Rapp. Grønlands geol. Unders. 99, 43–49 (1980)

CARBONATE DEBRIS FLOWS IN THE CAMBRIAN OF SOUTH-WEST PEARY LAND, EASTERN NORTH GREENLAND

J. R. Ineson

In south-western Peary Land a thick carbonate dominated sequence of Early to Late Cambrian Age conformably overlies the Early Cambrian Buen Formation, and is overlain, unconformably, by the Wandel Valley Formation of Early–Middle Ordovician age (Peel, 1979; Palmer & Peel, 1979). This sequence is subdivided into the Brønlund Fjord Group and the overlying Tavsens Iskappe Group (Peel, 1979; Ineson & Peel, this report). The Brønlund Fjord Group characteristically forms resistant bluffs along the north side of Wansel Dal from J. P. Koch Fjord in the west to Independence Fjord (fig. 20) in the east. The Tavsens Iskappe Group is confined to western areas by the south-easterly overstep of the Wandel Valley Formation.

Field work in 1979 involved a stratigraphical and sedimentological study of this Cambrian sequence from the Henson Gletscher region in the west (fig. 20) to the better described

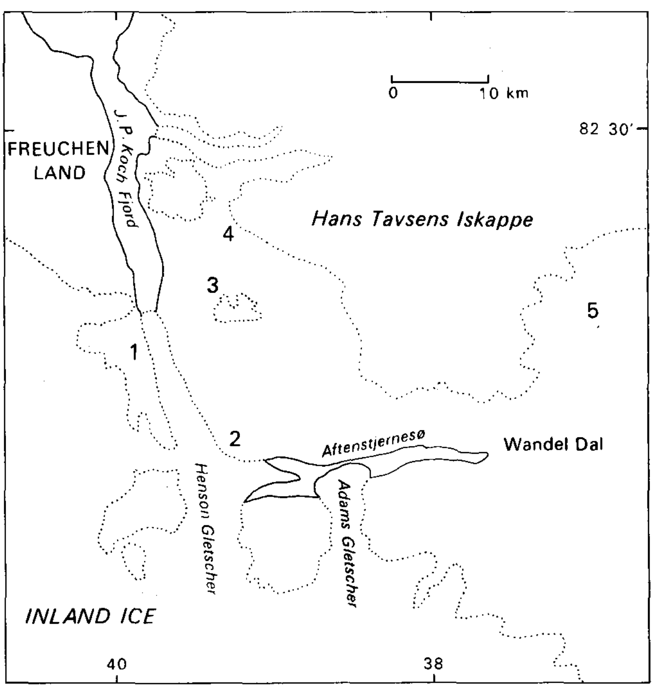

Fig. 20. Sketch map of the J. P. Koch Fjord – Adams Gletscher region, west Peary Land. Numbers refer to localities mentioned in the text.

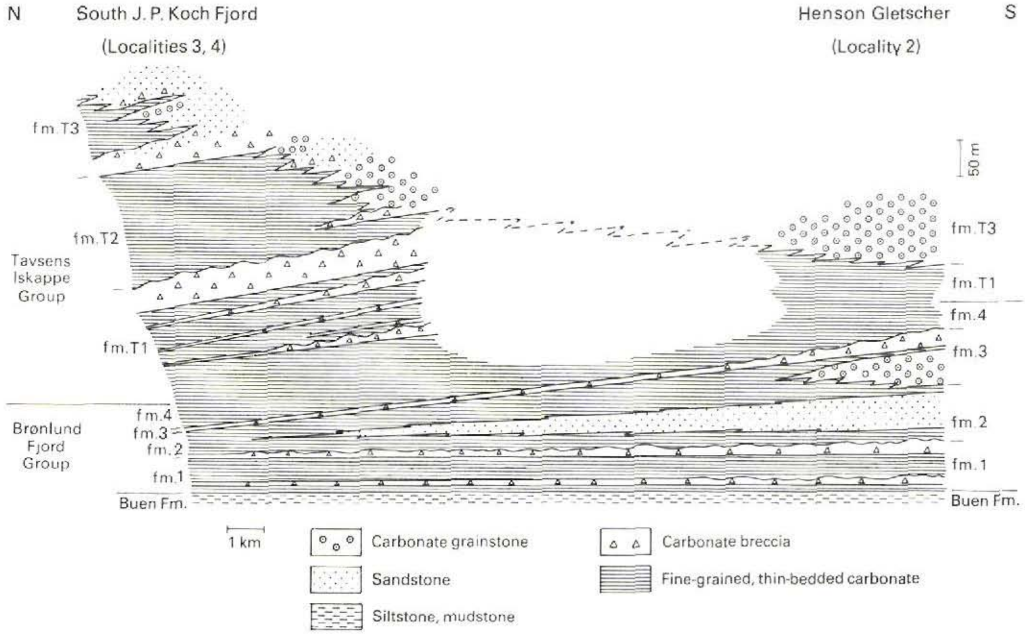

Fig. 21. Generalised facies relationships of the Brønlund Fjord Group and Tavsens Iskappe Group. Breccia sheets less than 5 m thick are not shown. Fm. 1–4, formations of the Brønlund Fjord Group; fm. T1–T4, formations of the Tavsens Iskappe Group. Localities 2, 3, 4, are shown on fig. 20.

sequence in the east near Jørgen Brønlund Fjord (Troelsen, 1949, 1956; Christie & Peel, 1977). This report contains observations and preliminary interpretations made during the season in the Henson Gletscher region, with emphasis on the interpretation of the carbonate breccia beds which characterise the sequence.

The conformable succession in the Henson Gletscher region comprises carbonates with subsidiary mudstones and sandstones, which attain a thickness of about 950 m. Siltstones and mudstones of the upper Buen Formation are overlain by a variable succession of dark, fine-grained, thin- to medium-bedded carbonates, interbedded with prominent carbonate breccia sheets (fig. 21). These are, in turn, overlain by pale, cross-bedded, carbonate grainstones, sandy carbonate breccias and cross-bedded sandstones, which first appeared in the south in the Middle Cambrian (fig. 20, locality 2) and which prograded intermittently northwards during the Middle and Late Cambrian. The carbonates have suffered extensive selective dolomitisation. The majority of the thick breccia sheets, the cross-bedded grainstones and adjacent carbonates are medium- to coarse-crystalline dolomites, often sucrosic, vuggy and dolomite veined, whereas the thin-bedded, argillaceous, fine-grained carbonates are commonly unaltered or only partially dolomitised.

Brønlund Fjord Group

A typical section through these rocks is summarised in fig. 22, which shows the subdivision into 4 formations recognised by Peel (1979) and Ineson & Peel (this report) in the Henson Gletscher area. The sequence is dominated by dark, thin- to medium-bedded, planar-and wavy-bedded dolomites and micritic limestones, which are commonly bituminous, argillaceous and cherty, especially in northern exposures (localities 1, 3 and 4). The dominant sedimentary structure is planar-lamination, but graded beds are common in formation 1 and occur elsewhere in the sequence, sometimes in shallow channels. Small scale slump-folding, faulting and *in situ* brecciation are common features in the succession, as are nodular and concretionary structures which show irregular, sheet-like and spherical or ovoid forms. Carbonate-breccia beds, which form between 20 and 30 per cent of the Brønlund Fjord Group, are described below.

Formation 2 contains a pale-cream dolomitic sandstone unit which thins northwards, as do all the formations of this group (see fig. 21, and Peel, 1979). These well-sorted, fine-grained sandstones occur in 0.1 to 4 m thick, parallel-sided sheets with sharp boundaries. They are generally structureless or faintly parallel-laminated, but in places show low-angle cross-bedding, internal erosion surfaces and bed amalgamation. Interbedded with the sand sheets are bioturbated, laminated, silty sandstones and siltstones which are ripple-cross-laminated in southerly exposures (locality 2).

In the northern exposures formation 3 characteristically comprises dolomitic nodular micrites, capped by a thin breccia bed but, at Henson Gletscher (locality 2), a thick wedge of grey, bioclastic, dolomite grainstones, which thins rapidly northwards, forms the lower half of the formation (fig. 21). Cross-bedding indicates a dominant transport direction towards the north-west.

The undolomitised carbonates are commonly fossiliferous; formation 4 and the upper beds of formation 2 yield rich Middle Cambrian trilobite faunas (Palmer & Peel, 1979). Bioturbation is restricted in type and distribution in northern localities, but becomes more widespread in the south (locality 2).

Tavsens Iskappe Group

The Tavsens Iskappe Group has been subdivided into 4 formations to the west of Hans Tavsens Iskappe (fig. 20). As it was impossible to recognise these to the east of the ice cap, a further three formations have been defined in the area around locality 5 (Ineson & Peel, this report).

The lower two formations (formations T1 and T2, see Ineson & Peel, this report) in the Henson Gletscher region have a combined maximum thickness of about 330 m, and are lithologically similar to the underlying Brønlund Fjord Group. Dark, recessive units of thin-bedded dolomites and argillaceous micritic limestones are inter-bedded with pale, cliff-forming, carbonate-breccia sheets. Formation T3 comprises a variable sequence, up to 400 m thick, of pale, cross-bedded dolomite grainstones sometimes recognisable as oolitic and bioclastic grainstones, medium- to fine-grained, cross-bedded sandstones, and thick units of slumped, brecciated dolomite and sandy dolomite. Individual units are commonly lenticular, thinning northwards with a northerly depositional dip of up to 20°. This facies prograded

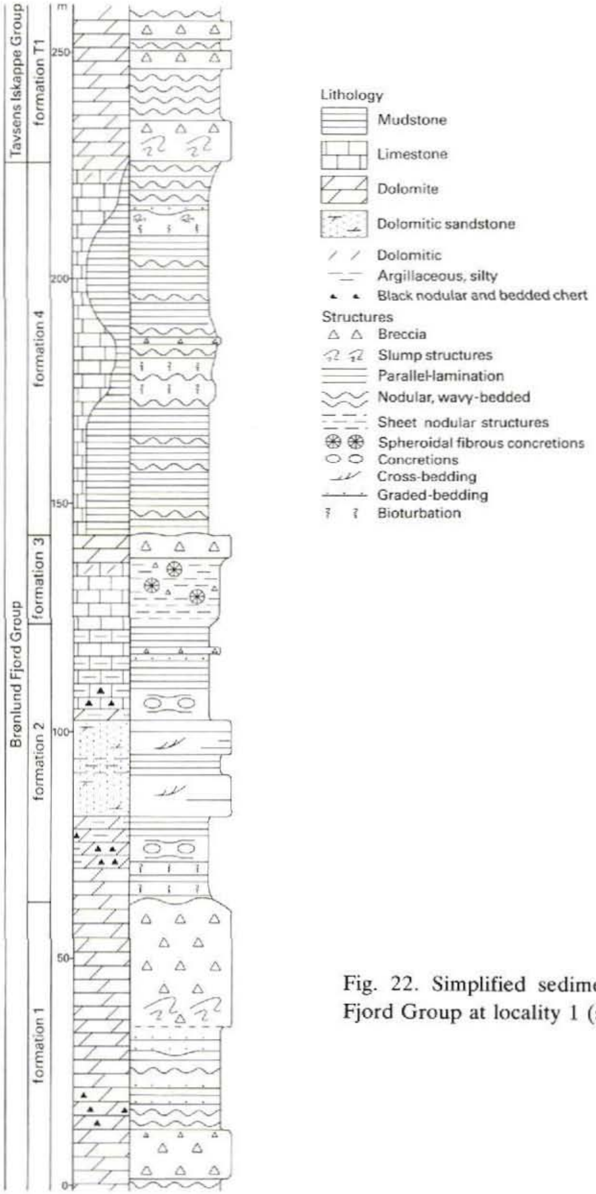

Fig. 22. Simplified sedimentary section through the Brønlund Fjord Group at locality 1 (see fig. 20).

northwards (fig. 21) so that formation T3 is strongly diachronous from south to north, formation T1 doubles in thickness from locality 2 to localities 3 and 4, and formation T2 is only recognised in northern exposures (Ineson & Peel, this report).

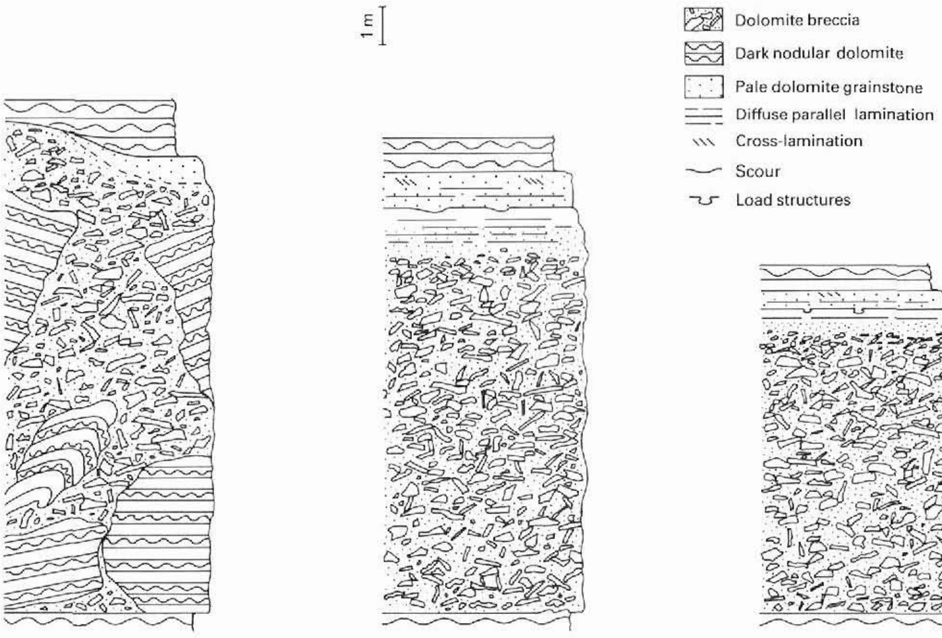

Fig. 23. Sketch sections of the lower breccia sheet of formation 1, Brønlund Fjord Group at localities 1, 2 and 3 (see fig. 20).

Carbonate breccia beds

The breccia beds in the Brønlund Fjord and Tavsens Iskappe groups vary in thickness from 0.5 to 40 m (fig. 21), although the thicker beds are possibly unrecognised composite beds. They are sheet-like to lenticular bodies, commonly exhibiting pinch and swell but rarely showing channelling. Individual sheets can be demonstrated to have considerable lateral extent. In the Henson Gletscher – J. P. Koch Fjord area, the two thick breccia beds in formation 1 of the Brønlund Fjord Group (figs 21 and 23) can be confidently correlated over a distance of 20 km from north to south and about 15 km from west to east. The beds have sharp planar bases and planar or irregular, hummocky tops which, in places, result from the inclusion of large clasts. At locality 5, for example, a clast of cream, cross-bedded dolomite grainstone protrudes 15 m above the general level of the surrounding breccia sheet.

The breccias are predominantly composed of tabular, angular and irregular, sub-rounded carbonate clasts with a typical maximum clast size of 30 to 50 cm in a pervasive, darker, fine-grained carbonate matrix. In undolomitised breccia sheets, the clasts are laminated and bioturbated micrites and peloidal micrites in a dark micritic matrix which is often argillaceous. The breccias are poorly sorted, generally clast-supported, but dispersed, matrix-supported breccias were observed. Although elongate clasts are often subparallel to bedding, or

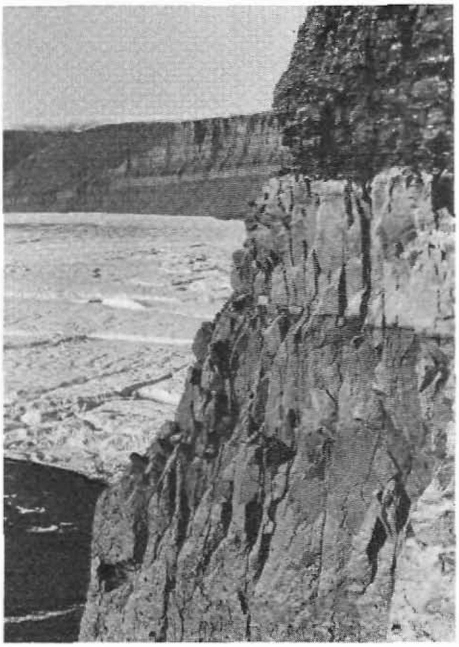

Fig. 24. Pale dolomite grainstone bed (90 cm thick) sharply overlying the graded top of af 10 m breccia bed. Formation 1, Brønlund Fjord Group. Locality 1 (see fig. 20).

locally show a crude imbrication, the overall impression is of a random, chaotic fabric. The majority of the breccia beds are disorganised and ungraded over much of their thickness, although coarse-tail grading was observed in one breccia sheet. The breccia beds commonly show rapid grading in the upper metre or so, and are commonly overlain by a pale grainstone bed with an erosional or transitional base (figs 23 and 24). Such grainstone beds appear predominantly structureless but may show diffuse planar-lamination and ripple cross-lamination in their top half.

The variation observed in a single breccia sheet from south to north is schematically illustrated in fig. 23. The hummocky slump-breccia sheet in the south (locality 2) is composed of large, contorted and partially brecciated slabs of thin-bedded, dark grey dolomite, supported in a chaotic, poorly sorted dolomite breccia. This passes northwards into a parallel-bounded sheet of clast-supported breccia with a continuous grainstone cap (localities 1 and 3).

The clasts and the large, bedded slabs in the breccia sheet illustrated in fig. 23, are lithologically similar to the enclosing thin-bedded dolomites but, in the Tavsens Iskappe Group, the breccia sheets often contain a recognisable proportion of pale grainstone clasts. They are angular to sub-rounded, commonly equidimensional, and range from cobble- and boulder sized clasts up to blocks 40 metres across.

The lack of internal stratification, the disorganised ungraded fabric, the pervasive fine-grained matrix and the polymictic, poorly sorted nature of the clasts are characteristic features of mass flow deposits (Johnson, 1970). In view of the interbedded, quiet water, marine sediments, the breccia beds are interpreted as submarine debris flow deposits, as described by Middleton & Hampton (1973). The great extent of individual sheets indicates a highly mobile flow which, in some cases, was sufficiently competent to transport house-sized boulders. The pale grainstone beds which commonly cap the breccia sheets can be structureless, but they often show traction structures (fig. 23) and were probably deposited during a more turbulent phase of the flow. Experimental modelling, by Hampton (1972), has shown that sub-aqueous debris flow can produce an accompanying turbulent cloud. This observation has been used to interpret turbidite caps on breccia beds in the Cambrian of north-west Canada (Krause & Oldershaw, 1979).

References

Christie, R. L. & Peel, J. S. 1977: Cambrian–Silurian stratigraphy of Børglum Elv, Peary Land, eastern North Greenland. *Rapp. Grønlands geol. Unders.* **82,** 48 pp.

Hampton, M. A. 1972: The role of subaqueous debris flow in generating turbidity currents. *J. sedim. Petrol.* **42,** 775–793.

Johnson, A. M., 1970: *Physical processes in geology.* San Francisco; Freeman, Cooper & Co., 577 pp.

Krause, F. F. & Oldershaw, A. E. 1979: Submarine carbonate breccia beds – a depositional model for two-layer, sediment gravity flows from the Sekwi Formation (Lower Cambrian), Mackenzie Mountains, Northwest Territories, Canada. *Can. J. Earth Sci.,* **16,** 189–199.

Middleton, G. V. & Hampton, M. A. 1973: Sediment gravity flows: mechanics of flow and deposition. *In* G. V. Middleton & A. H. Bouma (edit.) *Turbidites and deep-water sedimentation,* 1–38. Los Angeles: Soc. Econ. Paleontologists and Mineralogists Pacific Sec.

Palmer, A. R. & Peel, J. S. 1979: New Cambrian faunas from Peary Land, eastern North Greenland. *Rapp. Grønlands geol. Unders.* **91,** 29–36.

Peel, J. S. 1979: Cambrian – Middle Ordovician stratigraphy of the Adams Gletscher region, south-west Peary Land, North Greenland. *Rapp. Grønlands geol. Unders.* **88,** 29–39.

Troelsen, J. C. 1949: Contributions to the geology of the area round Jørgen Brønlunds Fjord, Peary Land, North Greenland. *Meddr Grønland* **149**(2), 29 pp.

Troelsen, J. C. 1956: The Cambrian of North Greenland and Ellesmere Island. *In* El sistema Càmbrico, su paleogeografía y el problema de su base. *20. Congr. geol. int. Mêxico. Symp.* **3**(1), 71–90.