Glacial features of the Børglum Elv region, eastern North Greenland

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Lauge Koch recognised in 1921 that the Inland Ice had not overwhelmed all of North Greenland during the Glacial Epoch and, although his data were few, he suggested a generalised probable outward extent of the former ice cap (Koch, 1923, fig. 2). The mapping of the outward limit was based on the identification of erratics of rocks unique to parts of the present northern margin of the Inland Ice. Field work by Troelsen (1952) confirmed the existence of the limit in the vicinity of Børglum Elv. Data collected in 1974 suggest that Koch's line, in the Børglum Elv region at least, was well located, but that the boundary relationships may be complex due to overlapping of limits of ice from the south and the north.

The glacial deposits of Børglum Elv comprise mainly moraine and outwash. The moraines are widespread but variable in thickness and content; gravel and sand deposits occur in the major valleys and upland depressions. Marine and lacustrine(?) silt deposits are present in the lower parts of major valleys and along Jørgen Brønlund Fjord but will not be discussed here.

Three types of moraine which were also noted or implied by Troelsen (1952), have tentatively been identified: (a) 'old' ground moraine with pink and white sandstone, pink and grey gneiss, and dark diabase erratics; (b) 'local' moraine of Silurian, flysch-type sandstone; and (c) 'younger' moraine, confined to valleys, and apparently a mixture of older moraines and local rock. The 'old' moraine certainly represents a period of expansion of the Inland Ice which is now located to the south of the area; the 'local' moraine is presumed to have been derived from a contemporary, expanded Nordkronen ice cap, to the north; and the 'younger' moraine evidently represents either a late-glacial readvance or some stage of the general glacial retreat.

The 'old' moraine is characteristically found on the upland plateau surface north of Jørgen Brønlund and Independence Fjords, or at least is identified there with greatest certainty. The characteristic pink erratics were derived from the late Precambrian terrain of Midsommersøerne, Jørgen Brønlund Fjord, and Independence Fjord. The 'old' moraine has been disturbed widely by frost action and is mixed with heaved, local rock. The original fabric is probably largely destroyed.

Till-like material consisting entirely of locally derived Silurian sandstone, where observed, was probably deposited from an expanded Nordkronen ice cap. The larger blocks are mainly angular and, in places, there is a small fraction of more or less rounded boulders. Silt and mud form a yellow matrix. Knolls and ridges of such moraine can be observed in certain secondary or tributary valleys and in places along the north wall of the main, west tributary of the upper part of Børglum Elv. Similar till-like material, but entirely of angular debris in yellow-grey matrix, covers the rolling upland ridges adjacent to Nordkronen ice cap. The 'old' and the 'local' moraines are assumed to be more or less contemporaneous, the Inland Ice and the local or Peary Land ice presumably meeting in a zone, the northern border of which is represented by the present northern limit of pink erratics.

The 'younger' moraine system is represented by distinct but discontinuous morainic deposits in the valley of the lower reaches of Børglum Elv. These moraines are taken to be deposits of alpine-type glaciers flowing down existing valleys. Rough-surfaced, relatively fresh-appearing moraine at the mouth of a tributary valley stands topographically higher than subdued and well-washed morainal deposits in the secondary valley. The pink, white, and grey erratics characteristic of moraine from the south may be abundant to rare; their presence and variable proportion is assumed to be due the reworking of 'old' moraine and the admixing of morainic debris from nearby sources.

One feature of the supposed 'younger' moraine appears enigmatic: nowhere was a moraine found as rich in rocks of northern provenance – the Silurian flysch sandstone – as would be expected had alpine glaciers occupied the Børglum Elv valley. Perhaps only a very short period of southward flow took place, so that no substantial amount of 'northern' rock was incorporated into the moraine. However, ice-smoothed outcrops in the floor of Børglum Elv valley indicate a southward flow of alpine-type glacial ice. These directional data could be inherited from an early (pre-Inland Ice) or initial alpine glacial phase; or, they may be a feature of the supposed 'young' alpine glaciation.

Limited deposits of glacial silts suggest that a small lake was retained for a time by ice in an eastern tributary valley of Børglum Elv.

Channels and deep cuts or gorges attributable to glacial meltwater streams are widespread; the trends and slopes of these now largely abandoned or misfit stream courses suggest that meltwater escaped southward and eastward. On the other hand, features such as abandoned beaches, which would be expected had meltwater been ponded extensively by ice dams, appear to be absent. Thus, in general, the features associated with glacial retreat suggest a 'normal' retreat in the Børglum Elv region: that is, from the coast (Independence Fjord) to the existent ice cap (Nordkronen).

A brief examination was made of the upper layers of silts in the silt plain at Kap Harald Moltke (Davies, 1961; Davies & Krinsley, 1961). Attention had earlier been drawn by Eigil Knuth to regular, well-developed jointing in the silts, and a small pit had been dug by the station personnel at Kap Moltke some weeks before the examination. The pit, about 0.5 m deep, exposed fine grained, grey, pink, and red silts. Vague colour bands 3 or 4 cm thick, apparently bedding, dipped gently toward the centre or axis of the local silt 'basin'. Two sets of steeply dipping to vertical joints were evident: a primary set of relatively evenly spaced, straight joints; and a secondary set perpendicular to the first, but discontinuous and of irregular spacing. The intervals between the primary joints, about 15 cm, were not quite as uniform as first impressions suggested. Other, nonconforming and often curved joint surfaces were also present. All the joints were ice-filled below the thaw zone; the ice formed clear septa up to about 1 mm thick.

Similar jointing was observed throughout the Kap Harald Moltke silt basin, with, however, various trends. Identical vertical joints have been seen by the author (Christie, 1967, p. 17) in marine silts on northern Ellesmere Island. It seems probable that in both localities the joints are a shrinkage phenomenon, perhaps formed during dewatering of the sediments, and that they form orthogonal systems conforming to the basin margins.

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Ceratopea and the correlation of the Wandel Valley Formation, eastern North Greenland

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The presence of heavily calcified, horn-shaped opercula of the gastropod *Ceratopea* Ulrich, 1911 (fig. 7) in the Wandel Valley Formation was first noted by Troelsen (1949) in his description of the Lower Palaeozoic sequence of southern Peary Land, eastern North Greenland. Silicified faunas collected by Troelsen are dominated by gastropods, with rare cephalopods, rare bivalves, and some echinoderm debris. As a result, Troelsen (1949, p. 18) suggested a Late or possibly Middle Canadian (Early Ordovician) age for the formation on the basis of the occurrence of *Ceratopea*. The specimens have not been further described although Peel *et al.* (1974) commented on the occurrence.

Since the time of the original collection by Troelsen, the importance of *Ceratopea* as a stratigraphic guide fossil within the Late Canadian (late Early Ordovician) has been increasingly recognised (Yochelson & Bridge, 1958; Yochelson, 1973; Yochelson & Copeland, 1974). Consequently, it is now possible to determine the Peary Land specimens at the specific level and to suggest a more precise correlation for the Wandel Walley Formation.

All the material discussed here was collected by J. C. Troelsen in 1947 during the Danish Peary Land Expedition. Additional, as yet unprepared, material collected by Peel & Christie (this report) has not been examined and is not described. The greater part of the Troelsen collections comprises material etched from the matrix by Troelsen but some untreated blocks of dolomite from collections 11 and 15 have subsequently been digested in acid (J.S.P.). The material was collected from four localities within the Wandel Valley Formation, the positions of which are indicated