Facies distributions and lithostratigraphic correlation in the late Precambrian Ekkerøy Formation, east Finnmark, Norway

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The late Precambrian Ekkerøy Formation of east Finnmark occurs at the top of the Vadsø Group and extends throughout the Tanafjorden–Varangerfjorden region. It consists of a uniform vertical and lateral facies pattern, in which four facies characteristically form part of a large-scale coarsening upward, marine- dominated regressive sequence. Lateral facies and thickness variations between inner Varangerhalvøya (120–190 m thick) and Varangerfjorden (15–35 m thick) are the product of both primary depositional thickness variations and a gentle, southerly dipping unconformity at the base of the overlying Grønnes Formation. The transgression at the base of the Grønnes Formation (basal Tanafjord Group) marked a major change in depositional conditions from the fluvially-dominated Vadsø Group below to the shallow marine-dominated Tanafjord Group above. This junction is the most distinctive lithostratigraphic horizon in an otherwise conformable 2,000 m thick, clastic-dominated succession.

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Stratigraphic framework

The approximately 2,000 m thick succession of late Precambrian (Upper Riphean) clastic-dominated sedimentary rocks, which occur between the metamorphic rocks of the Baltic Shield and the Eocambrian (Vendian) tillites in East Finnmark, has been divided into two groups: the Vadsø Group and the Tanafjord Group.

The older, Vadsø Group is 585–800 m thick (Banks et al. 1974) and consists mainly of alternations of relatively thick brided fluvial sandstone units (ca. 50–140 m thick) separated by thinner interfluvial (lacustrine and/or deltaic) and offshore siltstone-dominated units (ca. 25–50 m thick). The Tanafjord Group in contrast consists mainly of alternations of sandstones and siltstones which were deposited mainly in shallow marine, shoreline, and offshore environments (Johnson 1975b, 1977a, b). The boundary separating these two groups, therefore, documents an important change in depositional conditions which, if recorded elsewhere, may aid lithostratigraphic correlation.

One aim of this paper is to look more closely at the nature of this junction in the Tanafjorden–Varangerfjorden region (Fig. 1), where it is also the contact between the Ekkerøy and Grønnes Formations. In particular, sedimentological information and facies patterns within the underlying Ekkerøy Formation, based on observations at Tanafjorden, Varangerfjorden and inner Varangerhalvøya (Fig. 1), provide an opportunity for documenting the geometry of this junction. The second aim is to summarize the main vertical and lateral facies distributions within this formation and to discuss their significance in terms of the contact between the Ekkerøy and Grønnes Formations.

The Ekkerøy Formation was first referred to as the upper part of Member V by Røe (1970) and later termed the Upper Siltstone by Banks et al. (1971). The type section at Ekkerøy, however, was first formally defined as the Ekkerøy Formation by Banks et al. (1974), and was subsequently interpreted by Johnson (1975a) as a tidally influenced regressive deltaic sequence (Fig. 2). The junction between the Ekkerøy and Grønnes Formations has been variously defined with the first conglomerate-bearing coarse grained sandstones in the Ekkerøy section being placed either at the base of the Grønnes Formation (e.g. Røe 1970) or at the top of the Ekkerøy Formation (e.g. Banks et al. 1974, Johnson 1975a). All these studies, however, were based on the single section at Ekkerøy (Figs. 1 and 2).

Lateral correlation and mapping of the Ekkerøy Formation has hinged mainly on thickness changes and the correlation of the conglomeratic sandstones at the base of the Grønnes Forma-

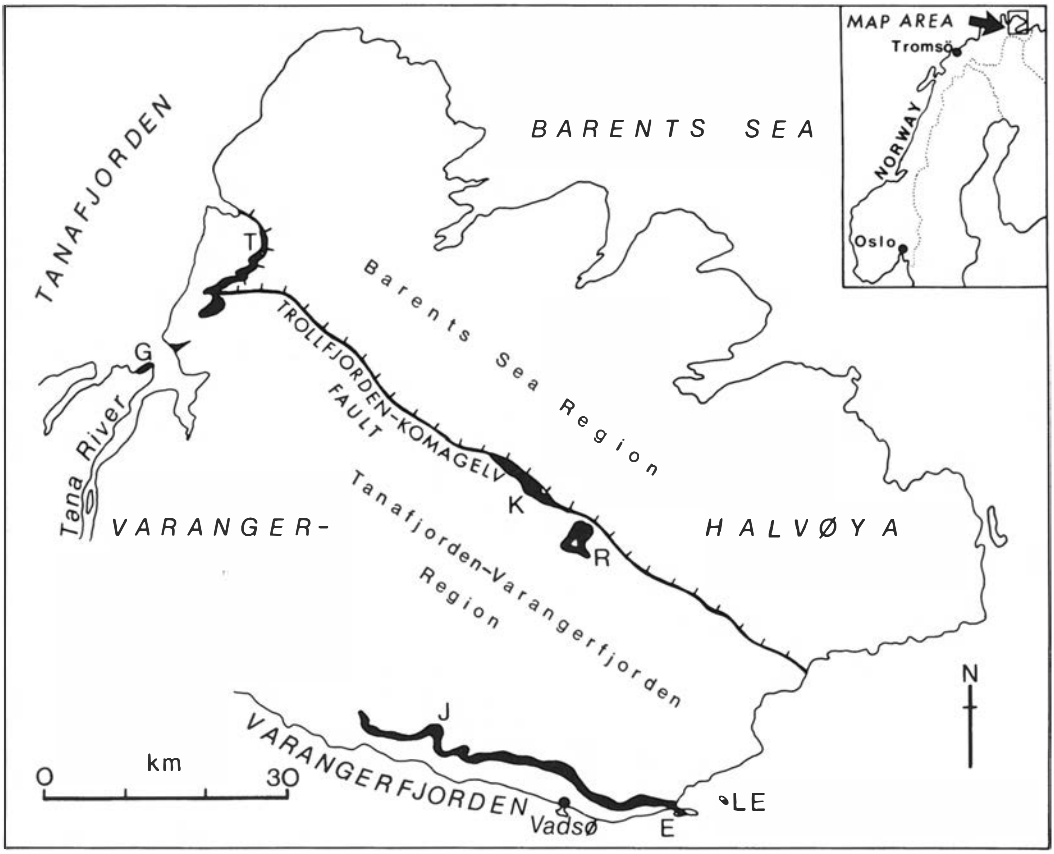


Fig. 1. Distribution of the Ekkerøy Formation in the Tanafjorden–Varangerfjorden Region and location of the main study sections: G – Gavesluft; T – Trollfjorddalen; K – Kjølstua; R – Ragnarokk; J – Jacobselv; E – Ekkerøy; LE – Lille Ekkerøy.

tion. Røe (1970), for example, demonstrated that the formation thins in a westerly direction, and suggested that it may die out completely. Banks et al. (1974), however, noted the similarity of the arenaceous shales and siltstones in the deposits below the Grønnes Formation at Tanafjorden (Sub-Grønnes deposits of Siedlecka & Siedlecki 1971) with those at Ekkerøy and therefore suggested their probable lateral equivalence. The only description of these deposits at Tanafjorden was that of Føyn (1937, beds a, b and c), but Siedlecka & Siedlecki (1972) believed that they covered extensive areas in western Varangerhalvøya where they referred to all rocks below the Grønnes Formation as the Lille Molvik Formation.

The present work forms part of a detailed study into the sedimentological history of the Ekkerøy Formation (Johnson 1975b). The scope for this work was considerably extended by several field excursions organised by Dr. S. Siedlecki (Norges Geologiske Undersøkelse, Trondheim), who introduced the writer to previously unknown sections through the Ekkerøy Formation at Lille Ekkerøy, inner Varangerhalvøya (Ragnarokk and Kjølstua), and Trollfjorddalen. The distribution of these sections enables a three-dimensional picture to be established of the facies distributions within the formation.

The sections at Ekkerøy, and Lille Ekkerøy (Fig. 1) are virtually undeformed, apart from gentle tilting (ca. 6°) and local disharmonic folding at Lille Ekkerøy, which provides laterally extensive exposures parallel to the strike.

Tectonic deformation is slightly increased in the Ragnarokk and Kjølstua sections from inner Varangerhalvøya (Fig. 1), where the rocks are deformed into large-scale open folds lying against

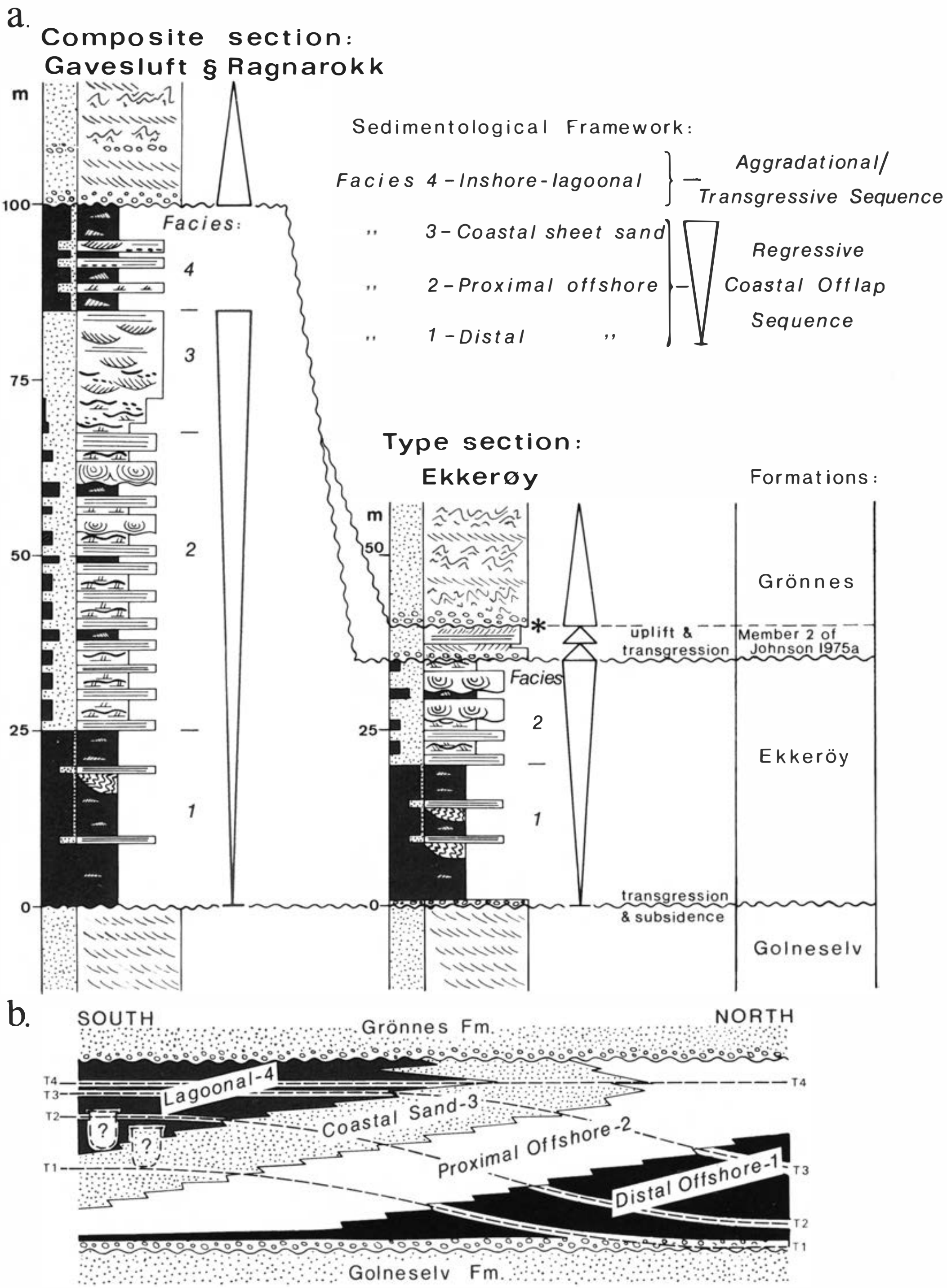


Fig. 2. Lithostratigraphic and sedimentological summary of the Ekkerøy Formation. (a) Composite vertical section (left) through the Ekkerøy Formation based on the Gavesluft and Ragnarokk sections, and its comparison to the type section (right) at Ekkerøy. The former base of the Grønnes Formation (asterisk) is lowered to the first conglomeratic sandstone (base of Member 2, Johnson 1975a). (b) Inferred time-facies relationship illustrating the envisaged regressive-transgressive nature of the sequence.

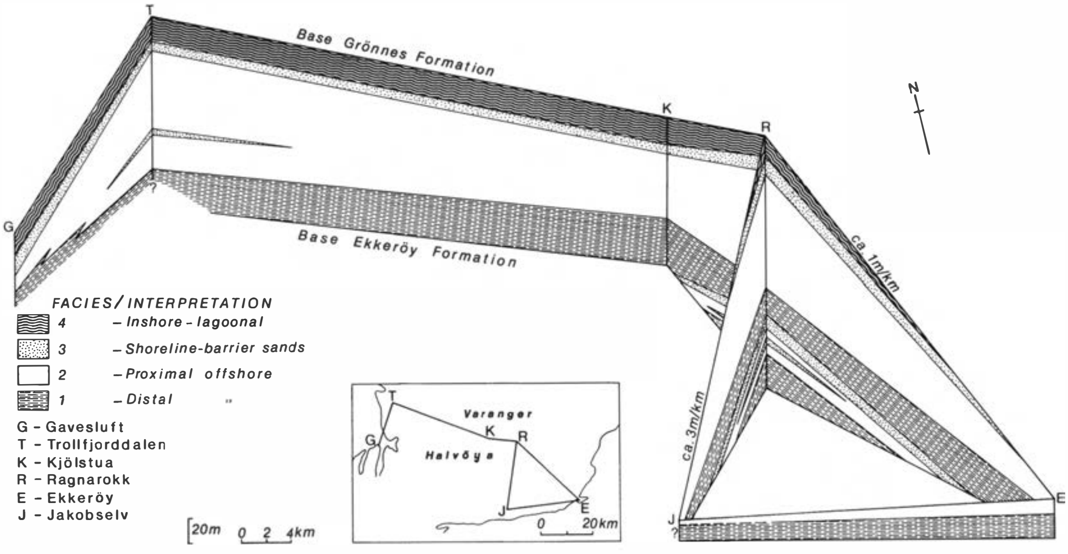


Fig. 3. Fence diagram of the main facies within the Ekkerøy Formation. Erosional gradients indicated along the Ragnarokk-Ekkerøy and Kjølstua-Jakobselv traverses are based on inferred basal Grønnes Formation unconformity.

the major Trollfjorden–Komagelv disturbance. Both sections occur in the sides of small valleys, where tectonic dip is between 40–50° and where cleavage is only weakly developed. The Ragnarokk section must be singled out since it represents the thickest known development of the formation (190 m) and is continuously exposed in an east-west oriented stream section.

The section at Gavesluft (Fig. 1) occurs at the base of the Tananes section (Føyn 1937). Tectonic disturbances are locally extreme but an unbroken and only gently deformed section occurs through the upper 60 m of the formation in a 500 m long, laterally continuous coastal section.

The section at Trollfjorddalen outcrops in two parts of an unnamed stream near the head of the valley of Lille Molvik. Deformation is greatest in this section with the base of the formation marked by a major fault-trace which separates rocks of the Tanafjorden–Varangerfjorden region from those of the Barents Sea region (Johnson et al. 1978). Lithostratigraphic sections at Ekkerøy (type section of Banks et al. 1975) and in inner Varangerhalvøya are summarized in Fig. 2a.

Sedimentological and facies summary of the Ekkerøy Formation

Results of regional lithofacies mapping reveals that the formation is everywhere characterized by a coarsening upward sequence, except at Ragnarokk where two such sequences occur. This characteristic sequential pattern is always composed of four distinctive facies which are regularly distributed both vertically (Fig. 2A, composite section) and laterally (Fig. 3), thus providing a three-dimensional facies framework. Although a detailed sedimentological analysis will be presented elsewhere, the following section summarizes the main lithostratigraphic attributes of the facies.

Main attributes of the facies

Facies 1 consists mainly of grey and grey-green siltstones with subordinate intercalations of fine-grained sandstone and more rarely granule grade beds. The siltstones commonly contain isolated lenses of current ripple cross-laminated fine sandstone (Fig. 4A) in which transport directions are mainly to the NW and very rarely to the SE. The thicker sandstone intercalations are parallel sided (Fig. 4B) and laterally persistent for several hundred metres and even for more than 2 km. They have sharp, planar bases and

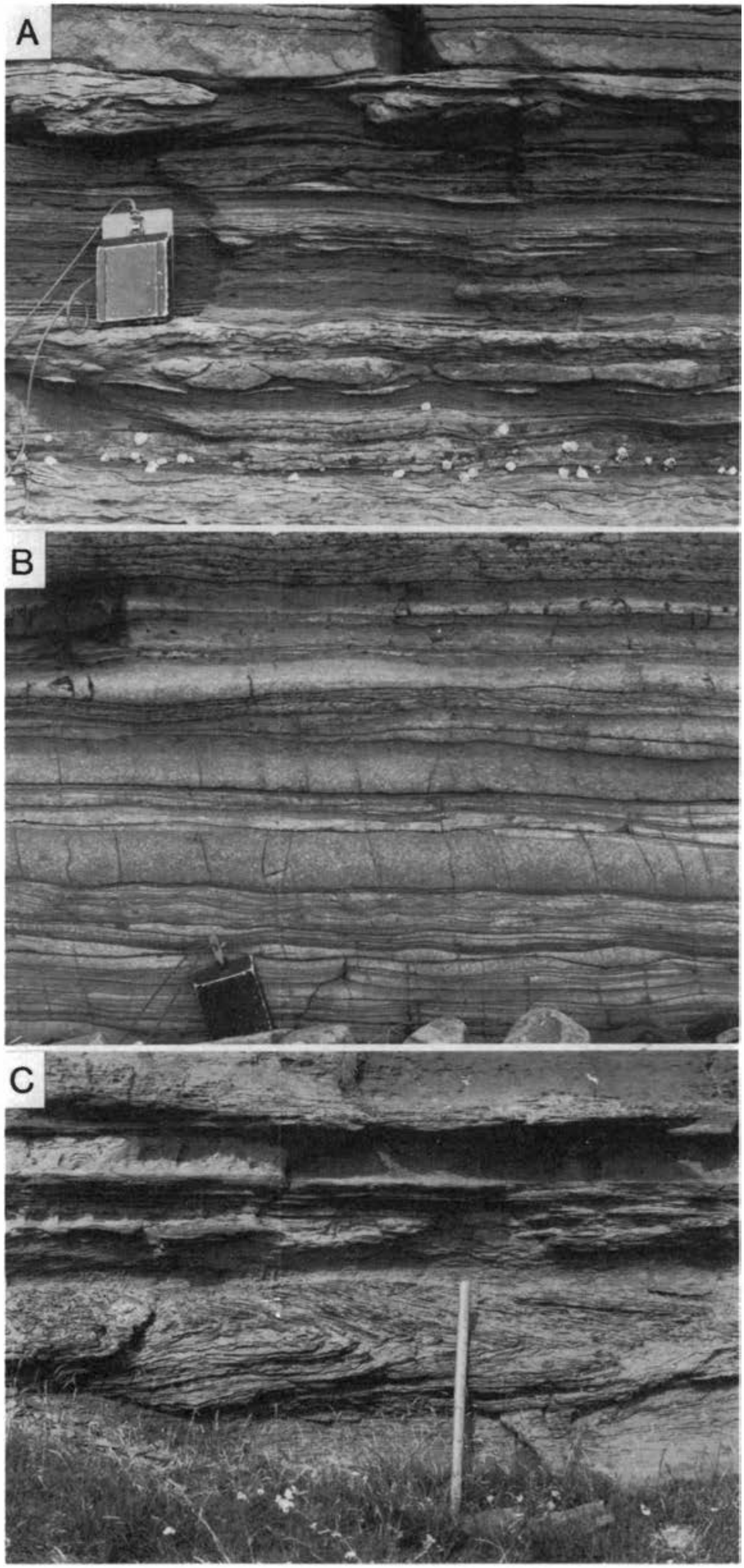
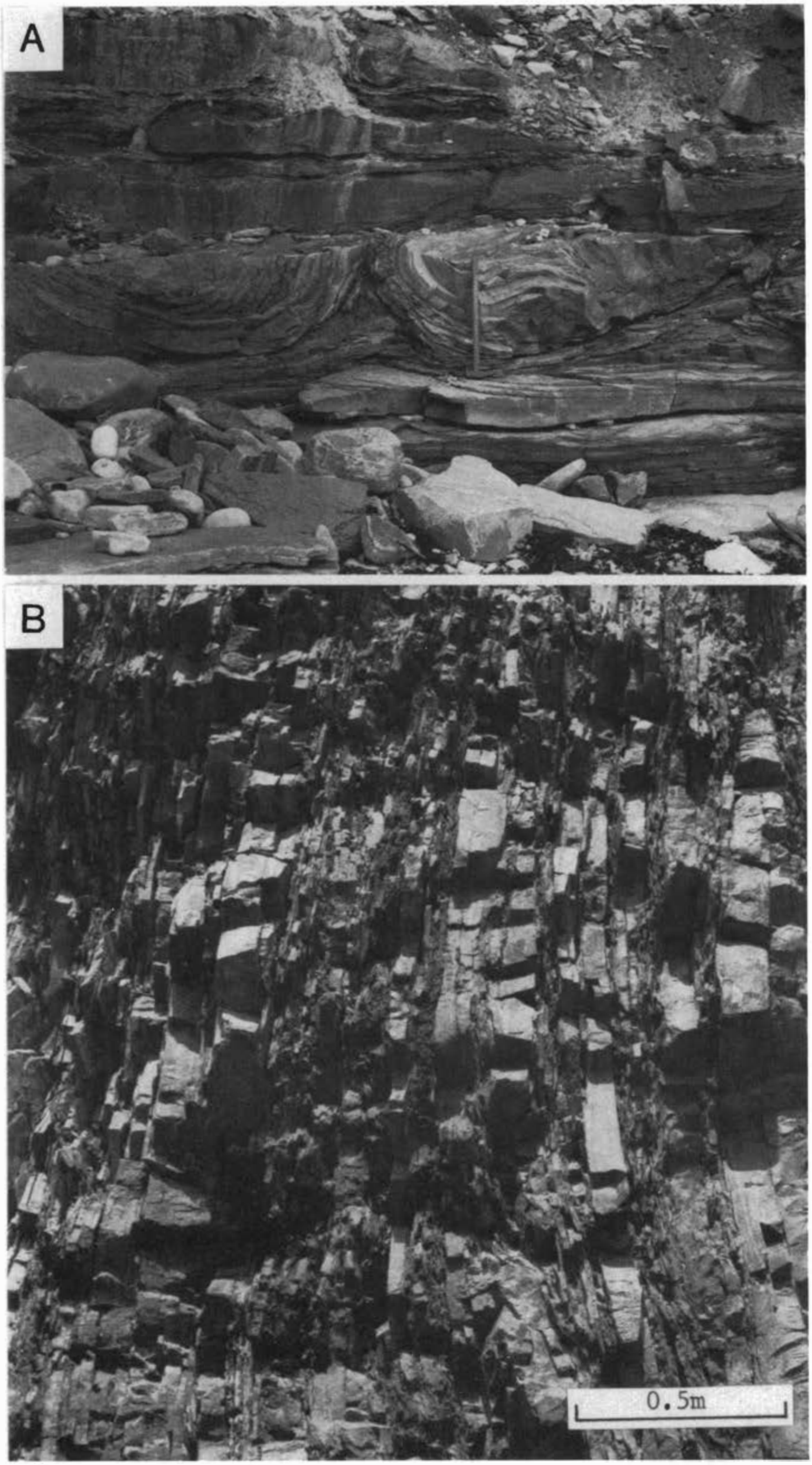


Fig. 4. Typical lithofacies and sedimentary structures in facies 1. A. Dark grey siltstones with thin, flat and isolated current rippled sandstone lenses showing sediment transport to the SE Ekkerøy section. B. Sandy subfacies consisting of rippled sandstone and siltstone with thicker sandstone interbeds displaying sharp planar bases, wave rippled or planar tops, internal flat lamination and grading. Ekkerøy section. C. Sub-isoclinal sedimentary folds with a horizontal axial plane developed in a finely laminated siltstone – fine sandstone subfacies. Ekkerøy section.


A
B
0.5m

wave rippled or planar tops. Internally they display parallel lamination, wave and current ripple cross-lamination and grading (Fig. 4B). At Ekkerøy the siltstone horizons display frequent occurrences of sedimentary folds and rotational slumps (Fig. 4C). Similar deformation structures are not apparent in other occurrences of this facies, such as at Kjølstua and Ragnarokk.

Facies 2 consists mainly of fine-grained sandstone with subordinate intercalations of dark grey siltstone. This heterolithic facies contains a most complex array of sedimentary structures, but is mainly characterized by alternations of laterally persistent sandstone beds with rippled sandstones and siltstones (Fig. 5B). The former display all the attributes of those in facies 1, but where they are thicker, as spectacularly visible at Ekkerøy, they commonly display ball and pillow structures (Fig. 5A). The thinner bedded lithologies consist of current rippled sandstones, indicating continuation of the dominant NW direction of sediment transport as evident in facies 1. The sandstones alternate rapidly on a decimetre scale with siltstone and mudstone intercalations (Fig. 5B). This is volumetrically the most abundant facies in the Ekkerøy Formation.

Facies 3 consists of cross-bedded, well-sorted medium grained and rarely coarse grained sandstones, which usually contain more than 95% total quartz. The cross-bedding commonly fills shallow troughs (30 cm deep) and foresets are frequently low-angled (ca. 15°). Parallel lamination is only rarely apparent. Further characteristics of these sandstones are thin mud-drapes and locally abundant mud-flakes (Fig. 6B).

In the best exposed example of this facies at Gavesluft there is also a well-developed coarsening upward sequence (Fig. 6A). It forms a laterally persistent sandstone body which varies between 5–15 m thick and extends throughout the study area forming an important field marker horizon.

Facies 4 consists of alternations of well-sorted medium to coarse grained sandstone beds with dark grey mudstones and siltstones, and is best exposed at Gavesluft. Petrographically the thicker sandstones are identical to those in facies

Fig. 5. Typical lithofacies and sedimentary structures in facies 2. A. Ball and pillow structure developed within a flat laminated, micaceous, fine grained sandstone bed, which alternates with subordinate rippled sandstones and siltstones. Ekkerøy section. B. Characteristic alternation of parallel sided or slightly lenticular sandstone beds (parallel to cross-laminated), with rippled sandstones and siltstones. Ragnarokk section.

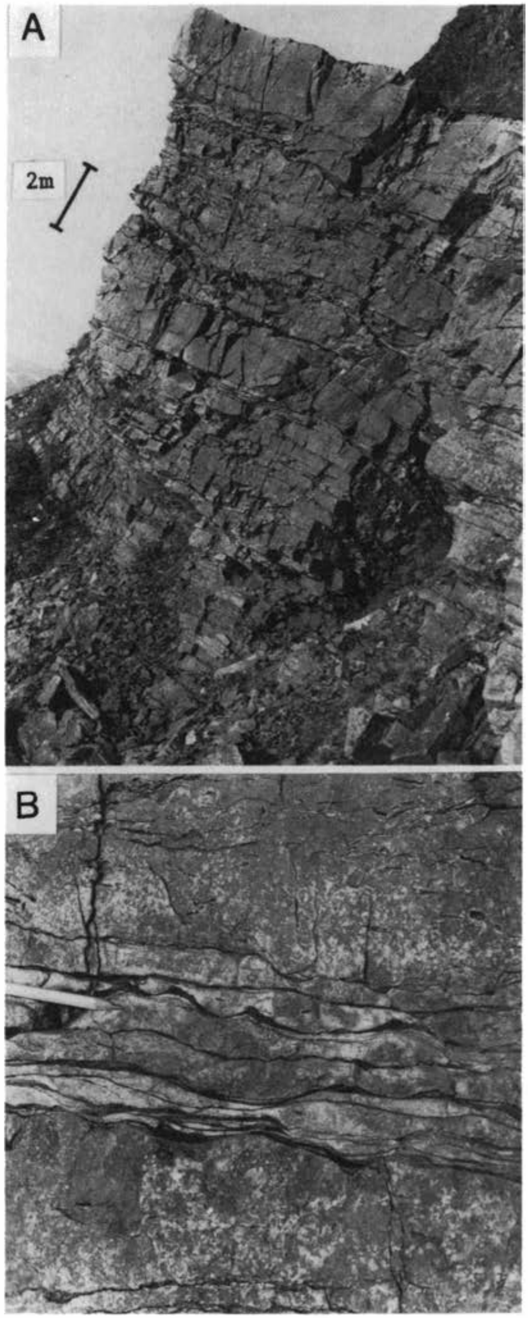


Fig. 6. Typical lithofacies and sedimentary structures in facies 3. A. Coarsening upward sequence in the Gavesluft section. Note occasional low-angle cross-bedding, erosional bed contacts, and upward increase in bed thickness. B. Close-up of the lower part of the above sandstone unit showing rippled sandstone with mud drapes, overlain by a more homogeneous sandstone with abundant mudflakes.

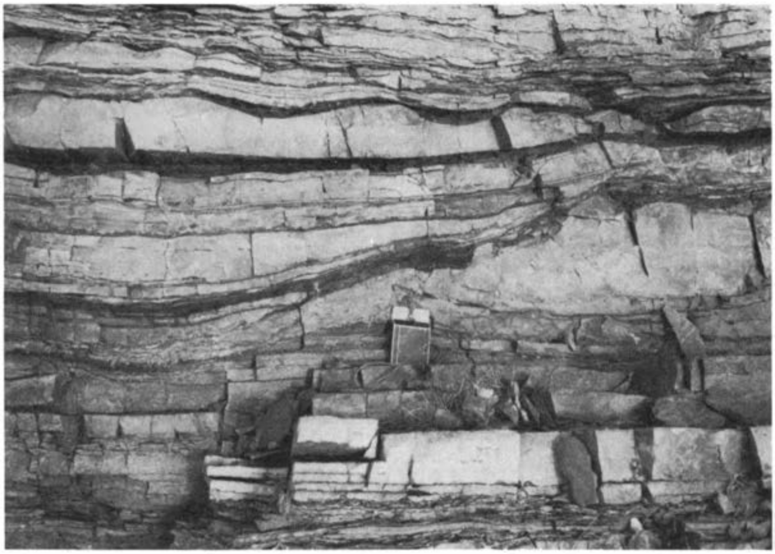


Fig. 7. Typical lithofacies and sedimentary structures in facies 4, showing lenticular sandstone beds alternating with subordinate dark grey siltstone and mudstone. The sandstone beds contain numerous mudflakes. Note the shallow channel with a mud-lined trough. Gavesluft section.

Fig. 8. Disharmonic folding within the upper part of the Ekkerøy Formation on Lille Ekkerøy.

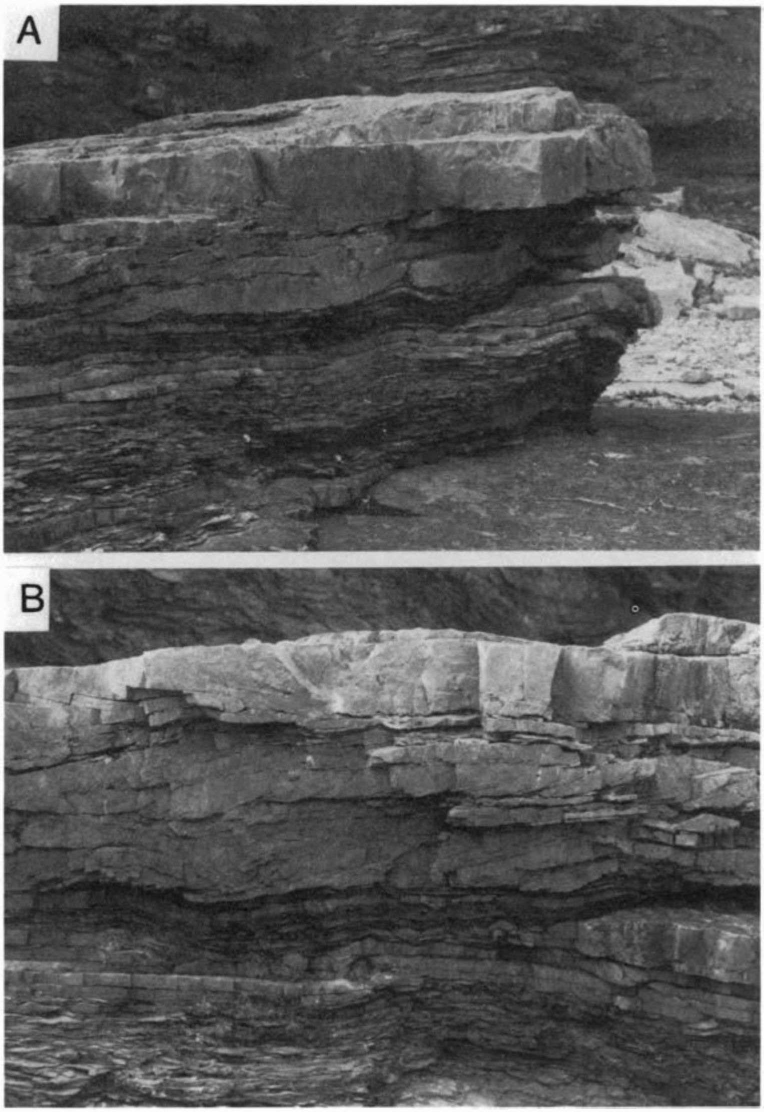


Fig. 9. Sequences and structures in the alternation of facies 3 (cross-bedded sandstones) and 4 (rippled sandstone and mudstone with mudcracks) immediately below Johnson's (1975a) Member 2 in the Lille Ekkerøy Section. A. Small-scale coarsening upward sequence 2.30 m thick. B. Close-up of the upper sandstone unit showing cross-bedding which develops a herringbone pattern at the top.

3. They form laterally persistent beds, which become locally lenticular due to small-scale channelling (Fig. 7), and are usually characterized by numerous, rounded mudflakes which are concentrated along the bases of these beds. The intervening mudstones are characterized by ubiquitous mudcracks and isolated rippled sandstone lenses. The proportion of sandstone beds to mudstone layers varies vertically and laterally.

Interpretation of the vertical facies sequence

The most complete vertical sequence is always associated with those areas of thickest development (e.g. Ragnarokk and Kjølstua, Fig. 2A and Fig. 10), and is characterized by the following facies sequence:

1→2→3→4

This sequence is most completely developed at Ragnarokk and Kjøstua. However, even where

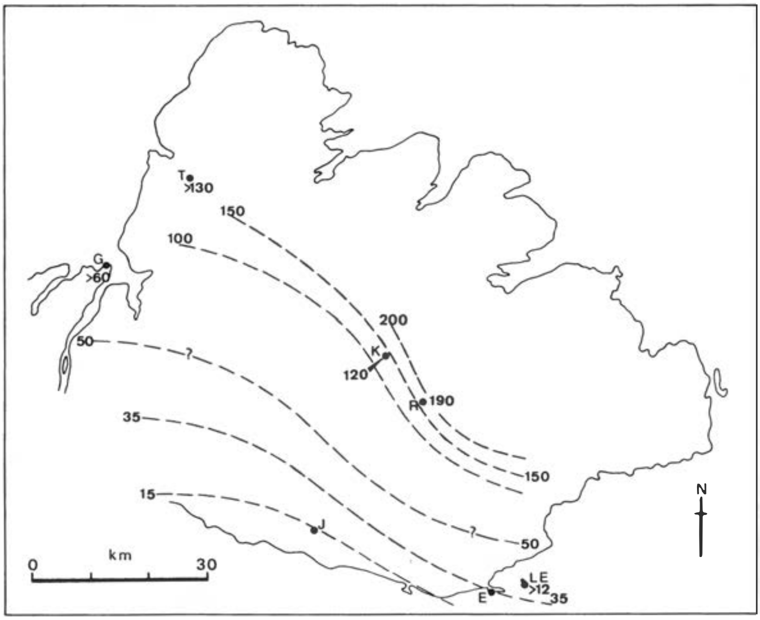


Fig. 10. Generalized isopach map of the Ekkerøy Formation (thickness in metres). Abbreviations as in Fig. 1.

this is not completely developed the same sequential relationships are always evident. The single most important feature of the formation is the large-scale coarsening upward sequence which characterizes the facies sequence: 1→2→3 (Fig. 2A). Facies 4 in contrast usually sharply overlies facies 3 but occasionally interfingers with facies 3 as seen at Lille Ekkerøy (Fig. 11). The interpretation of the four facies and their sequences will be discussed more fully elsewhere, but a summary is provided below.

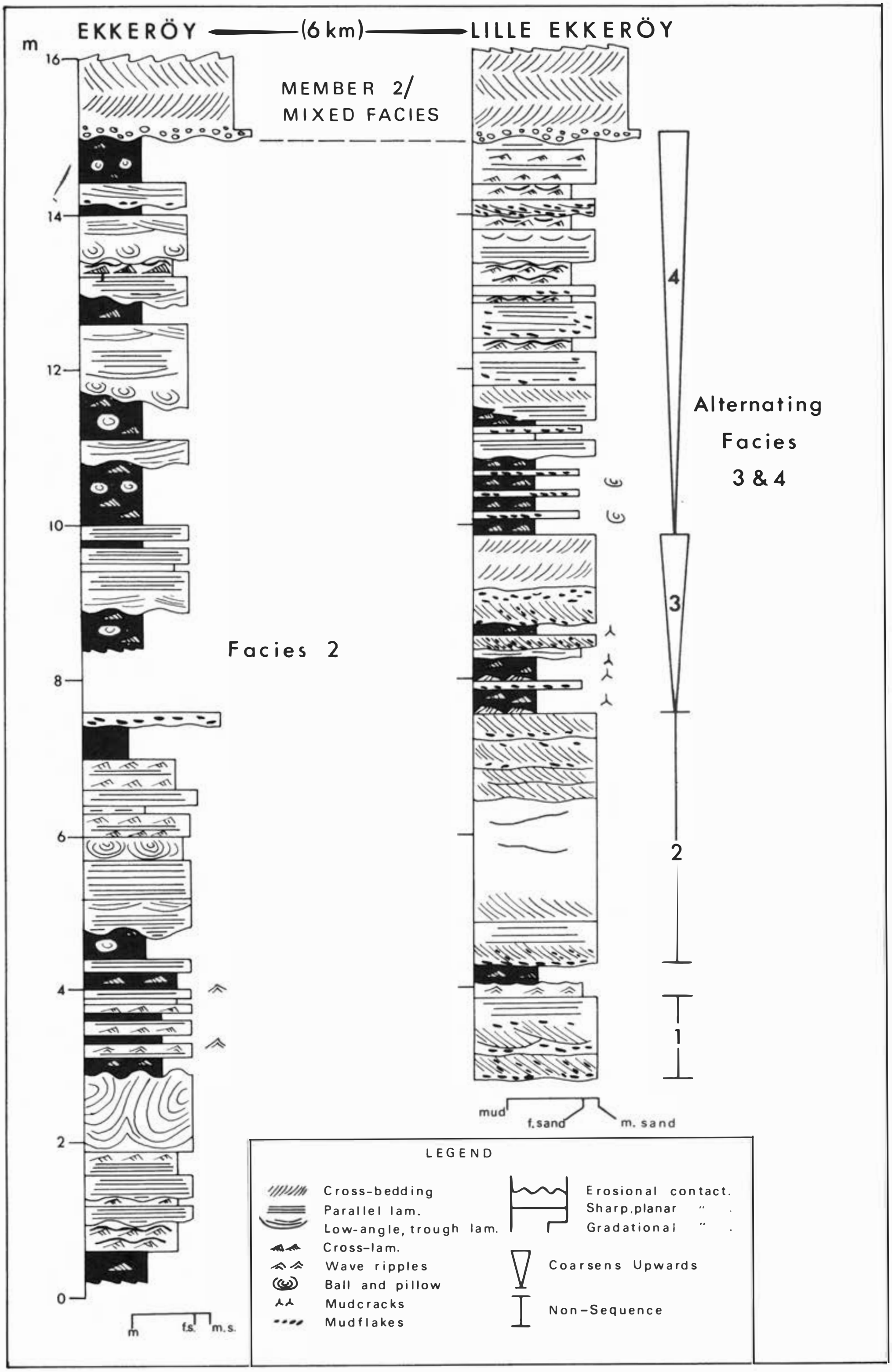
The complete vertical sequence from facies 1 to 4 (Fig. 2A, composite section) clearly represents a major regressive phase of sedimentation in which distal offshore muds (facies 1) give way gradually to alternating proximal offshore sands and muds (facies 2), followed by shoreline sand bars and barriers (facies 3) before terminating in sediments of restricted and emergent inshore environments including lagoons and tidal flats (facies 4). The sediment transport directions suggest that the shoreline prograded approximately from south to north (Fig. 2B). It is debatable, however, whether the prograding shoreline was within a deltaic or interdeltaic coastal setting. The ubiquity of slump deposits at Ekkerøy led Johnson (1975a) to infer a delta slope, although there is abundant evidence of marine activity based on features indicative of tidal currents. Evidence from the other sections is not conclusive, but unambiguous fluviatile deposits are absent from facies 3 and 4.

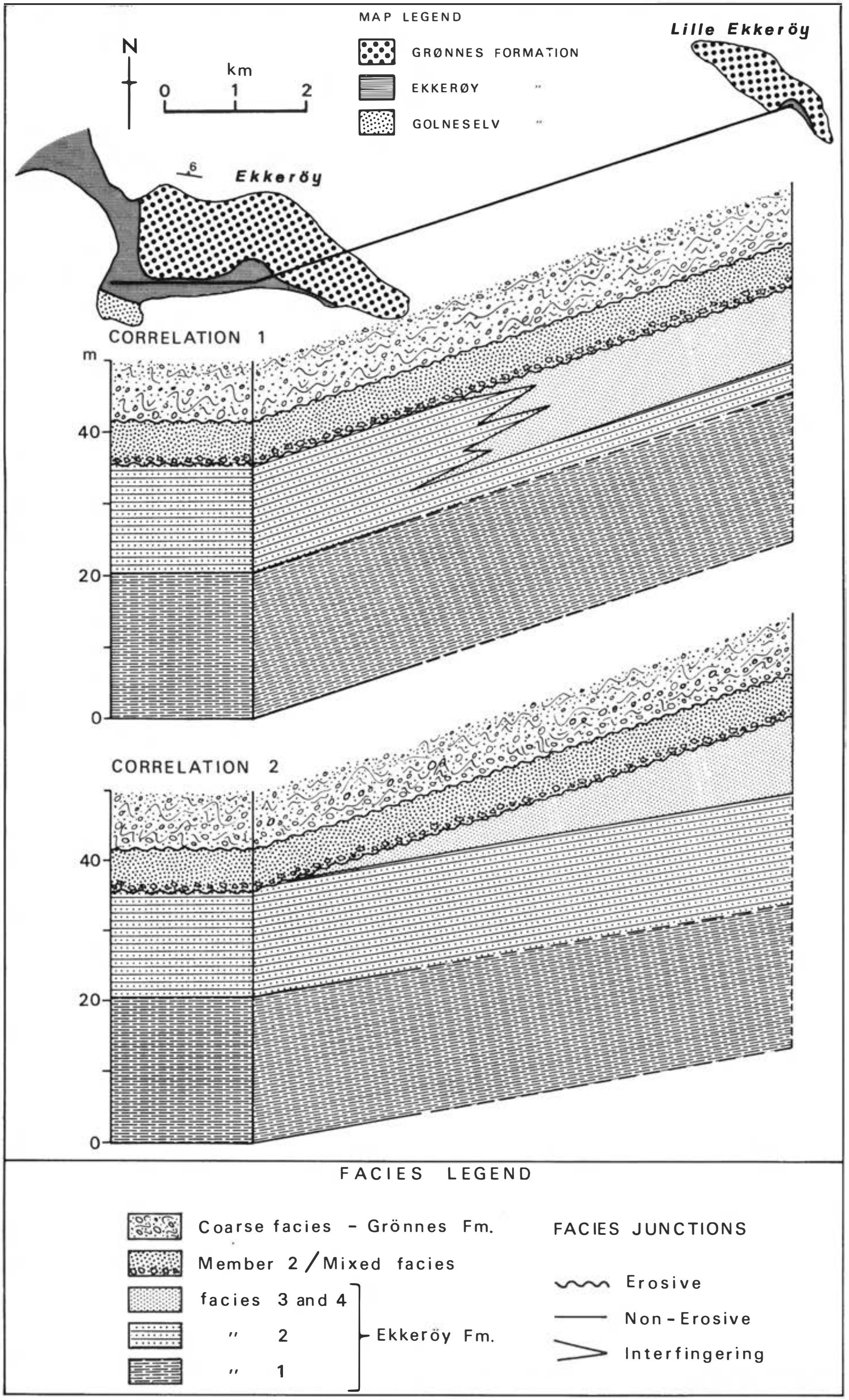
Lateral facies variations

The apparent vertical uniformity of the regressive sequences was also accompanied by a similarly uniform lateral distribution of the facies (Fig. 3). Thus throughout the time of deposition of the Ekkerøy Formation in the Tanafjorden–Varangerfjorden region a regressive phase of sedimentation prevailed.

This uniform facies pattern is most complete in the thicker northern and western sections as seen at Gavesluft, Trollfjorddalen, Kjølstua and Ragnarokk (Fig. 3). However, when traced into the thinner southern sections (e.g. Ekkerøy and

Fig. 11. Vertical sections taken through the Ekkerøy Formation immediately below Johnson's (1975a) Member 2 at Ekkerøy and Lille Ekkerøy. The Ekkerøy section is characterized by a typical sequence of facies 2 consisting of parallel, low-angle and undulatory laminated sandstone beds alternating with linsen bedding (sandstone lenses in mudstone). The Lille Ekkerøy section is characterized by distinct cross-bedded sandstone bodies forming either small-scale coarsening upward seequences (3 and 4) or random alternations (1 and 2). These latter lithofacies are typical of facies 3 and 4.


EKKERÖY —(6 km)— LILLE EKKERÖY
m
16
14
12
10
8
6
4
2
0
MEMBER 2/
MIXED FACIES
Facies 2
Alternating
Facies
3 & 4
4
3
2
1
m
f.s.
m.s.
mud
f.sand
m. sand
LEGEND
Cross-bedding
Parallel lam.
Low-angle, trough lam.
Cross-lam.
Wave ripples
Ball and pillow
Mudcracks
Mudflakes
Erosional contact.
Sharp,planar " .
Gradational " .
Coarsens Upwards
Non-Sequence


MAP LEGEND
GRØNNES FORMATION
EKKERØY "
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N
km
0 1 2
Lille Ekkeröy
6
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CORRELATION 1
m
40
20
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CORRELATION 2
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FACIES LEGEND
Coarse facies - Grönnes Fm.
Member 2 / Mixed facies
facies 3 and 4
" 2
" 1
Ekkeröy Fm.
FACIES JUNCTIONS
Erosive
Non-Erosive
Interfingering

Lille Ekkerøy) there are several notable changes.

Ekkerøy. – The type section at Ekkerøy coarsens upwards from facies 1 to facies 2 (Fig. 2A). The top of this sequence is terminated by a planar erosion surface which is overlain by approximately 8 m of inferred shoreline deposits consisting of coarse grained sandstones with a quartz pebble conglomerate at the base (Johnson 1975a). These latter deposits (Member 2 of Johnson 1975a) were originally considered to represent the uppermost deposits of the Ekkerøy Formation (Banks et al. 1974; Johnson 1975a), with the base of the Grønnes Formation taken at the next major junction, namely the base of some poorly sorted and contorted conglomeratic sandstones. These nearshore and shoreline sandstone deposits (Member 2) at the top of facies 2 are quite different to facies 3, particularly in terms of grain size, sedimentary structures, and facies sequences. Either these deposits belong to the Ekkerøy Formation and there is a facies change, or they belong to the Grønnes Formation (discussed later).

Lille Ekkerøy. – A small anticlinal flexure has domed-up beds of the Grønnes Formation to expose rocks of the Ekkerøy Formation in a narrow coastal section at the southern end of the island. This section is unusual because of the local occurrence of disharmonic folding (Fig. 8). The section exposes the contorted conglomeratic sandstones of the Grønnes Formation, which is underlain by an almost identical sequence of Member 2 (Johnson 1975a) as at Ekkerøy. A remarkable change, however, occurs below the basal conglomerate bed of the latter deposits where sandstones of identical character to facies 3 alternate with beds similar to facies 4 (Fig. 11). The sandstones compare with those of facies 3 in the following manner: abundant trough cross-bedding, mud drapes along foresets, numerous mudflakes, small-scale coarsening upward sequences, medium sand grain size, quartzitic composition, grey colour (Fig. 9A and B). The intervening finer grained lithologies compare with facies 4 in the following manner: numerous mudcracks, numerous mudflakes in the sandstone beds, current rippled sandstone lenses displaying oppositely dipping cross-lamination, lenticular sandstone interbeds, sandstones have similar composition and texture to sandstones in facies 3.

These deposits differ from those assigned to facies 2 below Member 2 at Ekkerøy (Fig. 11), where the following features are characteristic: fine grained micaceous sandstones which weather red-brown, predominance of low-angle and parallel lamination, abundant loading structures, especially ball and pillow structures, rarity of mudflakes, rarity of cross-bedding, absence of abundant mudcracks, and absence of vertical sequences.

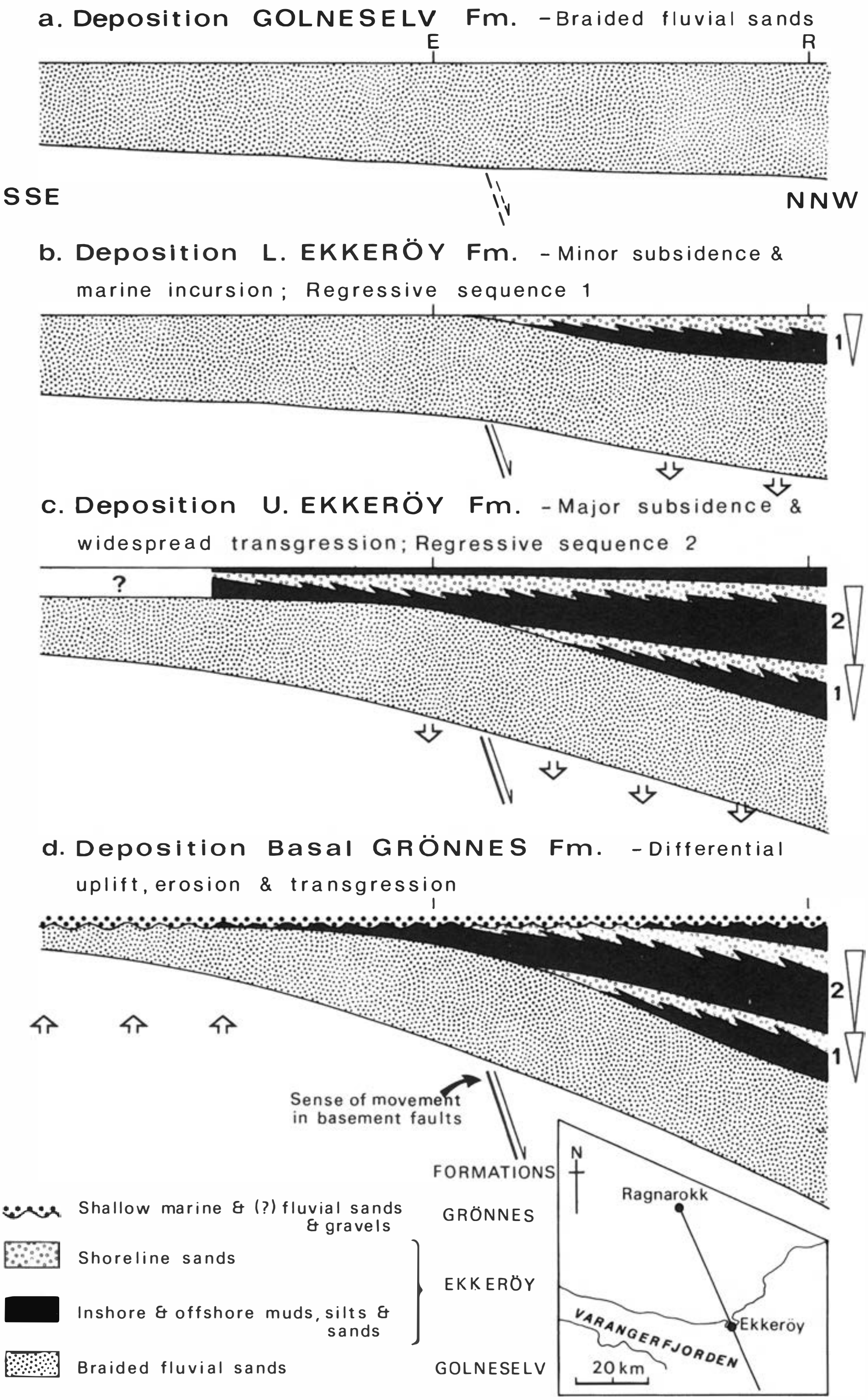
Fig. 12. Two possible facies correlation diagrams between Ekkerøy and Lille Ekkerøy. Correlation number 2 is considered most acceptable based on arguments in the text. This requires Member 2/Mixed facies to be placed at the base of the Grønnes Formation and overlying a gentle erosional unconformity.

Interpretation of lateral facies changes between Ekkerøy and Lille Ekkerøy

There are only two possible explanations for the lateral facies relationships in those deposits below Member 2 between Ekkerøy and Lille Ekkerøy (Fig. 11): (1) They are laterally equivalent due to rapid lateral facies changes, or – (2) The rocks of facies 3 and 4 at Lille Ekkerøy are stratigraphically higher than those of facies 2 at Ekkerøy (Fig. 12).

There are two main objections to the first explanation (Fig. 12, correlation number 1). Firstly, the contrasting environments of facies 3 and 4 (nearshore, shoreline and intertidal environments) and facies 2 (offshore, sublittoral environment) would necessitate rapid facies changes normal to the dominant northward sediment transport path. Such lateral changes are unlikely in view of the relatively stable facies geometries developed elsewhere in the formation. Secondly, in all the complete sections observed through the formation, facies 3 always overlies facies 2, forming a laterally persistent sheet-like sand body which is continuous in the northern sections (Fig. 3). Its sudden lateral transition into facies 2 therefore seems unlikely.

These arguments suggest that the second explanation may be more likely, in which the succession of facies 3 and 4 at Lille Ekkerøy is stratigraphically higher than the succession of facies 2 at Ekkerøy (Fig. 12, correlation number 2). Thus instead of invoking rapid lateral facies changes it is suggested that if the section at Lille Ekkerøy could be continued downwards, the sequence of facies 3 and 4 would be underlain by facies 2 and then facies 1 as seen at Ekkerøy. Complimentary to this explanation is that the



a. Deposition GOLNESELV Fm. - Braided fluvial sands
E
R
SSE
NNW
b. Deposition L. EKKERÖY Fm. - Minor subsidence & marine incursion; Regressive sequence 1
1
c. Deposition U. EKKERÖY Fm. - Major subsidence & widespread transgression; Regressive sequence 2
?
2
1
d. Deposition Basal GRÖNNES Fm. - Differential uplift, erosion & transgression
2
1
Sense of movement in basement faults
FORMATIONS
Shallow marine & (?) fluvial sands & gravels
GRÖNNES
Shoreline sands
EKKERÖY
Inshore & offshore muds, silts & sands
Braided fluvial sands
GOLNESELV
N
Ragnarokk
Ekkeröy
VARANGERFJORDEN
20 km

absence of facies 3 and 4 at Ekkerøy is the product of gradual erosion at the base of Member 2 (Fig. 12). This interpretation, therefore, envisages a similar vertical facies sequence to that recorded in all the complete sections seen further north and west. The main difference in these thinner southern sections, however, is that they are incomplete due to erosion at the base of the Grønnes Formation, rather than to lateral facies changes (Fig. 13). This interpretation is critical to Johnson's (1975a) Member 2, because since this erosional unconformity occurs at the base of Member 2, the latter should be included in the basal part of the Grønnes Formation rather than the top of the Ekkerøy Formation.

Stratigraphic significance of the lateral facies distributions

Accepting the previous explanation for the facies distributions between Ekkerøy and Lille Ekkerøy, it is possible to extend the discussion to facies distribution patterns and thickness variations in the Ekkerøy Formation throughout the Tanafjorden–Varangerfjorden Region. Furthermore, this provides information on the nature of the transgressive surface at the base of the Grønnes Formation.

The removal of the 12 m thick succession of facies 3 and 4 between Lille Ekkerøy and Ekkerøy (6 km) requires a gentle erosional gradient of 2 m per kilometre at the base of the Grønnes Formation. Equating the rocks of facies 3 at Lille Ekkerøy with the sheet-like sandstone body in the northern sections, and inferring their disappearance at Ekkerøy, an erosional gradient of 1 m per kilometre is calculated between Ragnarokk and Ekkerøy. Similarly a value of 3 m per kilometre is estimated between Kjølstua and Jakobselv. This gentle erosional gradient is never visible in the field.

The progressive southerly thinning of the Ekkerøy Formation can therefore be explained both in terms of a primary depositional feature and a subsequent erosional feature caused by a gentle, southerly dipping angular unconformity at the base of the Grønnes Formation (Fig. 13). The main reason for the decrease in thickness from Ekkerøy to Jakobselv as noted by Røe (1970) is probably this unconformity.

The shoreline deposits formerly assigned to the Ekkerøy Formation (Johnson 1975a) are now considered to form the basal part of the transgressive Grønnes Formation. These developed during the initial transgression and were succeeded during the main transgression by the contorted conglomeratic sandstones. Whilst the former display both NW and SE directed palaeocurrents, the latter only display SE directed palaeocurrents. This parallelism of palaeocurrent directions combined with the similarity in grain size and composition further emphasises a close relationship between these two deposits.

Although the unconformity is slightly angular and marks an important change in the overall depositional conditions of the Vadsø and Tanafjord Groups, it did not result in any major change in palaeogeography. Comparison between the two groups suggests a relatively stable palaeogeography throughout the time of their deposition (Johnson 1975b).

The envisaged depositional and tectonic conditions which have contributed to the contrasting lithostratigraphic sections in the Ekkerøy Formation are summarized in Fig. 13.

Fig. 13. Summary of the main depositional and tectonic phases active during Ekkerøy Formation times. Note the contrasting lithostratigraphic sections preserved in the basinal areas (e.g. Ragnarokk – R) compared with those in the platform areas (e.g. Ekkerøy – E).

Conclusions

The main conclusions from this preliminary regional analysis of the Ekkerøy Formation are as follows:

The Ekkerøy Formation extends throughout the Tanafjorden–Varangerfjorden region, and is equivalent to the sub-Grønnes deposits at Tanafjorden previously termed the Lille Molvik Formation by Siedlecka & Siedlecki (1972).

The formation is always characterized by four main facies, of which facies 1 to 3 are arranged in a large-scale, coarsening upward, regressive coastal off lap sequence.

Lateral facies mapping demonstrates a uniform lateral development of the facies, except at Ragnarokk where two regressive sequences are developed.

The most complete vertical facies sequences occur in the north (inner Varangerhalvøya) and west (Tanafjorden) and coincide with the thickest development of the formation (up to 190 m thick).

The thinnest development of the formation occurs along the northern shores of Varangerfjorden where it is 15–35 m thick. This is partially a primary depositional feature but it has been enhanced by a gentle, southerly dipping unconformity at the base of the overlying Grønnes Formation.

Erosion at the base of the Grønnes Formation is concluded from facies changes immediately below Johnson's (1975a) Member 2 which extends continuously between Ekkerøy and Lille Ekkerøy, and which was formerly included in the upper part of the Ekkerøy Formation. Since the erosional unconformity occurs below Johnson's Member 2, the latter should be elevated to the base of the Grønnes Formation.

Estimates of the erosional gradient of the sub-Grønnes unconformity, based on the inferred removal of facies from the Ekkerøy Formation between inner Varangerhalvøya and Varangerfjorden, give values of between 1 and 3 m per kilometre.

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References

Banks, N. L., Edwards, M. B., Geddes, W. P., Hobday, D. K. & Reading, H. G. 1971: Late Precambrian and Cambro-Ordovician sedimentation in East Finnmark. *Nor. Geol. Unders. 269,* 197–236.

Banks, N. L., Edwards, M. B., Geddes, W. P., Hobday, D. K. 1974: Stratigraphy of the Late Precambrian 'Older Sandstone Series' of the Varangerfjord Area, Finnmark. *Nor. Geol. Unders. 303,* 1–16.

Banks, N. L. & Røe, S-L. 1974: Sedimentology of the Late Precambrian Golneselv Formation, Varangerfjord, Finnmark, North Norway. *Nor. Geol. Unders. 303,* 17–38.

Føyn, S. 1937: The Eocambrian Series of the Tana District, Northern Norway. *Nor. Geol. Tidsskr. 17,* 65–164.

Hobday, D. K. 1974: Interaction between fluvial and marine processes in the lower part of the Late Precambrian Vadsø Group, Finnmark. *Nor. Geol. Unders. 303,* 39–56.

Johnson, H. D. 1975a: Tide- and wave-dominated inshore and shoreline sequences from the Late Precambrian, Finnmark, North Norway. *Sedimentology 22,* 45–74.

Johnson, H. D. 1975b: Sedimentological Studies in the Late Precambrian Upper Vadsø Group and Lower Tanafjord Group of East Finnmark, North Norway. 453 pp. Unpublished Ph. D. thesis, University of Oxford.

Johnson, H. D. 1977b: Shallow marine sand bar sequences: an example from the late Precambrian of North Norway. *Sedimentology 24,* 245–270.

Johnson, H. D. 1977b: Sedimentation and water escape structures in some late Precambrian shallow marine sandstones from Finnmark, North Norway. *Sedimentology, 24,* 389–411.

Johnson, H. D., Levell, B. K. & Siedlecki, S. 1978: Late Precambrian sedimentary rocks in East Finnmark, north Norway and their relationship to the Trollfjord-Komagelv fault. *J. Geol. Soc. Lond. 135.*

Røe, S-L. 1970: Correlation between the Late Precambrian Older Sandstone Series of the Varangerfjord and Tanafjord Areas: Preliminary Report. *Nor. Geol. Unders. 266,* 230–245.

Siedlecka, A. & Siedlecki, S. 1971: Late Precambrian sedimentary rocks of the Tanafjord–Varangerfjord region of Varanger Peninsula, Northern Norway. *Nor. Geol. Unders. 269,* 246–294.

Siedlecka, A. & Siedlecki, S. 1972: Lithostratigraphic correlation and sedimentology of the Late Precambrian of Varanger Peninsula and neighbouring areas of East Finnmark, Northern Norway. *XXIV Intern. Geol. Congress, Montreal 6,* 349–358.