Nares Strait and the down-current termination of the Silurian turbidite basin of North Greenland

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Combined palaeoenvironmental and palaeocurrent evidence demonstrates that a significant change took place in large-scale Silurian palaeogeographic configuration along the North Greenland – Canadian continental margin. The source area of the deep-water turbidite basin of North Greenland was the rising Caledonides to the east. The currents flowed towards the west parallel to the southern carbonate platform. There is no evidence of a northern landmass and the abyssal plains off the present-day east coast of the United States are suggested as analogues. The axial flows seem to have continued westwards along the axis of the Ellesmere Island turbidite basin. West of Nares Strait a significant inflow of turbidity currents from a northerly shelf area enters the basin where they were deflected down the axis, and the existence of a northern landmass, possibly of volcanic arc origin, has been demonstrated in Ellesmere Island. The Ellesmere Island turbidite basin thus represents a deeply submerged back-arc rift or perhaps an intracontinental aulacogen. There is no evidence from the Silurian turbidites of any contemporaneous or later wrench faulting along Nares Strait. Rather, Nares Strait represents the transitional area in the Silurian between two different types of continental margins or even greater geotectonic differences. Future studies of this difference may be instrumental in unravelling the later history of this enigmatic segment of the Earth's crust.

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The Silurian turbidite basin of North Greenland is one of the world's largest ancient 'longitudinal flysch basins'. It has a preserved length of about 800 km, a width of about 200 km and a thickness of up to 4 km. Until GGU's expeditions in 1979 and 1980 it was, however, relatively little known due to its remote and inaccessible position, scarcity of biostratigraphic data, and tectonic disturbances, especially in the northern part. In 1979 a large number of representative sections covering the whole basin were measured in detail by the author and J. M. Hurst. The palaeocurrent pattern appeared to be extremely uniform from east to west, following the basinal axis (Fig. 1). The basin continues south-westwards into Ellesmere Island, Arctic Canada, where a SE-directed palaeocurrent direction was introduced in addition to the axial SW direction. This indication of a north-westerly provenance is supported by the presence of a Silurian shelf area in northernmost Ellesmere Island. The change in provenance and palaeocurrent pattern took place in the Nares Strait region. The present paper aims to demonstrate this in more detail and to discuss the possible geotectonic implications.

Geological setting

The Lower Palaeozoic rocks of North Greenland can be divided into a southern carbonate platform and a northern deep-water clastic basin. This division is particularly well displayed by the Silurian section. The platform to basin transition seems to be controlled by major east–west-trending fault systems. To the east it is developed like a scarp (Surlyk et al. 1980) and to the west like a ramp (Hurst 1980). The outer northern part of the platform underwent a major collapse phase in the early Silurian and the turbidite basin expanded several hundred kilometres to the south (Hurst & Surlyk 1980). Thus, mid- and late Silurian turbiditic sediments overlie shallow marine carbonates in a broad belt along the southern margin of the basin. The northern limit of the basin is unknown since the turbiditic facies extend to the coast.

The distribution of the main facies belts is roughly the same in Ellesmere Island, although the configuration of the basin margin is less clear as a result of much stronger tectonic disturbances. In contrast to Greenland a north-

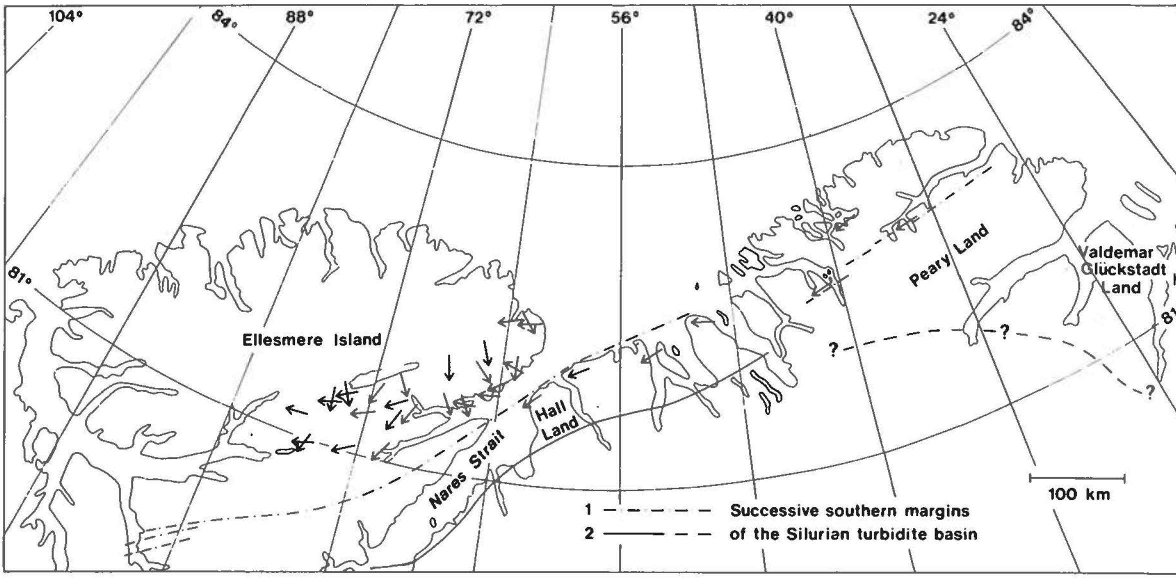

Fig. 1. Palaeocurrent map of the Silurian turbidite basin of Ellesmere Island (data from Trettin 1979) and North Greenland (based on 340 measurements made by the author and J. M. Hurst in 1979). K = western coast of Kronprins Christian Land. The two successive margin positions of the Silurian turbidite basin correspond to the two geological markers discussed in this volume by Hurst & Kerr.

ern platform and shelf sequence is preserved in northernmost Ellesmere Island.

Sedimentary environments of the Silurian turbidite basin

Silurian turbidite deposition followed a long period of basin starvation with deposition of mainly black mudstones and cherts, which lasted through most of the Ordovician. Three stages of Silurian turbidite sedimentation can be recognised. The basal sandy unit is of mainly Llandovery age. It is followed by a muddy unit of latest Llandovery – early Wenlock age, which is topped with marked diachroneity by the final sandy latest Llandovery – Ludlow turbidite unit.

Llandovery turbidites

The initial phase of turbidite sedimentation can only be demonstrated to the east in the Peary Land area. Farther to the west the Silurian platform–basin transition lay north of the present coastline (Fig. 1). The sedimentary faices are mainly medium-bedded rather fine-grained sandy turbidites, which conform to the Bouma model (Bouma 1962). The sand–shale ratio is high and bed geometry is sheet-like apart from scours and channels in the upper part of the unit. Facies analysis by this author and J. M. Hurst (in prep.) demonstrates the presence of basin plain, outer fan fringe and lobe and, towards the top, braided midfan. Transport is towards the west throughout the unit and the overall setting is one of an extremely elongate sand-rich deep-sea fan, imperceptibly passing into a basin plain.

Latest Llandovery – Wenlock mudstones

The catastrophic collapse of the platform margin led to basin expansion, transgression, and starvation of the fan and turbidite basin system. As a result, a sequence of mudstones was deposited on top of the lower turbidite sequence and on the collapsed platform carbonates along the southern basin margin. The mudstone unit is rather thin towards the east but thickens drastically to the west where muddy deposition continued for a long time even when turbidite sedimentation was resumed towards the east in late Llandovery times. Along the axial parts of the basin thin-bedded turbidites occur within the mudstones, while resedimented limestone and chert conglomerates fringe the southern carbonate platform. The depositional environments can be interpreted as a muddy basin plain passing gradually into slope muds along the southern basin margin. Transport data are few, but the quite drastic westward decrease in grain size and increase in thickness of the mudstone unit again point towards a longitudinal east–west fill of the elongate basin.

Late Llandovery – Ludlow turbidites

Turbidite deposition was resumed in late Llandovery time and the basin reached its widest extent from Kronprins Christian Land in the east to Hall Land in the west and from the north coast to Valdemar Glückstadt Land in the south. The southern limit is, however, purely erosional and the basinal facies may have had an even wider extent.

The sedimentary facies include mainly medium- and thin-bedded turbidites, which can be described by the Bouma model. To the west the proportion of muddy units increases, while resedimented chert conglomerates dominate the upper parts of the sequence to the east.

The sedimentary environments include outer fan fringe and lobe, and braided midfan towards the top in the eastern part of the basin. The main western part of the unit was, however, deposited in a system of huge deep-sea channels, levées and intervening basin plains. The transport was as in the two preceding units towards the west along the axis of the basin.

Environments and transport patterns in Ellesmere Island

Knowledge of the depositional environments of the Silurian turbidites in north-eastern Ellesmere Island is mainly based on provenance and transport direction studies (Trettin 1970, 1971, 1973, 1979). Trettin demonstrated that the turbidite palaeocurrents could be divided into a south-easterly and a south-westerly population. The first was interpreted as reflecting deposition in a canyon deep-sea fan system developed south-east of the north-western shelf. The turbidity currents which reached the fan toe were deflected towards the south-west where they flowed down the basin axis parallel to the southern platform margin. This interpretation is accepted here with the modification that parts of the axial component probably represent the direct down-current westward continuation of the axial flows of the North Greenland basin.

Discussion

Combined palaeocurrent and palaeoenvironmental evidence demonstrates that a significant change in large-scale palaeogeographic configuration of the Silurian North Greenland – Canadian continental margin took place in the Nares Strait area.

The source area of the North Greenland part of the basin was located in the northern end of the Atlantic Caledonian mountain belt. The Silurian orogenic phases obviously resulted in uplift of enormous landmasses which became the subject of erosion ultimately resulting in deposition of an up to 4 km thick, 800 km long and several hundred kilometres wide basin fill. There is no direct evidence of a northern borderland. The very clearly defined east to west palaeocurrent pattern indicates, however, the existence of a northern barrier, which assisted in funnelling the turbidity currents down an east–west axis. The absence of any southward directed palaeocurrents suggests that the North Greenland basin was a normal continental margin deep-sea plain, perhaps directly analogous to the present-day abyssal plains occurring off the east coast of the United States (Pilkey et al. 1980). These deep basins are fed by turbidity currents entering via submarine canyons at one end. Some of the currents are deflected when they bypass the fan toes and flow along much of the length of the abyssal plains parallel to the continental margin.

In contrast, the Ellesmere Island part of the basin is limited by shelf areas towards the north-west and the south-east. The geotectonic nature of the northern landmass and source area is not known, although it is illustrated as a volcanic arc by Trettin & Balkwill (1979: fig. 8). The basin, as illustrated, was probably formed by back-arc spreading. It could alternatively be interpreted as a linear intra-continental feature formed by rifting conforming to the aulacogen model.

The Silurian North Greenland – Canadian turbidite basin thus seems to change from a simple continental margin deep-sea plain to a deeply submerged back-arc rift or aulacogen in a down-current direction in the Nares Strait region. The axial transport appears to have continued uninterruptedly, while a very important northern source area came in west of Nares Strait. Thus, Nares Strait seems not to have been the locus of any significant wrench faulting during or after the Silurian. Rather, it represents the transitional area between two different types of continental margins or possibly an even greater geotectonic difference in the Silurian. The description of the precise nature of this difference may be instrumental in unravelling the later history of this segment of the Earth's crust.

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References

Bouma, A. H. 1962. Sedimentology of some flysch deposits. A graphic approach to facies interpretation. – Elsevier Publ. Co., Amsterdam: 168 pp.

Hurst, J. M. 1980. Paleogeographic and stratigraphic differentiation of Silurian carbonate buildups and biostromes of North Greenland. – Bull. Am. Ass. Petrol. Geol. 64: 527–548.

Hurst, J. M. & Kerr, J. W. 1982. Upper Ordovician to Silurian facies patterns in eastern Ellesmere Island and western North Greenland and their bearing on the Nares Strait lineament. – This volume.

Hurst, J. M. & Surlyk, F. 1980. Notes on the Lower Palaeozoic

clastic sediments of Peary Land, North Greenland. – Rapp. Grønlands geol. Unders. 99: 73–78.
Pilkey, O. H., Locker, S. D. & Cleary, W. J. 1980. Comparison of sand-layer geometry on flat floors of 10 modern depositional basins. – Bull. Am. Ass. Petrol. Geol. 64: 841–856.
Surlyk, F., Hurst, J. M. & Bjerreskov, M. 1980. First age-diagnostic fossils from the central part of the North Greenland foldbelt. – Nature, Lond. 286: 800–803.
Trettin, H. P. 1970. Ordovician–Silurian flysch sedimentation in the axial trough of the Franklinian geosyncline, northeastern Ellesmere Island, Arctic Canada. – In: Lajoie, J. (ed.), Flysch sedimentology in North America. – Spec. Pap. geol. Ass. Can. 7: 13–35.
Trettin, H. P. 1971. Geology of the lower Paleozoic formations, Hazen Plateau and southern Grant Land Mountains, Ellesmere Island, Arctic Archipelago. – Bull. geol. Surv. Can. 203: 134 pp.
Trettin, H. P. 1973. Early Paleozoic evolution of northern parts of Canadian Arctic Archipelago. – In: Pitcher, M. G. (ed.), Arctic geology. – Mem. Am. Ass. Petrol. Geol. 19: 57–75.
Trettin, H. P. 1979. Middle Ordovician to Lower Devonian deep-water succession at southeastern margin of Hazen Trough, Cañon Fiord, Ellesmere Island. – Bull. geol. Surv. Can. 272: 84 pp.
Trettin, H. P. & Balkwill, H. R. 1979. Contributions to the tectonic history of the Innuitian Province, Arctic Canada. – Can. J. Earth Sci. 16: 748–769.