-relief land mass situated east of the Jameson Land Basin. This land could correspond to the eastern part of Liverpool Land or its eastward prolongation, now part of the East Greenland continental shelf. It is well known that Liverpool Land had formed a horst-like block which was active as a source of clastics during most of Triassic time (see Perch-Nielsen et al. 1974), and which was responsible for the majority of unconformities in the Triassic and Jurassic sedimentary sequences, as is evidenced particularly well at Kap Hope (table 1). The eastern border of the marine Bathonian basin of Jameson Land (fig. 7) would certainly be expected not very far east from the Kap Hope locality, as already suggested by Birkelund (1975, fig. 3). The maturity of the Pelion Member clastics at Kap Hope would, moreover, suggest a long transport by rivers from the source area.

The remaining, main occurrences of the shallow-marine Pelion Member sediments in the Jameson Land Basin, where its thickness

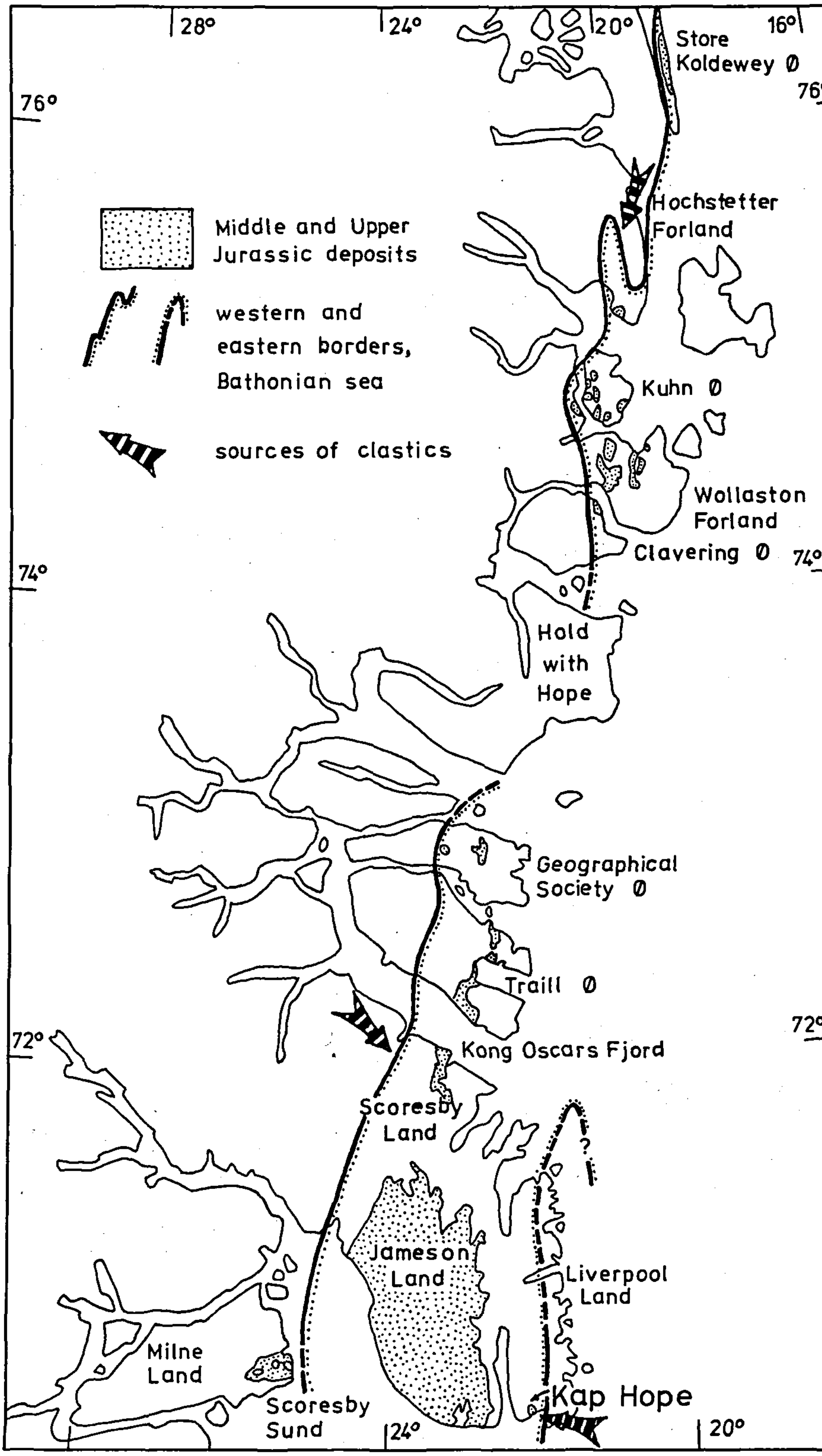

Fig. 7. Extension of the Bathonian sea in East Greenland. Data from Birkelund (1975) and Clemmensen and Surlyk (1976), modified.

grows from only 10 m on the south (southern Jameson Land) to about 900 m at Traill Ø (north of Scoresby Land) and the grain size increases from south to north, were supplied from the other, mainly north-western, coasts of the basin (Surlyk et al. 1973; pp. 33, 34, 70, 71; Clemmensen & Surlyk 1976, fig. 9; Birkelund 1975, fig. 4). The palaeocurrent directions measured in cross-bedded units and distribution of facies in the main basin indicate palaeoslope due south (Surlyk et al. 1973, p. 71; Birkelund 1975; Clemmensen & Surlyk 1976).

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Dansk sammendrag

Trias-Jura lagserien i et nedforkastet område ved Kap Hope, Liverpool Land, beskrives kort og sammenlignes med den langt mere komplette lagserie i Scoresby Land og Jameson Land (tabel 1).

De sandede sedimenter tilhørende den Mellem Jurassiske Vardekløft Formation blev afsat ved østranden af det østgrønlandske bassin. Målinger af palæostrømretninger fra øst viser tilstedeværelsen af et landområde ved Liverpool Land eller øst herfor i Mellem Jura.

Følgende fire hovedfaciestyper er påvist i Vardekløft Formationen: 1) massiv sandsten, 2) krydslejret sandsten, 3) pladet sandsten og 4) skifer. Sedimenterne antages at være afsat i et kystnært regime med såvel littorale som non-marine facies, heriblandt muligvis kystklitter, repræsenteret.

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The Fe_2O_3/FeO ratio of basalt analyses: an appeal for a standardized procedure

C. KENT BROOKS

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Brooks, C. K.: The Fe_2O_3/FeO ratio of basalt analyses: an appeal for a standardized procedure. *Bull. geol. Soc. Denmark,* vol. 25, pp. 117–120. Copenhagen, December, 21st 1976.

Due to the importance of the oxidation state in the classification of basaltic rocks many procedures have been adopted for the adjustment of this parameter to minimize the effects of secondary oxidation. An appeal is made here to standardize this procedure and a case is made for the adoption of a value for the Fe_2O_3/FeO ratio of 0.15. It is probable that this is close to the original value in nature, at least for tholeiites.

C. K. Brooks, Institut for Petrologi, Øster Voldgade 10, 1350 København K, Denmark.
May 4th, 1976.

It is now almost universally recognized that nearly all basaltic rocks have suffered significant late-stage and secondary alteration and that this has a critical effect on the calculated amounts of normative constituents, which form the basis of the classification of such rocks (Yoder & Tilley 1962). Thus, as the Fe_2O_3/FeO ratio rises, more *magnetite* will be formed and increasing amounts of SiO_2 will become available for converting *nepheline* to *albite, olivine* to *hypersthene* and eventually forming free *quartz*. As it is clearly of importance to know as closely as possible the original normative composition on the rock, it is with problems of classification that post-extrusion oxidation becomes most critical.

Most workers are aware of these problems, but, unfortunately, many different methods of correcting for this oxidation have appeared in the literature. Thus, Coombs (1963) and Kay et al. (1970) proposed reducing the Fe_2O_3 in all analyses to a maximum of 1.5 %. However, this may not be reasonable in cases where the basalts are high in total FeO or TiO_2. Irvine & Baragar (1971) therefore tried to improve this by making Fe_2O_3 equal to 1.5 % + wt % TiO_2. Similarly, Thompson et al. (1972) took into account the total alkali content in addition to allow for the effect of differentiation. On the other hand, Bass (1972) adopted a value for Fe^{3+}/Fe^{2+} (atomic) of 0.1, Pyke et al. (1973) used a value of $Fe^{3+}/Fe^{3+}+Fe^{2+}$ of 0.1, O'Hara (1973) a value of 0.2 and Baker et al. (1974) a value of 0.25. Still others have corrected the Fe_2O_3/FeO ratio to various values: 0.15 (Green et al. 1974), 0.123 (Frey et al. 1974), 0.25 (Stice, 1968) and 0.44 (Best & Brimhall 1974). In addition, norms have sometimes also been calculated with all iron as FeO, thus achieving the maximum degree of undersaturation. While the results of these various procedures are often not greatly at variance, discrepancies do arise, the situation is confusing and comparisons between the results of various workers are greatly hampered. The purpose of this note is firstly to urge that a standard data reduction method be adopted and secondly to argue for a specific value, which is probably close to the real one prior to oxidation, in the hope that this will increase the attraction of this value and lead to its widespread acceptance.

In recent years a number of analyses of low-K_2O tholeiitic glasses from the deep ocean floor have become available in the literature. Such glass is widely believed to represent highly chilled igneous material which preserves rather closely its pristine characteristics. Thus, Moore (1970) has shown that it retains unchanged its original magmatic water content and Dymond (1970) has shown that the same is true for the rare gases. It is therefore likely that the original oxidation state has been little changed. Miyashiro et al. (1969) noted that most analyses of fresh besalts from the ocean floor have Fe_2O_3/FeO ratios within a very

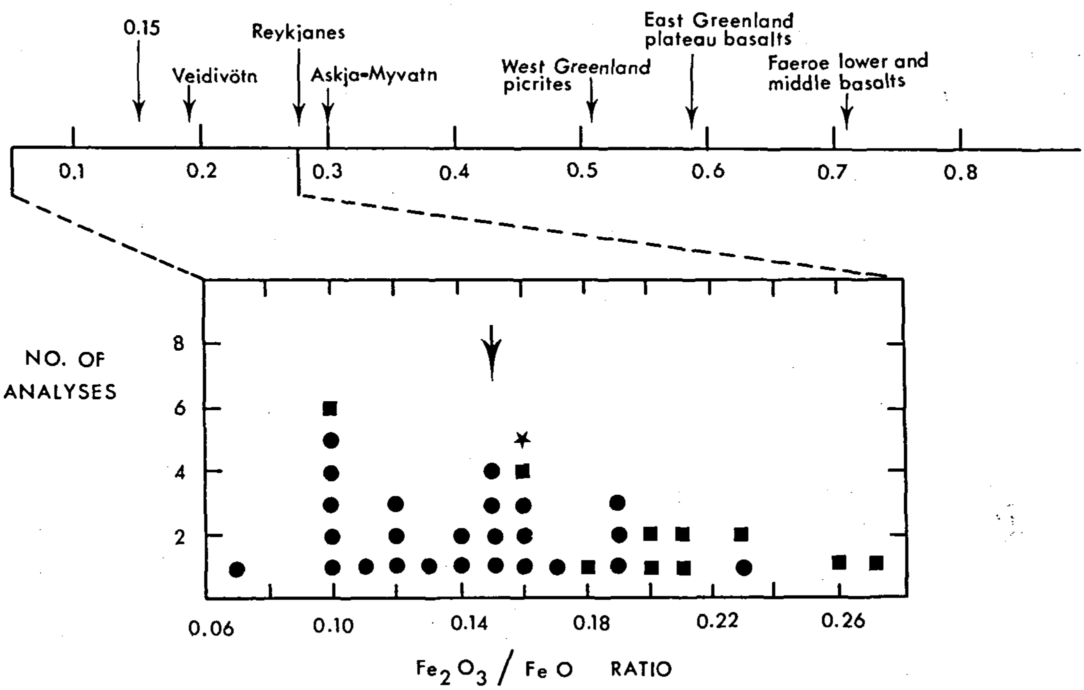

Fig. 1. The distribution of Fe_2O_3/FeO ratios in fresh basaltic glasses from the deep oceans with average values from different areas of the North Atlantic province for comparison. Circles indicate glasses analysed for both Fe_2O_3 and FeO. Data is from Campsie et al. (1973), Hekinian (1971), Melson (1969), Miyashiro et al. (1969), Moore (1965), Muffler et al. (1965), Nicholls (1965) and Thompson (1973). Values calculated from total FeO on the basis of the experimentally determined olivine-glass equilibrium are shown as squares (Melson & Thompson 1973; Fawcett et al. 1973). Comparative data for subaerial basalts from the North Atlantic province are taken from Bollingberg et al. (1975), Clarke (1970) and Brooks et al. (in press). For Postglacial Icelandic basalts from the tholeiitic rift-zone at Reykjanes, Veidivötn and Askja-Myvatn, the data are from the compilation of Jakobsson (1972). The star indicates the value for the preferred sample of the Skaergaard chilled margin (Wager & Brown 1968) and the arrow shows the suggested standard value of 0.15.

narrow interval of 0.1–0.3, which appears to confirm this assumption. I have examined all analyses of such fresh glass from the literature which report the determination of both Fe_2O_3 and FeO and have plotted the Fe_2O_3/FeO ratios in fig. 1. There are 25 points in all, more than 90 % of which lie in the interval 0.10–0.19, an extremely small range compared to subaerial basalts, of which some values from the North Atlantic are shown in the upper part of fig. 1. Similar values may be obtained by calculation using the olivine-liquid partitioning relationship for Fe^{2+} and Mg established by Roeder & Emslie (1970). Five values obtained this way by Melson & Thompson (1973) are also shown in fig. 1, along with a single value of 0.17 derived from the data for a hyaloclastite from East Greenland published by Fawcett et al. (1973). These clearly fall very close to the directly measured values although there is a slight tendancy for them to be higher.

In the light of this compilation, I propose that an approximate median value for the data in fig. 1 be adopted as a standard value in recalculation procedures. This value of 0.15 must lie very close to the true value, not only of the ocean-ridge tholeiites, but probably also for the majority of tholeiitic rocks. Thus many analyses of fresh subaerial basalts can be found around this level. For example, samples from the prehistoric Makaopuhi lava lake in Hawaii have Fe_2O_3/FeO down to 0.13 (Moore & Evans 1967).

Carmichael et al. (1974: 282–285) have discussed the dependance of the Fe_2O_3/FeO ratio in silicate melts on various factors. They show that it is dependent, among other things, on the alkali content of the melt, suggesting that in alkali basalts the suggested standard value of 0.15 may be too low. However, this effect is very small, and even in widely varying compositions there is not likely to be any great departure from this value.

The actual value chosen is of less importance than that a unique procedure be adopted by all. It seems that a value which is well-founded in reality has a better chance of receiving this universal adoption than one which is completely arbitrary. I believe that the value $Fe_2O_3/FeO = 0.15$ has the former characteristic. As it is common practice in petrochemical calculations to express relationships in percentage terms, I note that $Fe_2O_3/FeO = 0.15$ is equivalent to $Fe_2O_3/(Fe_2O_3+FeO) = 13\,\%$.

The star in fig. 1 represents the Fe_2O_3/FeO ratio of the preferred sample of the Skaergaard intrusion chilled margin. Skaergaard is often regarded as an unusually reduced magma and the differentiation trend ascribed to this character. However, according to the data discussed here, its oxidation state appears to be quite normal for such tholeiitic magmas and it may be that other magmas have become oxidized during their passage through the crust and follow different differentiation trends as discussed by Osborn (1957).

Dansk sammendrag

Petrokemiske parametre, beregnet udfra kemiske analyser af basalter, som normalt er sekundært oxiderede, afviger fra dem, det primære ikke oxiderede materiale ville have givet. I litteraturen gives mange metoder til korrektion af oxidationsforholdene i basaltiske bjergarter. Her argumenteres for en alment gældende standard værdi Fe_20_3/FeO på 0.15. Denne er baseret på konstaterede værdier i friske basaltiske glasser, hovedsagelig lav-K_20 tholeiiter fra oceanbundene men også andre basaltiske typer. Tilsvarende værdier er opnået ved beregninger baseret på $Fe^{2+}/Mg0$-fordelingen mellem olivin strøkorn og glasagtige grundmasse, kun analyseret for total jern.

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