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Stratigraphic and sedimentological studies of the Eleonore Bay Group (Precambrian) between 73° 30′ and 76°N in East Greenland

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As part of the North-East Greenland Project 1988–1990, a sedimentological study of the Precambrian Eleonore Bay Group between Grandjean Fjord and Bessel Fjord (75°–76°N) (fig. 1) was planned to start in 1988 with one two-man team and to continue in 1989 with two teams. This area was last visited in 1955 when Sommer (1957) as a member of Lauge Koch's expeditions to East Greenland carried out the mapping. This work, however, only dealt with stratigraphic and tectonic problems, and sedimentological data, apart from gross lithologies, were not recorded. Unfortunately, the field work of 1988 quickly revealed that the sediments had suffered from a relatively strong metamorphic recrystallisation, and hence it was generally not possible to carry out detailed sedimentological work in this area. As a consequence the team concentrated on stratigraphic problems, and after 3 weeks the working area was moved southwards to Vibeke Sø (Hudson Land) and Brogetdal (Strindberg Land) (fig. 1) where the rest of the season was spent.

Geology

The Eleonore Bay Group is a fundamental element of the East Greenland Caledonian fold belt. It is a sequence of sediments and metasediments up to 14 km thick which crop out over an area of 450 km north to south and 200 km east to west (fig. 1), forming the greater part of the pre-Caledonian sedimentary pile. Earlier investigations were mainly made by Lauge Koch's expeditions to East Greenland from 1930–1958, but were restricted to general mapping (see reviews by Haller, 1971 and Henriksen & Higgins, 1976).

There is no general agreement on a formal subdivision of the Eleonore Bay Group although one version was unsuccesfully proposed by Katz (1961). Hence we persist with the commonly used informal subdivision of Haller (1971) (figs 1, 2) into the basal Arenaceous–Argillacous 'Series' (up to *c.* 9000 m), the Quartzite

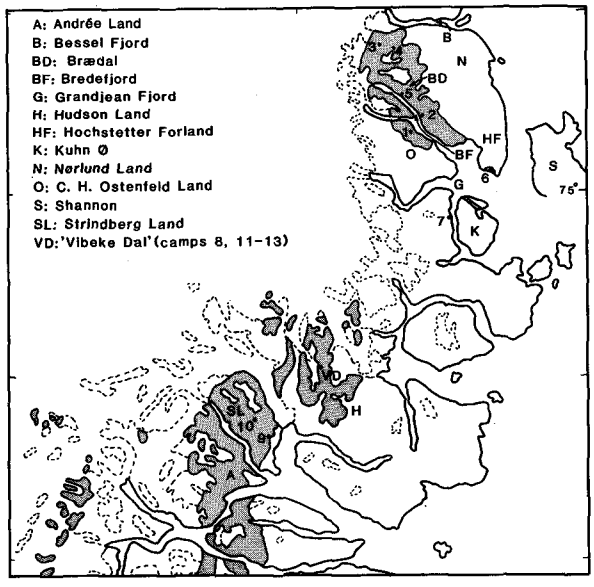

Fig. 1. Map showing distribution of Eleonore Bay Group in East Greenland and camp positions (1–13) during the 1988 field work.

'Series' (*c.* 2500 m, comprising Bed-groups 1–6) the Multicoloured 'Series' (*c.* 1200 m, comprising Bed-groups 7–13) and the upper Limestone–Dolomite 'Series' (up to *c.* 1500 m, comprising Bed-groups 14–20).

At the time of the earlier work, sedimentological knowledge was restricted and no interpretations of the sedimentary environments and basin evolution were made (Haller, 1971). Later, the Eleonore Bay Group in the Scoresby Sund area (70°–72°N) was studied in conjunction with field work carried out by the Geological Survey of Greenland from 1968 to 1972. An environmental interpretation was presented, though without the data which would allow its critical evaluation. Continental, mainly fluvial, environments were suggested for the lower two series of the group, while shallow marine environments dominated the upper two series (Caby, 1972; Caby & Bertrand-Sarfati, 1988).

Grandjean Fjord – Bessel Fjord region

In this area the Eleonore Bay Group was divided by Sommer (1957) into 7 mapping units which were tentatively correlated with the sequence established further to the south (fig. 2). This stratigraphic subdivision and the correlation with the southern sequence can generally be confirmed in the present study. Hence, it seems unnecessary to erect a local formal lithostratigraphy for this area since the Eleonore Bay Group as a whole awaits a thorough lithostratigraphic revision (cf. Haller, 1971, p. 81–82; Henriksen & Higgins, 1976, p. 189).

In the C. H. Ostenfeld Land – Nørlund Land area, the Eleonore Bay Group includes relatively high-grade metasediments (garnet-mica schists which are locally amphibolitic, and pure quartzites). In most cases the internal sedimentary structures of the quartzites are nearly totally obliterated, but bedding plane structures such as ripple marks are commonly preserved. In the pelitic intervals the sedimentary structures are locally preserved to such an extent that logging was possible. However, due to the very local nature of this preservation it is not feasible to make any firm interpretation of the depositional environments for these sediments.

Seven major informal mapping units could be followed throughout H. C. Ostenfeld Land and Nørlund Land (fig. 2). Unit 1, a sequence dominated by dark pelitic rocks corresponding to the Upper Argillaceous – Arenaceous 'Series', was further divided into five subunits (1a-e) based on the presence of paler, more quartzitic intervals which, however, are probably rather local. The thickness of unit 1 is in the order of several thousand metres but it cannot be determined exactly due to the lack of regional marker horizons and lack of recognised base. Units 2–7, reaching a total thickness of nearly 2000 metres, correlate with the lower part of the Quartzite 'Series' (Bed-groups 1–4 of Sommer, 1957) (fig. 2).

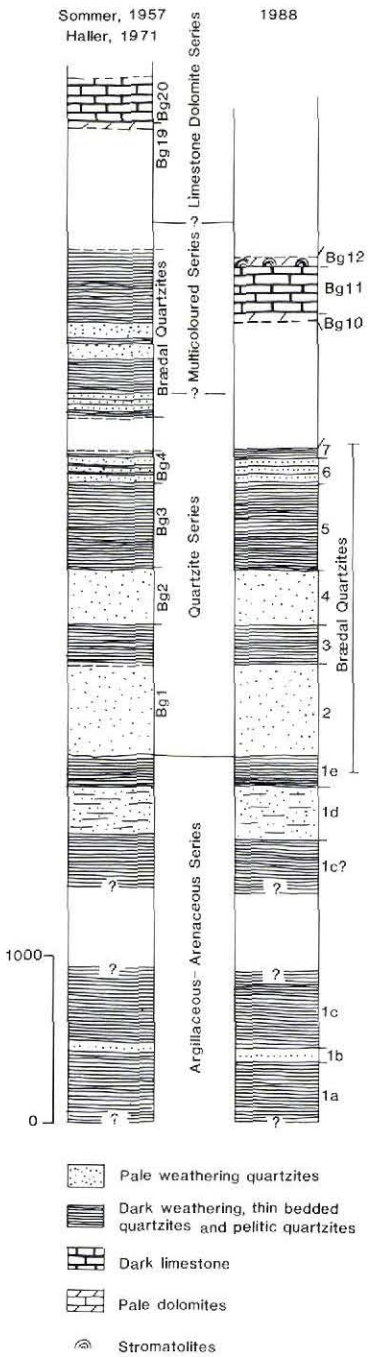

Fig. 2. Stratigraphic scheme of the Eleonore Bay Group in the Grandjean Fjord – Bessel Fjord region according to Sommer (1957) and Haller (1971) compared with the revised scheme resulting from the 1988 field work. Bg numbers refer to bed-groups, while other numbers refer to 1988 mapping units.

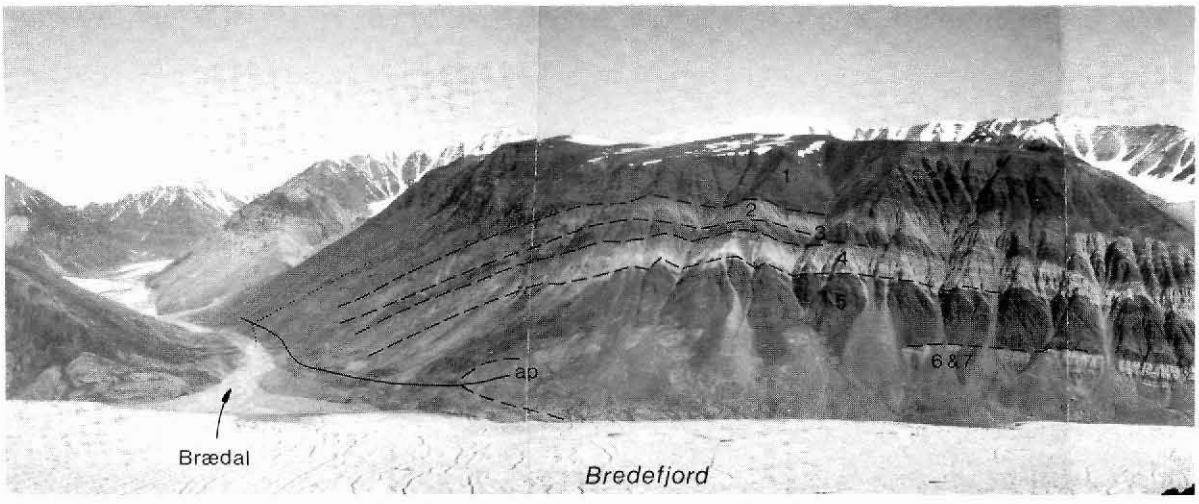

Fig. 3. The inverted sequence of the Quartzite 'Series' (the Brædal Quartzites of Sommer, 1957) along Bredefjord to the south-east of Brædal. Numbers refer to 1988 mapping units. Axial plane of fold: ap. Cliff-face approximately 1100 m high.

The Brædal Quartzites, tentatively correlated with parts of the Quartzite 'Series' and the Multicoloured 'Series' by Sommer (1957) and Koch & Haller (1971), were found to be an inverted sequence of the Quartzite 'Series', where the dark, thin-bedded pelitic quartzite units (units 3 and 5) have suffered from severe tectonic thinning (fig. 3). Furthermore, the outcrops on southern Hochstetter Forland, which were referred to Bed-groups 19 and 20 of the Limestone–Dolomite 'Series' by Sommer (1957), are now correlated with Bed-groups 10–12 of the Multicoloured 'Series' (fig. 2). Hence, there is no evidence of a local development of the Multicoloured 'Series' in this area as suggested by Sommer (1957) and Haller (1971).

The outcrops in the northern end of Kuhn Ø still have a somewhat enigmatic stratigraphic position, but probably represent part of the upper Quartzite 'Series'. The outcrops compared with the Quartzite 'Series' on the north-eastern tip of Shannon (Koch & Haller, 1971; Haller, 1971) were found not to belong to the Eleonore Bay Group (A. K. Higgins, personal communication, 1988).

Hudson Land – Strindberg Land area

Field work in this area was concentrated in 'Vibeke Dal' (Hudson Land) and Brogetdal (Strindberg Land) (fig. 1; 9,10). In 'Vibeke Dal' well-exposed sections were measured through the Quartzite 'Series' (Bed-groups 2–6), the Multicoloured 'Series' (Bed-groups 7–13) and the Limestone–Dolomite 'Series' (Bed-groups 14–18) in fault blocks along the northern side of 'Vibeke Dal'. In Brogetdal, studies mainly concerned Bed-groups 10 and 13; hence, the following description of the bed-groups is mainly based on the sections from 'Vibeke Dal' (fig. 4).

Quartzite 'Series'

Bed-group 2. Bed-group 2 consists of pale, purplish and greenish weathering, quartzitic sandstone with a minimum thickness of 100 m (base not exposed). Internally, the sandstone is dominated by medium scale cross-bedding in sets up to 15 cm thick, often showing current reversals and weak reactivation surfaces. Wave ripples are common. Channelling was not observed and mud drapes are rare. The dominant current direction is towards the north-west with reversals towards the south-east. Bed-group 2 was probably deposited in a shallow marine, tidally influenced environment.

Bed-group 3. This bed-group includes 500–600 m of bluish weathering, dark greenish brown siltstones with thin sandstone beds interbedded on a scale of a few centimetres. The sandstone beds are up to 20 cm thick and rather lenticular, internally ripple cross-laminated. Synaeresis cracks are common.

Bed-group 4. Bed-group 4 is an approximately 360 m thick sequence of interbedded thick, laterally persistent sandstone units and red, green and black shales and sandy siltstone. In the lower part, the sandstone units are between 5 and 50 m thick and generally less than 5 m thick in the upper part. The sandstones are rather massive; beds are mostly parallel sided, 5–20 cm thick and separated by thin silty partings. Amalgamation of

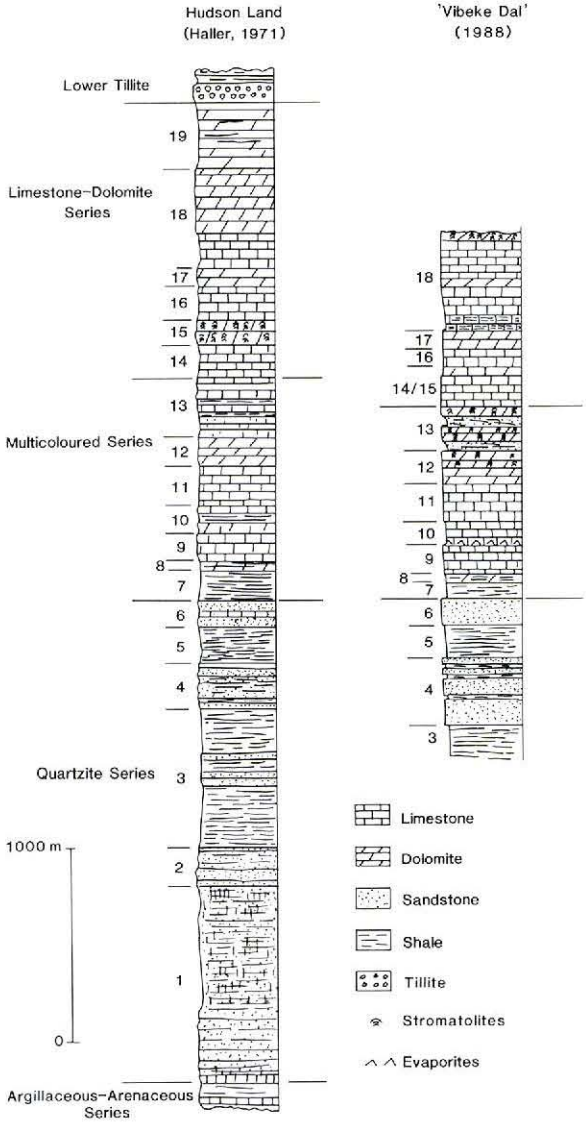

Fig. 4. Generalized stratigraphic section in 'Vibeke Dal' compared with Haller (1971). Numbers denote bed-groups.

beds is common. The sandstone is internally vaguely horizontally laminated; small-scale trough cross-bedded and current and wave generated ripple bedforms are common on bedding planes. Current directions are towards the north and west.

Bed-group 5. Bed-group 5 is a 170 m thick sequence of mainly red, in places greenish, siltstone with thin sandstone beds from 2 to 20 cm thick. The siltstone is parallel laminated but locally shows small-scale scouring. The sandstones are cross-laminated and mostly laterally continuous.

Bed-group 6. This bed-group consists of rather monotonous pale quartzitic sandstone with a thickness of 140 m. The sandstone reveals herring-bone cross-stratification and abundant reactivation surfaces within sets of large-scale cross-bedding, indicating a possible tidal origin. Large fields of straight-crested dunes preserved on bedding planes were observed to interfinger with large wave-ripples, supporting the interpretation of a shallow marine origin of this bed-group.

Multicoloured 'Series'

Bed-group 7. This bed-group is poorly exposed at 'Vibeke Dal', but consists of an approximately 70 m thick unit of parallel laminated red shale. In Brogetdal, however, Bed-group 7 (140 m) was found to show an overall coarsening upward trend and, in the upper part, fine-grained sandstone beds showing hummocky cross-stratification were observed. These sediments probably represent relatively deep shelf deposits forming a shallowing upward sequence which only in the upper parts was affected by periodic storm events.

Bed-group 8. Bed-group 8 consists of red, green and

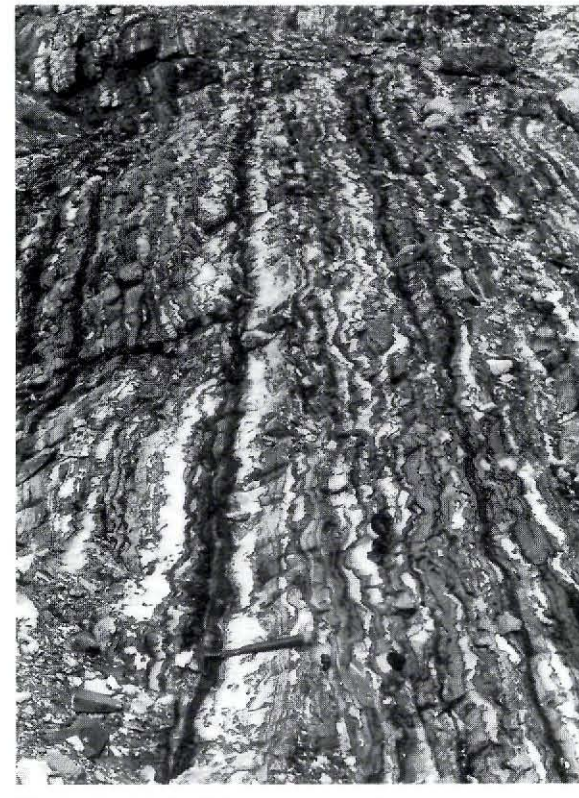

Fig. 5. Calcified sulphate evaporites from the base of Bed-group 10. Hammer *c.* 25 cm long.

Fig. 6. Bed-group 10 as developed on the south facing cliffs at the mouth of Brogetdal. Note the pale evaporite horizon (e) at the base and mounds (arrowed) near the top. Numbers refer to bed-groups. Combined thickness of Bed-groups 8 and 9 is approximately 120 m.

grey carbonate mudstone which shows gradational contacts to both the underlying and overlying bed-groups. The mudstones are mainly finely horizontally laminated or massive. The thickness of the bed-group is 30 m.

Bed-group 9. Bed-group 9 consists of approximately 100 m of dark, vaguely mottled lime mudstone in beds 3 to 20 cm thick which internally have a massive appearance.

Bed-group 10. This bed-group mainly consists of 130–150 m of red, finely horizontally laminated carbonate siltstone with varying amounts of green calcite nodules. In the basal part of the bed-group bedded calcified sulphate evaporite deposits with nodular, mosaic and sometimes contorted mosaic structures (*sensu* Maiklem *et al.*, 1969) were observed in both 'Vibeke Dal' and Brogetdal (figs 5 & 6).

In the upper part of Bed-group 10 hitherto undescribed large mounds were observed around both camp localities in Brogetdal (figs 6 & 7). The thickness of the mounds ranges from some metres up to *c.* 80 m and lateral dimensions are from 10 m to more than 150 m. The mounds, which are characterised by steep, sometimes overturned flankbeds (fig. 7), consist of pale, well-bedded limestone. The mound core is mostly massive, sometimes vaguely irregularly laminated. Towards the flanks it passes into more well-defined and thicker beds (0.3–1.5 m) which may show all transitions from undeformed thinly laminated but steeply dipping beds through coherent semiplastic deformation to brecciation. Over a distance of a few metres the flank beds thin to 10–20 cm and return to a sub-horizontal position, grading into red, finely laminated carbonate inter-mound sediments.

Bed-groups 11 and 12. Due to large-scale down-faulting in the order of 800–1000 m along faults running parallel to the valley side of 'Vibeke Dal', detailed logging of Bed-groups 11 and 12 was not possible, and thicknesses could not be measured.

Bed-group 11 consists of 5–20 cm bedded black lime mudstone which is finely, but irregularly, horizontally laminated and stromatolitic with a characteristic pattern of slightly paler vertical 'cracks'. Bed-group 12 mainly consists of thick-bedded (1–1.5 m) pale stromatolitic dolomite, in the upper part interbedded on a 10 m scale with black limestone resembling Bed-group 11. Haller

Fig. 7. Mound from Bed-group 10. Width of mound approximately 150 m.

(1971) reports a thickness of 200 m for Bed-group 11 and 150 m for Bed-group 12 in the Hudson Land area (fig. 4).

Bed-group 13. In Brogetdal a detailed section was measured through Bed-group 13 which could be divided into 12 sub-units (Bg 13a-l). The approximately 260 m thick mixed siliciclastic-carbonate sequence is characterised by thickening and coarsening upwards mudstone-sandstone sequences intercalated with carbonate mudstone, rip-up conglomerates and several spectacular, orange weathering stromatolitic horizons. In 'Vibeke Dal', the contact to the underlying unit is somewhat obscured by faulting, but at least 200 m of the unit is present. It is generally rather poorly exposed. However, most of the sub-units recognised in Brogetdal, as well as some beds within them, could be traced over the more than 55 km to 'Vibeke Dal'.

Limestone–Dolomite 'Series'

Bed-groups 14–18. The Limestone–Dolomite 'Series' is dominated by dark limestones intercalated with a few pale dolomitic horizons (Bed-groups 15 and 17). Bed-group 15, described in southern Andrée Land as an approximately 50 m thick whitish dolomite unit rich in algal biostromes (Fränkl, 1953; Haller, 1971), is not developed in the area around 'Vibeke Dal'. However, very irregular, patchy dolomitisation occurs within the upper part of Bed-group 14.

Bed-group 14/15 (*c.* 200 m) is dominated by dark algal-laminated limestone in beds 1 to 10 cm thick. Bed-group 16 (*c.* 80 m) is poorly exposed and strongly recessive weathering. Where exposed it consists of black limestone in 5–40 cm thick beds which internally are massive or show a weakly defined lamination. Bed-group 17 (*c.* 80 m) consists of poorly bedded, pale grey oolitic and oncolitic dolomitic wackestone and packstone which locally may be strongly brecciated. A total of 550 m were measured through Bed-group 18 in this area without reaching the upper contact. This unit comprises black, 10–20 cm bedded massive or irregularly laminated, stromatolitic lime mudstone. At some levels the massive mudstone becomes rather shaly with thin sandy stringers. Oolitic and oncolitic dark limestone and pale dolomite occur throughout. The top of the section was marked by a 13 m thick dark stromatolitic bed in which small mounds up to 1 m in diameter with a relief up to 30 cm locally are present.

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