Polarforschung 74 (1-3), 77 – 96, 2004 (erschienen 2006)

New Multi-Channel Seismic Reflection Data from Northwater Bay, Nares Strait: Indications for Pull-Apart Tectonics

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Abstract: New multi-fold marine seismic reflection data acquired as part of the 2001 Nares Strait Geoscientific Cruise totals 1201 km. Marine reflection seismic acquisition parameters were varied due to operating limitations in high arctic waters and standard marine data processing was performed resulting in stacked and partly migrated profiles located in Hall Basin, Kennedy Channel, Northwater Bay and one profile in Kane Basin offshore Cape Lawrence. In the present paper we only deal with the results from Northwater Bay north of the deep water Baffin Bay. These data totals 778 km and comprises a relatively high quality irregular grid covering about 17000 km^2. An additional 750 km covering 8000 km^2, of lesser quality 1970s industry marine seismic data were available in paper copy form and have been tied to the western part of the new data. Our interpretation suggests the presence of several fault-bounded NW–SE trending rift basins containing at least 4 km of sediments subdivided into at least four stratigraphic sequences. Differing axes of stratigraphic thickening and recognized unconformities imply several episodes of tectonic adjustment related to the opening of Baffin Bay. A N–S trending basin following approximately the 76th degree of longitude, is characterized by flower structures on all four lines crossing the basin. These may well indicate the trace of the Wegener strike-slip transform Fault. There is a direct continuation to similar structures decribed along the Carey Basin further south. To the north, the basin trends towards the west side of the narrow Smith Sound, where heavy pack ice prevented the collection of seismic data. Incorporation of the results from the geological mapping onshore around the investigated area indicates that several kilometres of imaged older strata can be interpreted as stratified successions of the Meso-Proterozoic Thule Super Group.

Zusammenfassung: Auf der Messfahrt 2001 in der Nares Strait wurden neue reflexionsseismische Mehrkanaldaten auf einer Gesamtlänge von 1201 Profilkilometern gewonnen. Die Akquisitions-Parameter waren wegen der widrigen Operationsbedingungen in den arktischen Gewässern unterschiedlich. Das durchgeführte Standard-Prozessieren umfasste Stapelung und z.T. Migration von Profilen aus Hall Basin, Kennedy Channel, Northwater Bay und einem Profil aus dem Kane Basin bei Cape Lawrence. In dieser Arbeit werden nur die Ergebnisse aus der Northwater Bay nördlich der ozeanischen Baffin Bay vorgestellt. Qualitativ gute seismische Linien mit 778 Profil-km umfassen ein unregelmäßiges Netzwerk von ca. 17000 km^2. Weitere 750 Linien-km (ca. 8000 km^2) von Industriedaten etwas geringerer Qualität standen in Papierform zur Verfügung und wurden in das eigenen Datennetz integriert.
Nach unserer Interpretation gibt es in der Northwater Bay mehrere an Störungen eingebrochene generell NW–SE streichende Riftbecken mit mindestens 4 km Sedimentmächtigkeit, die sich in vier stratigraphische Sequenzen gliedern lassen. Wechselnde Achsenrichtungen der Sedimenttröge und deutlich erkennbare Diskordanzen deuten auf mehrer Episoden tektonischer Unruhe im Zusammenhang mit der Öffnung der Baffin Bay.
Ein N–S streichendes Becken, das etwa dem 76. Längengrad folgt, ist gekennzeichnet durch Bündel von „flower structures", die durchaus die Spur der bedeutenden Wegener-Blattverschiebung darstellen könnten. Nach Süden wurde eine Fortsetzung dieser Struktur entlang des Carey Basin beschrieben, nach Norden streicht die Struktur Richtung Westküste des engen Smith Sounds, aber seismische Belege konnten hier wegen des schweren Packeises nicht gewonnen werden.

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Manuscript received 20 January 2004, accepted 24 July 2006

INTRODUCTION AND TECTONIC SETTING

The investigated area is located on the wide continental shelf north of the deep oceanic Baffin Bay Basin. This triangular shelf represents a down-faulted area between two basement highs, the Thule and Inglefield lands in Greenland and the Inglefield Uplift on Ellesmere Island. Most of the shelf is covered by the polynia of Northwater Bay and therefore of comparably easy access for ships during the Arctic summer.

Geological knowledge of the Northwater shelf is based on the adjacent onshore geology and a number of local geophysical surveys carried out previously. The surveys consisted of shipborne gravity and refraction work, wide-spaced aeromagnetic profiling and a few single-channel reflection lines acquired in the eastern Northwater Basin (Keen & Barrett 1973, Hood & Bower 1975, Ross & Falconer 1975, Jackson et al. 1992a,b). The data are sufficiently good to allow a definition of two sedimentary basins, the Northwater Basin in the east and the Steensby Basin off the Thule airbase.

On both onshore margins, the Northwater Bay is surrounded by gneissic basement rocks of the Archean and by sediments and volcanic rocks of the Proterozoic Thule Super Group. The unfolded Thule Super Group rocks fill several halfgrabens, in which they dip by a few degrees to the SW. Apart from glacial deposits no younger rocks are exposed onshore.

Tectonic events that affected the area (Fig. 1a) are a set of WNW–ESE trending normal faults which produce a subparallel series of halfgrabens (Dawes 2006). The faults are always on the deepest side of these halfgrabens. The faulting has supposedly a late Proterozoic age (Dawes 2006).

The fronts of the Paleozoic Ellesmerian and the Cenozoic Eurekan foldbelts lie some 150 km to the W and NW and should not have affected the Northwater area as part of the foreland.

The postulated Wegener Fault as a continental transform linking the oceanic areas of Baffin Bay and the Arctic Ocean (Fig. 1a, inset) is supposed to have crossed the Northwater area during the latest Cretaceous and the Paleocene. Our investigations were aimed at finding traces of the Wegener Fault system.

MULTI-CHANNEL DATA ACQUISITION AND PROCESSING

For acquiring the multi-channel seismic data, a 48-channel Teledyne analogue streamer with a total active length of 1200

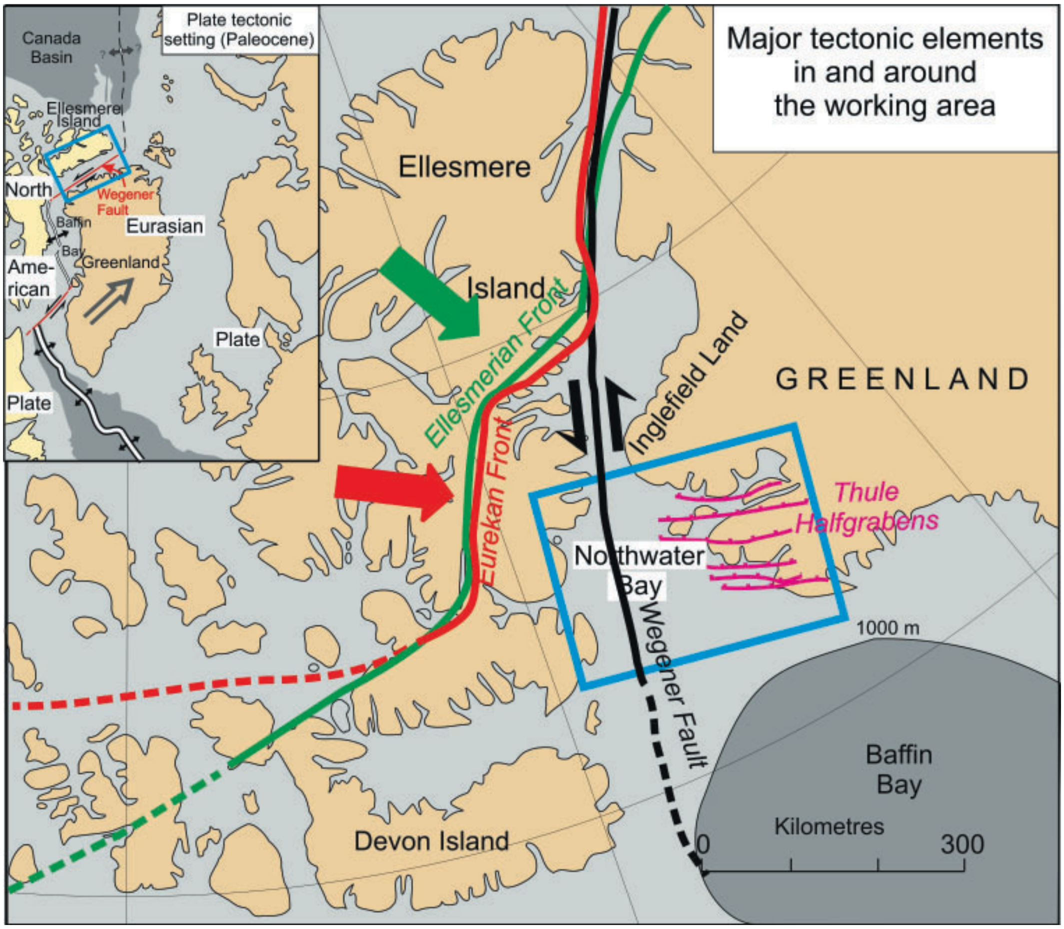


Fig. 1a: Major tectonic elements in and around the working area of Northwater Bay. Inset shows plate tectonic setting in the Paleocene, the time of the main activity of the continental Wegener Transform Fault.

m was used. The seismic signals were generated by two GI-Gun arrays with three guns each and a total volume of 20 l.

The acquisition parameters were adapted to the various ice conditions which were encountered during the cruise. In open water areas up to 2/10 of ice coverage (in Northwater Bay), the full streamer length and both GI-Gun arrays were used. In areas with denser ice coverage, e.g., Kennedy Channel and Eastern Hall Basin, we used only 200 m of active streamer representing eight channels and only one GI-Gun array. Thus we were able to manoeuvre more freely. With this configuration it was possible to work in conditions of up to 6/10 ice coverage. In both cases, the bubble system of the ship was successfully used to keep the wake free of loose ice.

The processing of the data comprised a standard processing up to final stack. Special emphasis was given to multiple reduction using velocity dependent and wave equation methods. Unfortunately, the reduction was only of little effect. This is most probably due to the strong sea floor reflection coefficient and limited common depth point (CDP) fold. So, the data exhibit trapped water bottom and primary energy whose reverberations limit the best subsurface imaging to above the first sea floor multiple.

DISCUSSION OF THE MULTICHANNEL SEISMIC DATA

Northwater Bay, the area north of the deep-water basin of Baffin Bay, was covered by a grid of irregularly spaced profiles representing approximately 780 line-km (Fig. 1b). The discussion will follow key profiles which represent the main structural results.

Line NARES 01-02A

This line shows the main structural elements found in the western part of Northwater Bay (Figs. 2a, 2b). The line trends SW–NE. From the beginning of the line (BoL) to shot point SP 250 (Fig. 2a) no or very little penetration into the sea floor is visible. The sea floor reflection is very strong and resembles the acoustic basement in this area. Small indications for a thin cover of glacial sediments are present. From SP 250 to SP 900 a sedimentary basin is visible. This basin is called "Northwater Basin" following Jackson et al. (1992a) who inferred a Late Cretaceous to Early Tertiary age for the formation of this basin. The sedimentary infill is approximately 1.5 s TWT thick. Faulting and folding affected the sediments after deposition and the sea floor forms a major erosional unconformity.

The Northwater Basin terminates at ~SP 900 at another basement high which extends to SP 1180 where a major fault is present. From SP 1180 to SP 2140 another 48 km-wide sedimentary basin is present which we call Kiatak Basin after the Inuit Name of Northumberland Island.

The sediments in the Kiatak Basin are approximately 2 s TWT thick and show strong post-depositional deformation at the southern part of the basin (SP 1250-1550, Fig. 2b). The sea

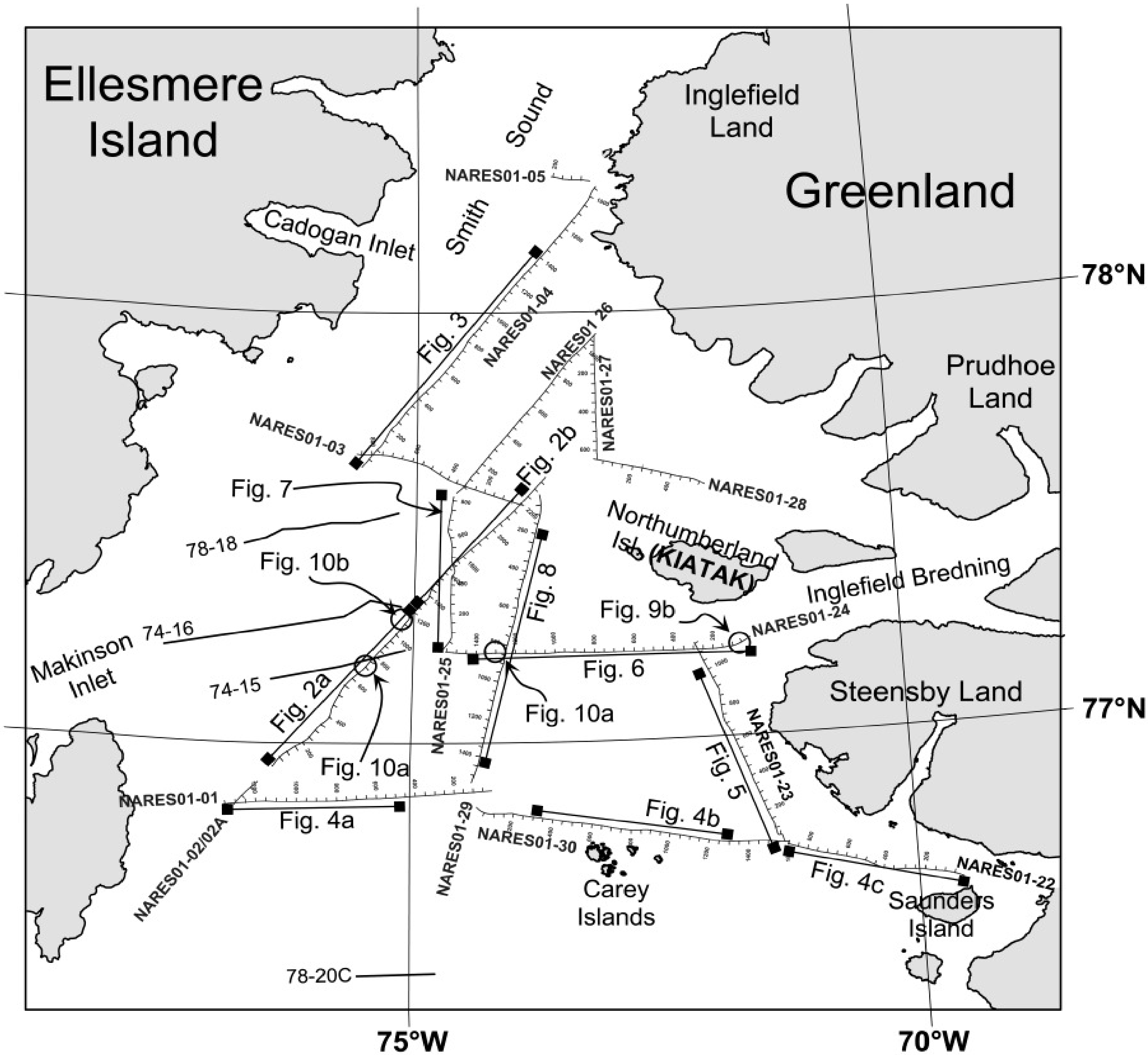


Fig. 1b: Location of multi-channel seismic reflection lines in the Northern Baffin Bay acquired during Nares Geocruise 2001 (see Figs. 2a through 8). Also shown are profiles from JACKSON et al. (1994) in the western part of the Baffin Bay. Open circles show locations of velocity analysis (see Figs. 10a, 10b).

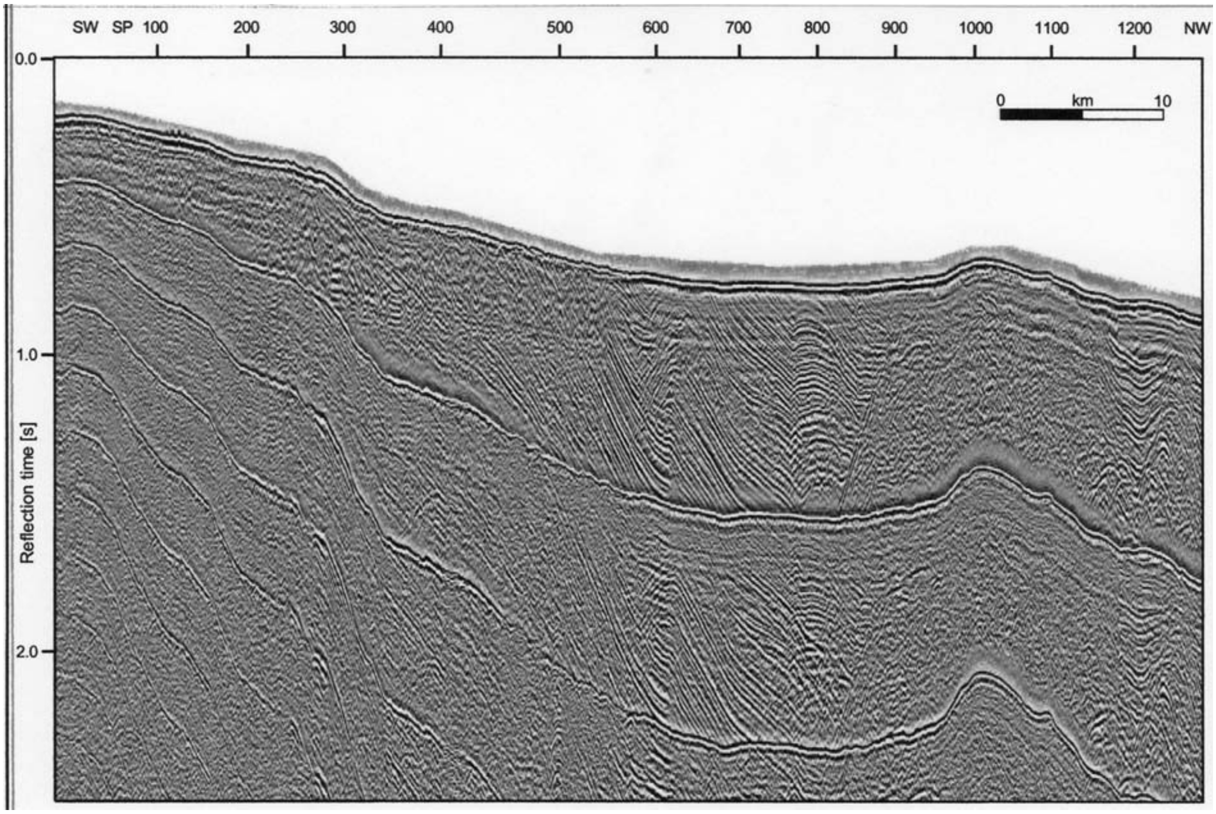
floor in this part of the basin forms a strong erosional surface. We infer a Late Cretaceous to Early Tertiary age for the development of this depocenter (similar to the Northwater Basin). In this basin five distinct major seismo-stratigraphic units and horizons are present. The unit bounding reflectors represent changes of the depositional regime in the basin. The deposition of these sediments and the changes in the depositional regime occurred most probably prior to major tectonic changes in the surrounding areas (e.g., opening of the Baffin Bay, termination of sea floor spreading in the Labrador Sea and reorientation of plate movements) and sea level changes. In the absence of drilling results in the investigated area we used seismo-stratigraphies from other arctic areas (e.g., CHALMERS & PULVERTAFT 2001, FRANKE et al. 2001) to tie the different horizons to the different events.

BB has an irregular reflection characteristic and shows in some areas indications of block faulting (Fig. 2b). It is interpreted to represent the basement of the basin. We infer a Late Cretaceous to Paleocene age to this horizon and correlate this event with the earliest onset of rifting and ocean crust production in the Labrador Sea between magnetic chron 31 = ~68 Ma (SRIVASTAVA 1978) and magnetic chron 27 = ~61 Ma (CHALMERS & LAURSEN 1995).

KT1a forms the top of the high reflective stratigraphic unit KT I. It's internal reflection characteristics is in parts chaotic and indicates rapid sedimentation (MITCHUM 1977).

KT1b forms the upper boundary of the well stratified unit KT II. This unit reaches a maximum thickness of ~0.35 ms TWT at SP 1800. KT2 indicates a change in the depositional regime and correlates with a time of uniform sedimentation on a stable basin floor respectively substratum.

KT1c forms the lower boundary of unit KT IV. The unit below



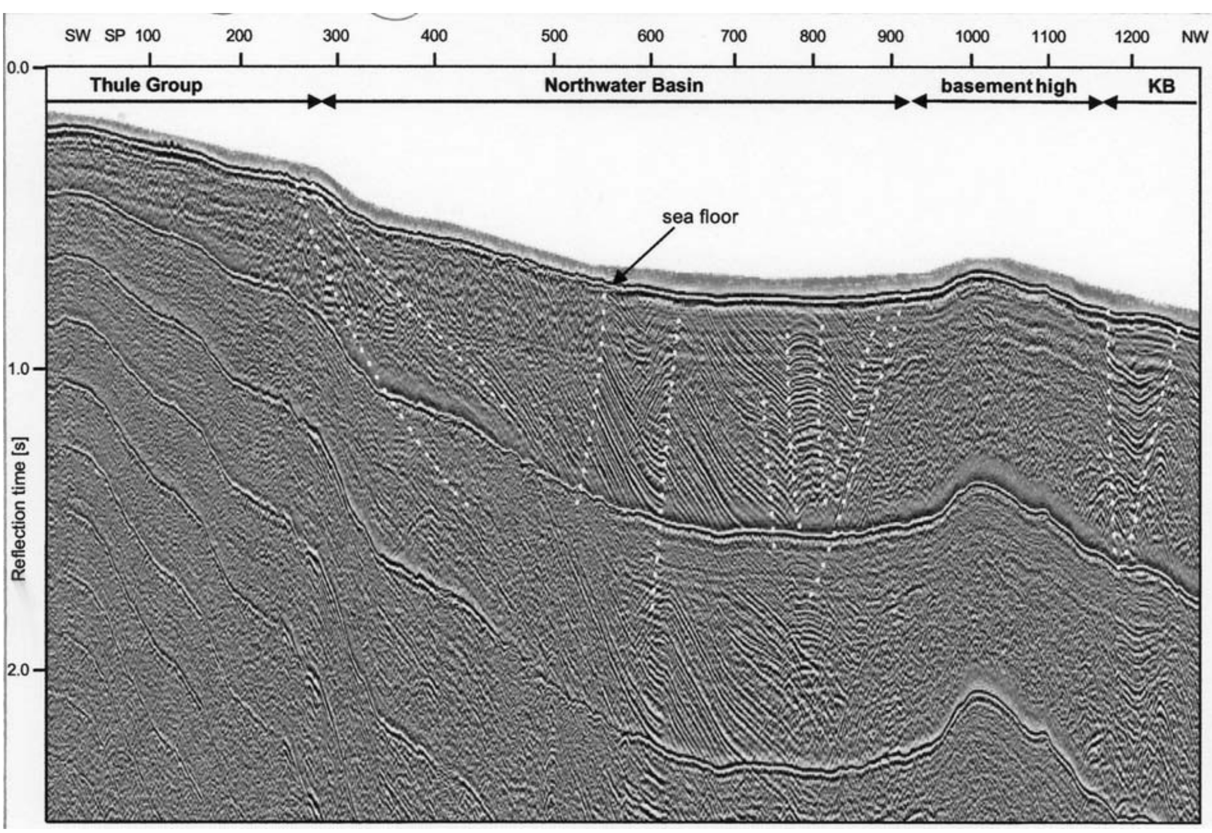


Fig. 2a: Stacked seismic section of line NARES 01-02A (SP BoL-1250). The section extends from south to the north over the Northwater Basin (JACKSON et al. 1994) which is at this location ~25 km wide. It is bounded to the south by the Thule Super Group and to the north by a basement high of inferred Thule Super Group. For location see Figure 1b.

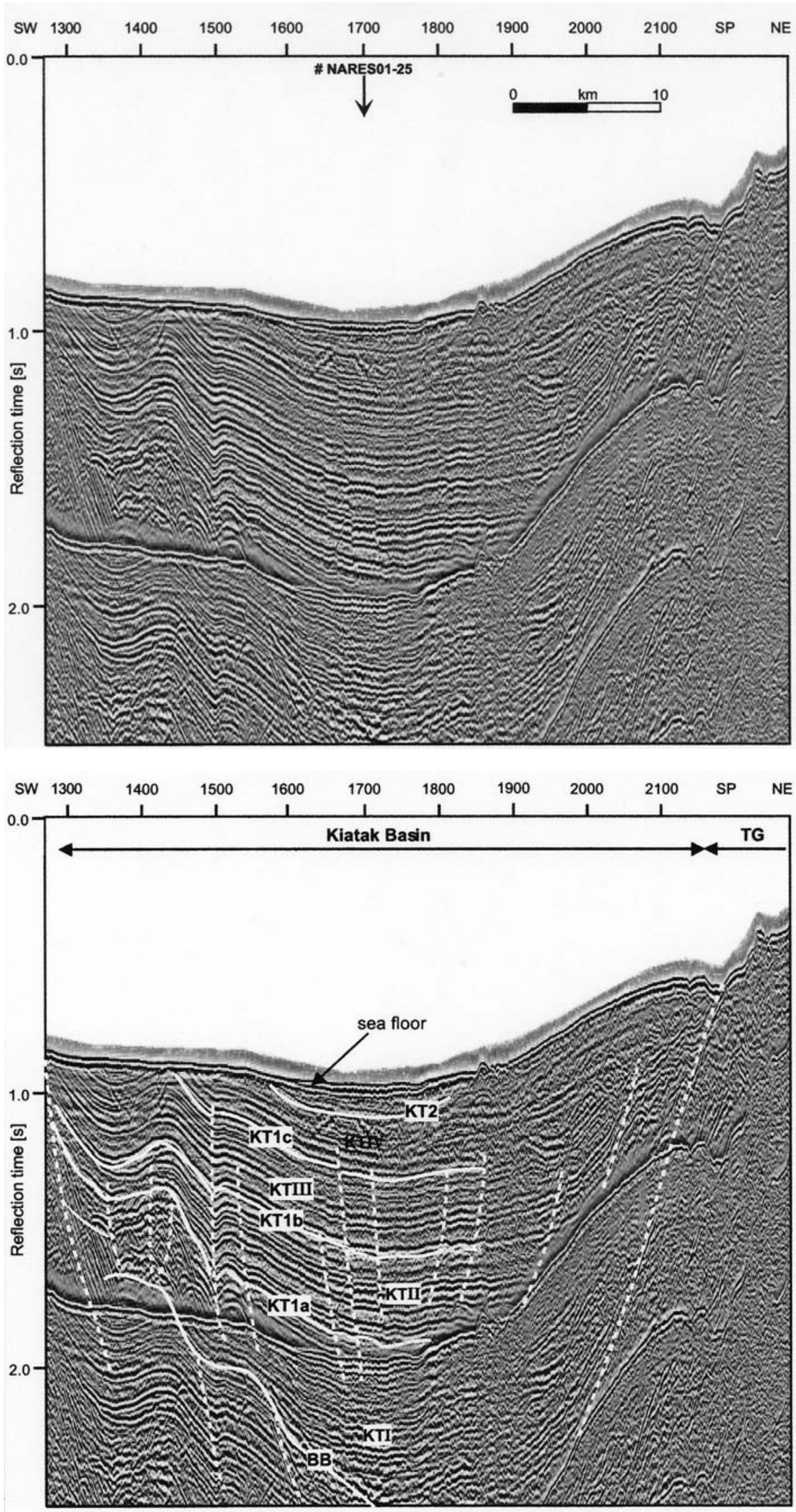


Fig. 2b: Stacked seismic section of line NARES 01-02A (SP 1300-2200). The section extends over the NW-part of the Kiatak Basin to the Thule Super Group (TG). KT1a – KT1c refer to sedimentary unconformities and KT I – IV to sedimentary units. The basin is ~30 km wide and has a maximum thickness of ~2.0 s TWT. For location see Figure 1b.

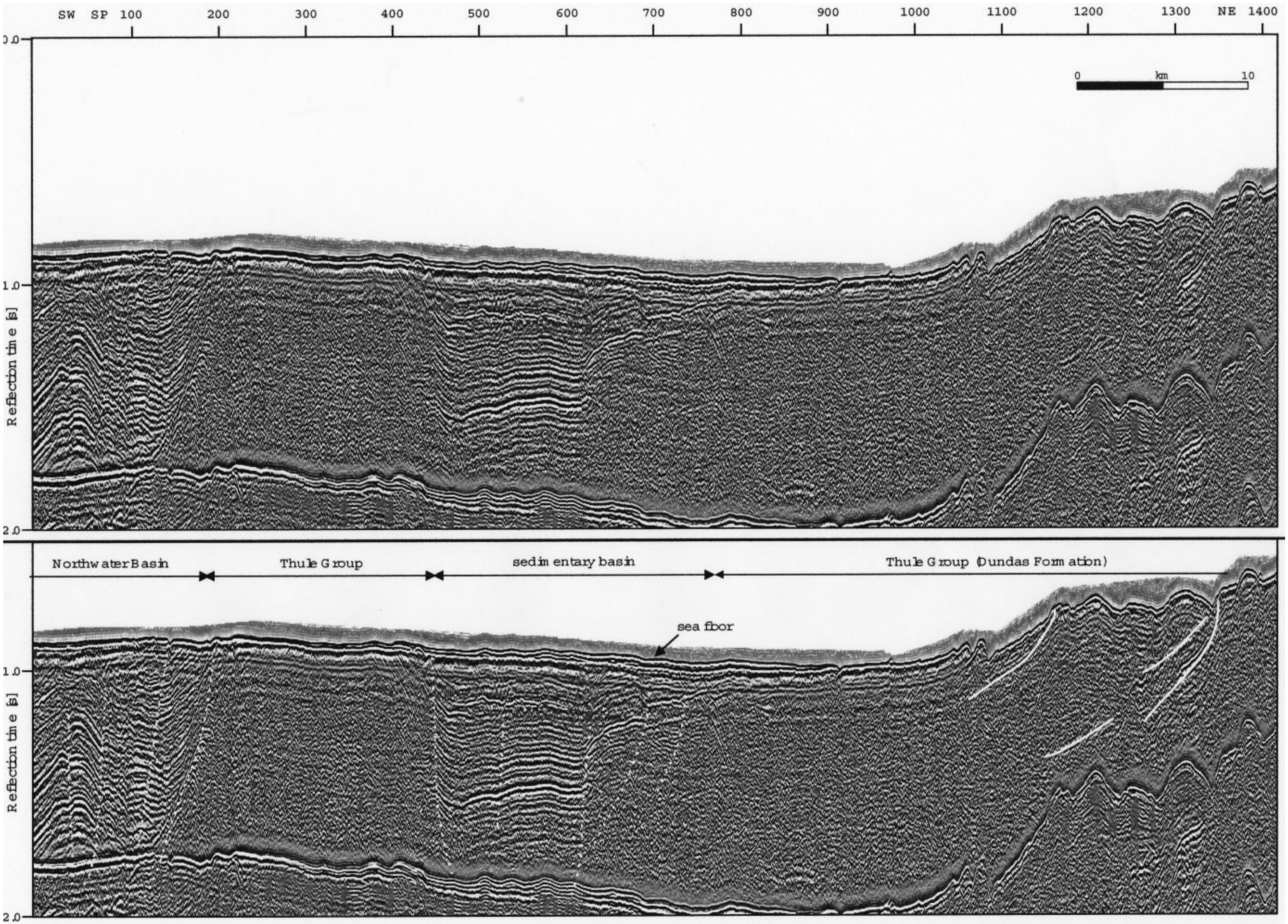


Fig. 3: Stacked seismic section of line NARES 01-04 (SP BoL-1400). The section covers the northernmost extension of the Northwater Basin. Between SP400 and 900 a small basin is present surrounded by inferred Thule Super Group. For location see Figure 1b.

KT III shows no or only weak internal reflection pattern. This indicates a very homogenous sedimentary body.

After deposition of units KT I to KT IV the sediments were deformed and uplifted. This deformation is tentatively correlated with major changes of the spreading pattern in the surrounding ocean.

In the eastern part of the Kiatak Basin unit KT IV is overlain by younger deposits which show no internal deformation and are therefore correlated to sedimentation which occurred after the above mentioned major changes in the tectonic environments

Line Nares 01-04

This line trends again SW–NE and roughly parallel to line NARES 01-02A (Fig. 1b). It represents the northern- and westernmost part of the area. Figure 3 shows a seismogram section of the line between BoL and SP 1400. From the BoL to SP 200 the ~1.0 s TWT a folded sedimentary succession represents the northernmost extension of the Northwater Basin. The basin terminates at SP 200 (Fig. 3) at a steep fault. From SP 200 to SP 370 no penetration into the sea floor was achieved and we interpret this area as Thulean. This outcrop extends along the line up to SP 370. From SP 370 to SP 900 another small basin of unknown age is present. The sedimentary reflectors are subparallel to the sea floor and have a low frequency reflection characteristic. This depocenter is bounded by steep normal faults. Another interpretation could be that the strong reflector at ~1.5 s TWT represents a sill. Because no crosslines and no other lines are available in this area both interpretations could be correct. The interval velocities derived from this part show values between 2.2 and 3.4 km s^{-1}. From these we prefer the interpretation of a small sedimentary basin in this area.

On the northernmost part of this line (SP 900-EoL), only small penetration into the subsurface is recognizable. From SP 1100 to end of line (EoL), the topography of the sea floor is rough and the reflectors are dipping to the SW. These dipping reflectors could represent small listric faults or SW-dipping Thule Super Group sediments in a halfgraben setting. We interpret this area as offshore continuation of the Proterozoic Thule Super Gp which is present onshore in Inglefield Land (Dawes 1991).

Lines NARES 01-01, 01-30 and 01-22

These lines form a combined transect along ~76°30' N, crossing nearly the whole northern Baffin Bay from the area between approximately 77° W to Saunders Island and Wolstenholme Fjord in the east. It also extends subparallel to the refraction/wide-angle line 3 which was acquired during the cruise from Makinson Inlet to Wolstenholme Fjord (Funck et al. 2006). We will discuss these lines from W to E (Figs. 4a, 4b, 4c). On the westernmost part of line NARES 01-01 (EoL-SP 770) the Thule Super Group forms the acoustic basement and crops out at the sea floor (Fig. 4a). The southward continuation of the fault-bounded Northwater Basin is found between SP 770 and SP 400. The sediments are bedded subparallel to the sea floor. The total recognizable sediment thickness is approximately 1.0 s TWT. The basin is affected by a fan-like set of apparent normal faults, there are, however, signs of compression in some of the fault-bounded segments which could indicate a negative flower structure, the trace of a strike-slip fault.

From SP 400 to the beginning of line (BoL) the basement is lying close to the sea floor but the internal reflectivity indicates faulting or folding. In small depocenters (SP 500 - SP 530, SP 600 - SP 630) a maximum of 0.2 s TWT sediment thickness is reached. Along the whole line the cover with glacial deposits is rather thin.

The transect continues eastward with the W–E trending line NARES 01-30 (Fig. 4b). From BoL to SP 300, the area of faulted basement continues as on line NARES 01-01. This segment is again interpreted as Thule Super Group. From SP 300 to SP 1150 the acoustic basement crops out at the sea floor. We interpret this area as the offshore continuation of the gneissic basement which is present on the Carey Islands. These islands are situated approximately 5-10 km to the South. From SP 1150 to EoL a sedimentary basin ispresent.

The easternmost segment of the transect is formed by line NARES 01-22 (Fig. 4c). It is located between Saunders Island and Steensby Land and ends off Thule Air Base in the east. In the area from EoL to SP 700 a sedimentary basin is present. The sediment reflectors dip steeply to the West. The basin terminates to the east at a steep step of the sea floor of approximately 300-400 m (SP 780). The sea floor in the area of the basin is a strong erosional unconformity.

From SP 650 to the BoL, the Proterozoic Thule Super Group prevents penetration almost completely and no coherent crustal reflectivity was found. The lack of penetration is probably due to the occurrence of sills in the Thule Super Group succession.

Line NARES 01-23

This line trends roughly S–N along the coast of Steensby Land in the eastern part of the Northwater Bay into Inglefield Bredning. Figure 5 shows a seismogram section of this line. From BoL to SP 480, sediments of the Steensby Basin are traversed. The axis of this basin is situated around SP 200. The basin terminates to the north at a small fault (~SP 480). From SP 480 to EoL the internal reflection characteristics show low frequency reflectors that dip to the south. These reflectors are interrupted by faults penetrating the sea floor (e.g., SP 600, SP 730, SP 810). The antithetic faults show offsets of up to ~150 m. This area is interpreted to represent the offshore equivalent of the Proterozoic Thule Super Group which crops out at the adjacent Steensby Land coast.

Line NARES 01-24

Trending in an E–W direction, this line extends from Inglefield Bredning between Northumberland Island and Greenland into the central Northwater Bay with a total length of 77.5 km. From east to west it crosses two structural elements. From

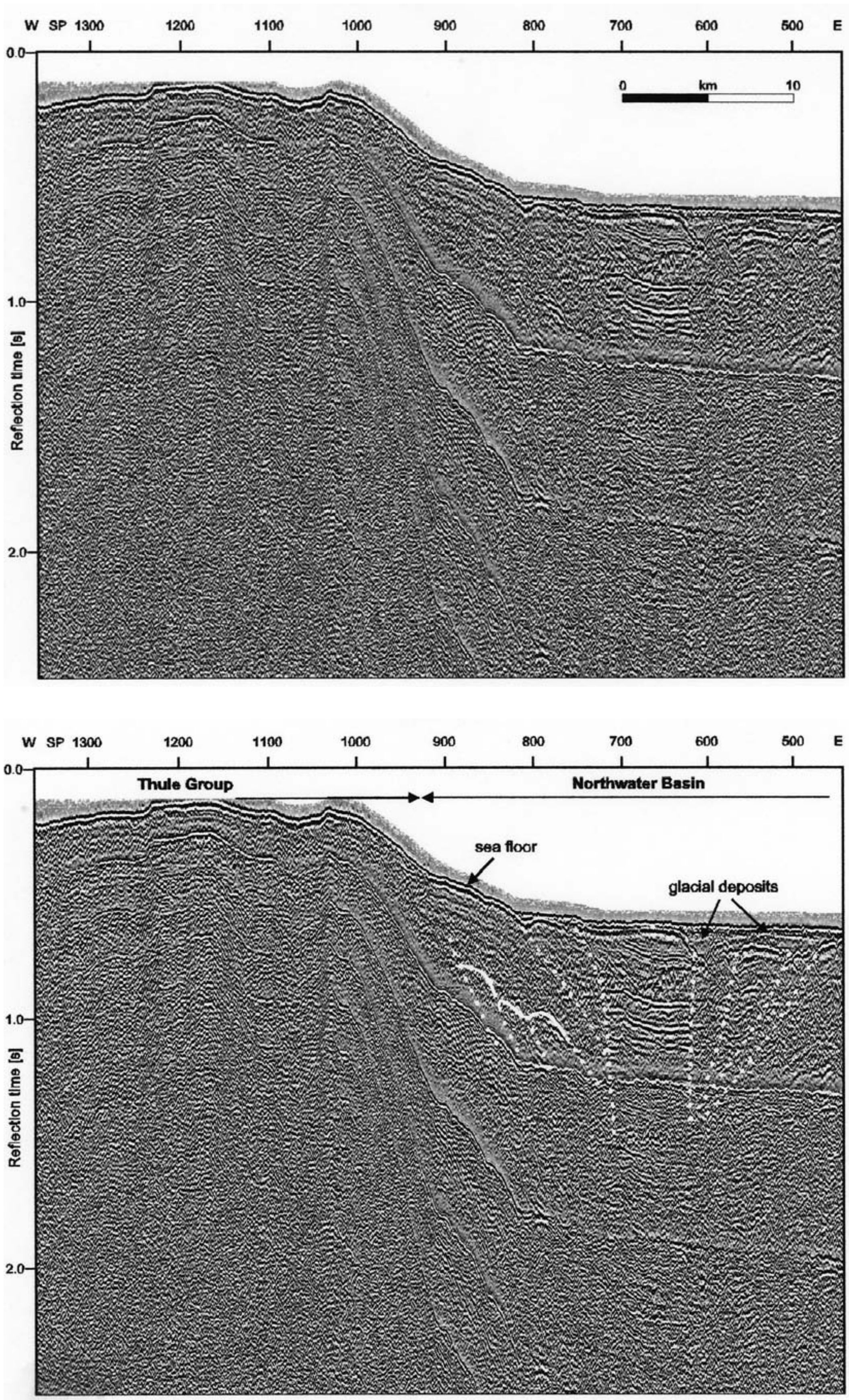


Fig. 4a: Stacked seismic section of line NARES 01-01 (SP 500-1350). The section extends over the Northwater Basin (Jackson et al. 1994) and the Thule Super Group in the west. In this area the basin is bound by normal faults. In some areas a thin glacial cover is present. For location see Figure 1b.

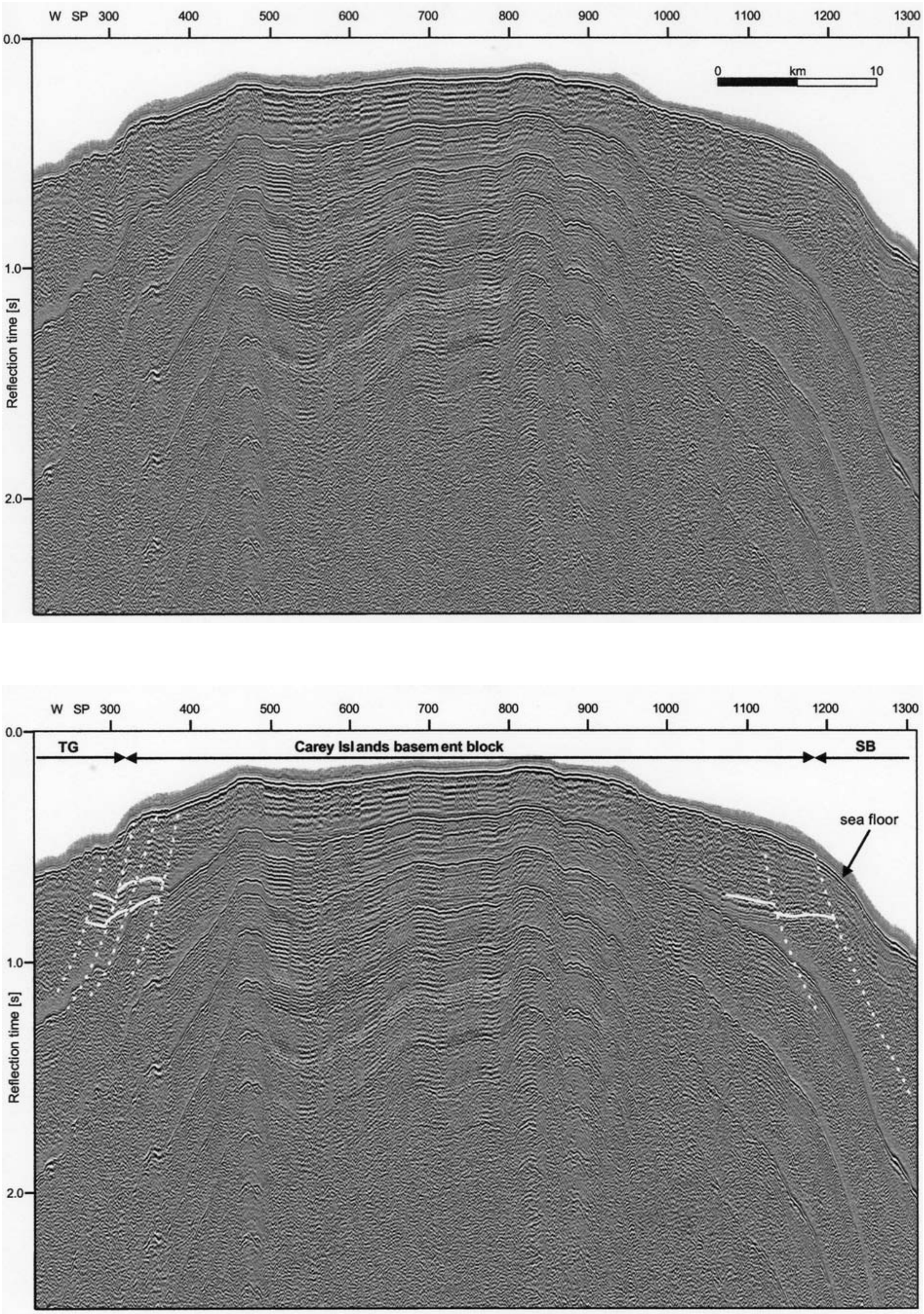
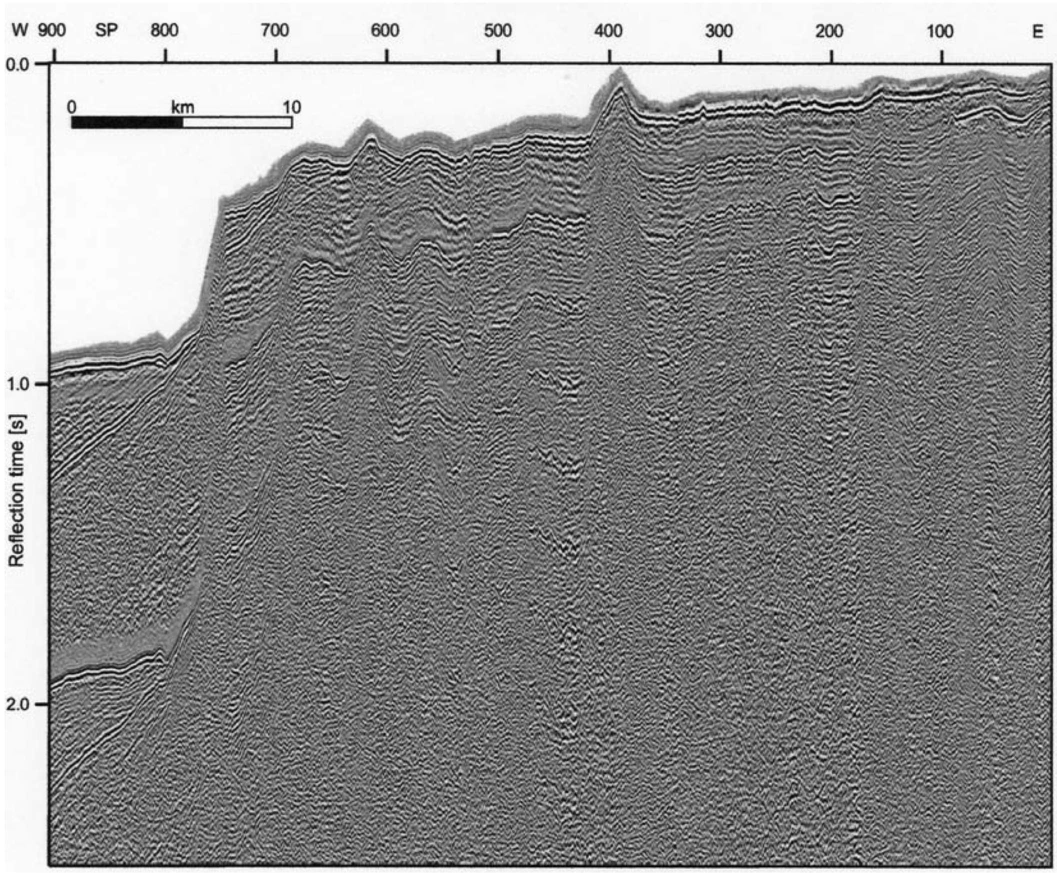


Fig. 4b: Stacked seismic section of line NARES 01-30 (SP 200-1300). The section extends from the Thule Super Group (TG) in the west over the gneissic basement block of the Carey Islands into the westernmost extension of the inferred Steensby Basin (SB) in the east. For location see Figure 1b.



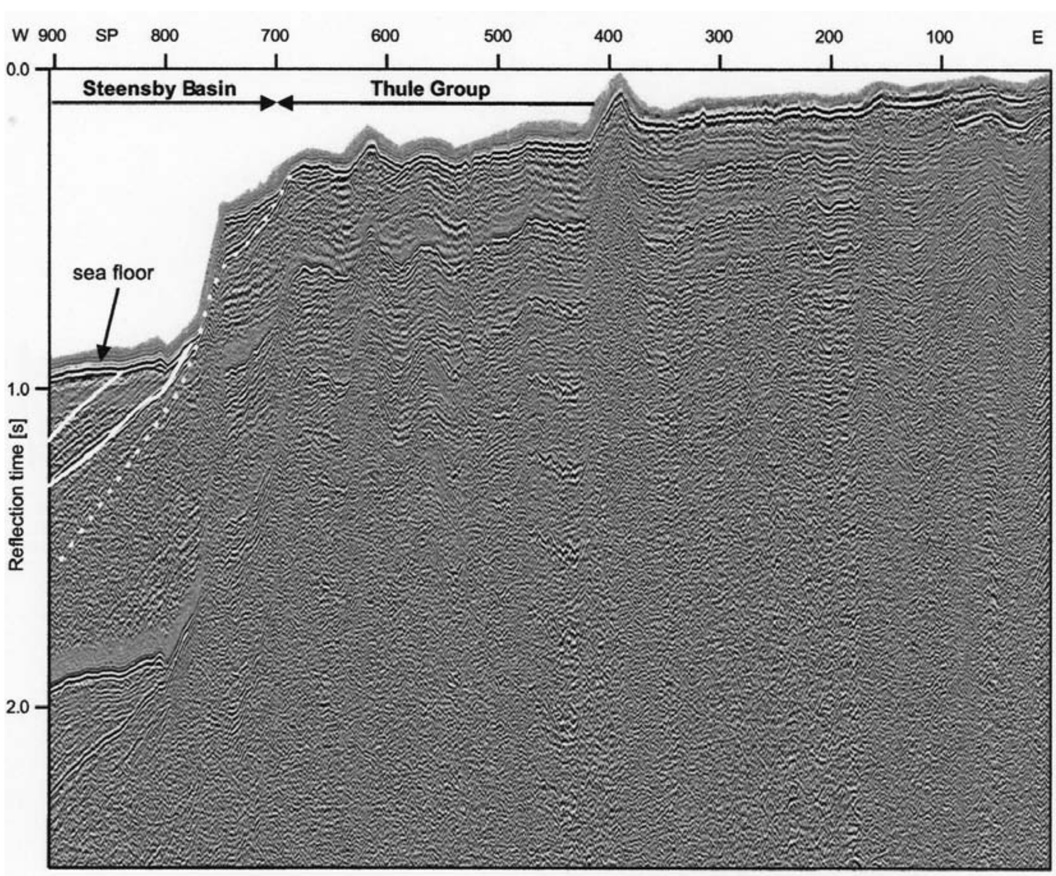


Fig. 4c: Stacked seismic section of line NARES 01-22 (SP BoL-900). The section extends from the Thule Super Group in the east over a steep fault into the Steensby Basin. In the basin the sea floor forms a prominent erosional surface. For location see Figure 1b.

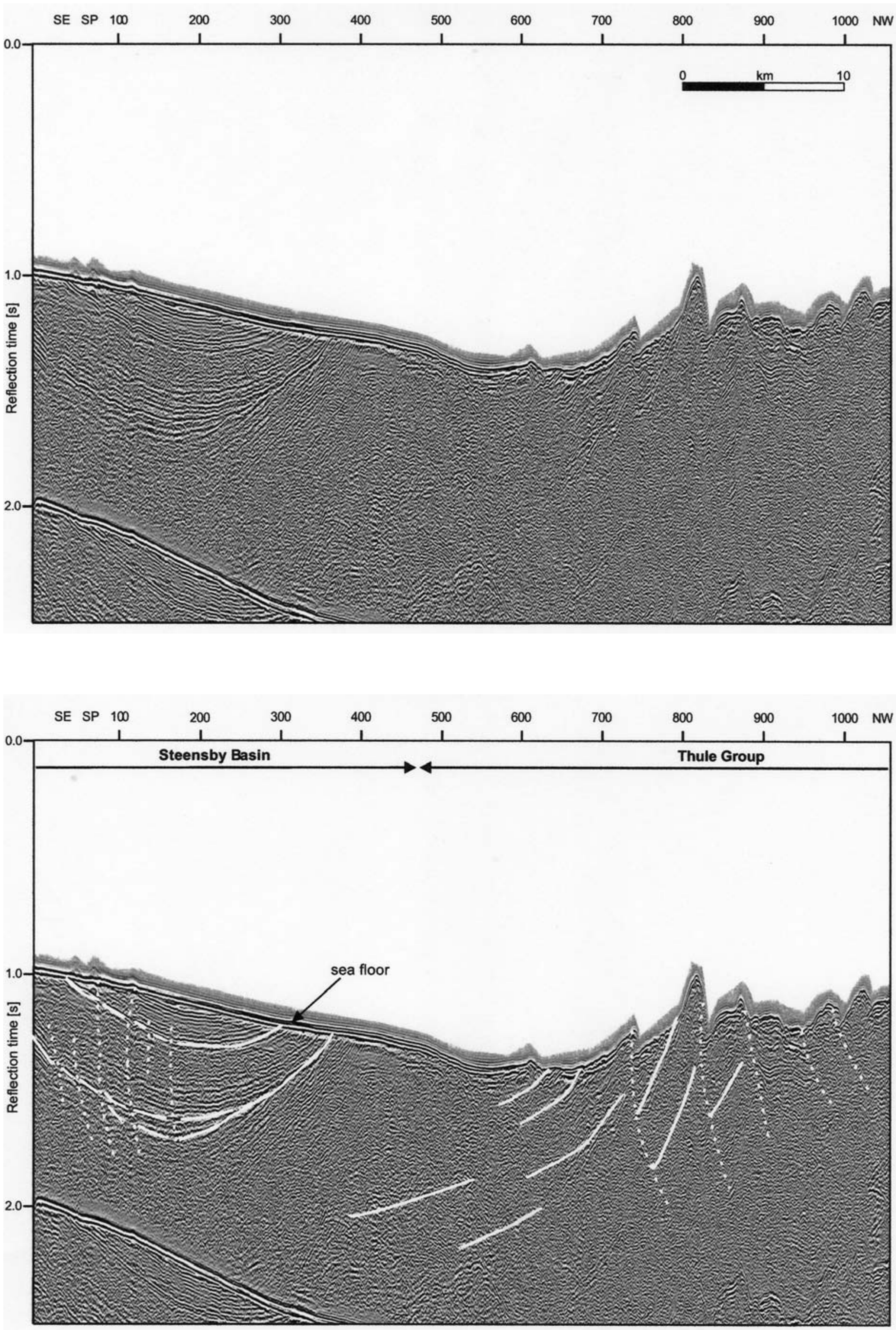


Fig. 5: Stacked seismic section of line NARES 01-23 (SP BoL-1050). The section covers the Steensby Basin in the south and extends into the Thule Super Group. As in Figure 4c the ocean bottom of the Steensby Basin forms a prominent erosional surface. For location see Figure 1b.

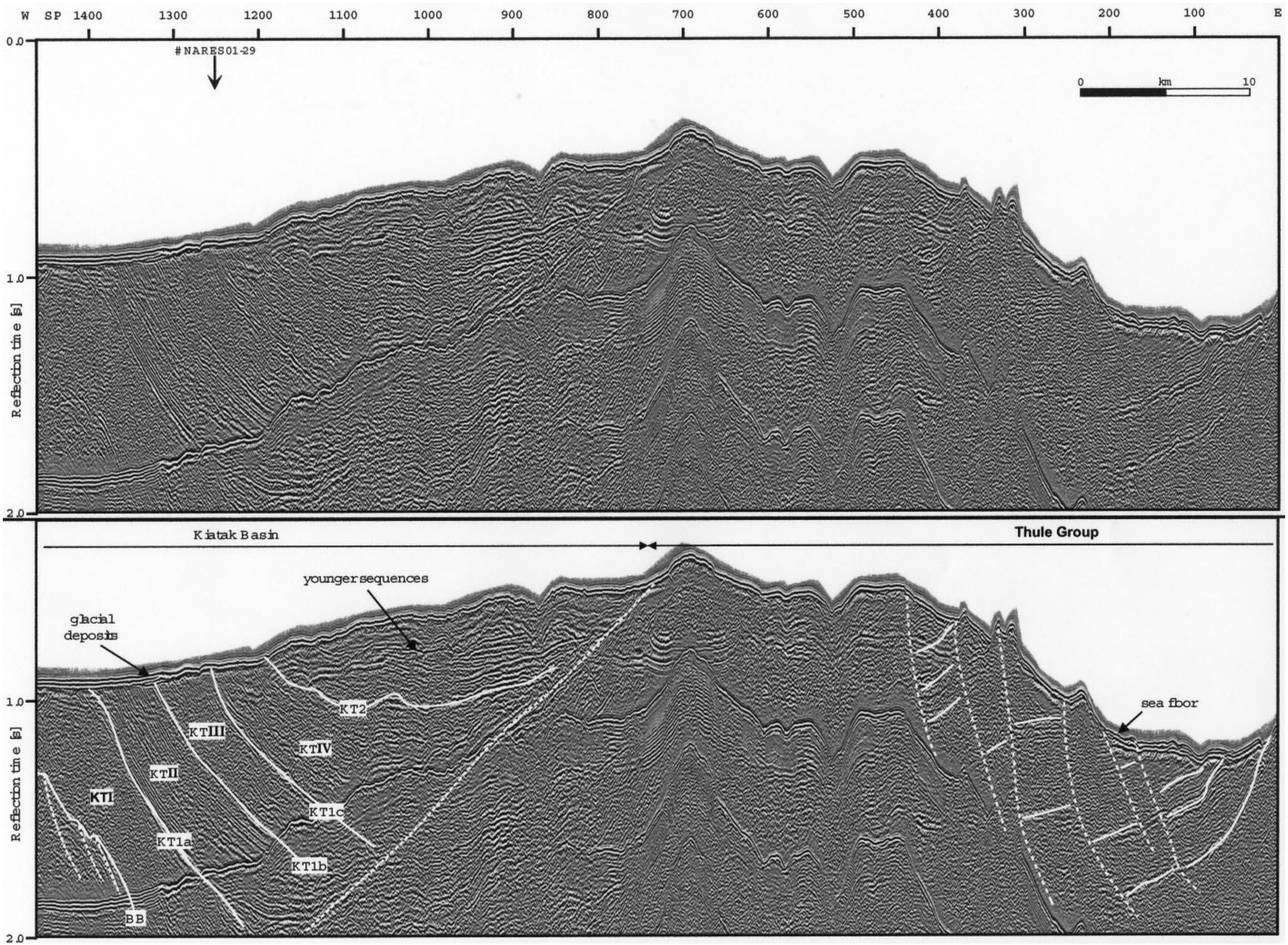


Fig. 6: Stacked seismic section of line NARES 01-24 (SP BoL-1450). The section extends from the Thule Super Group south of Northumberland Island into the Kiatak Basin. The basin is bounded to the east by a major fault. For location see Figure 1b.

BoL to SP 700 Thule Super Group sediments are encountered (Fig. 6). In the eastern part (BoL to SP 380), some strong low frequency reflectors are interrupted by steep faults. These faults are associated with rough sea floor topography. From SP 380 to SP 700 the roughness of the topography and the intensity of faulting decrease. The eastern part of Kiatak Basin is traversed from SP 700 to EoL. In this area, the basin reaches a maximum thickness of 2.0 s TWT. The basin is bound on its eastern termination by a normal fault. East of SP 1200 unit KT IV is overlain by a younger succession of rather irregular sediments. From the EoL to SP 1200 (units KT I to KT IV), the sea floor forms a strong erosional unconformity and, in the westernmost part (SP 1450 to EoL), the sediments show folding and normal faulting. A thin (<0.1 s TWT) cover of glacial sediments is present over the whole line.

Line NARES 01-25

Line NARES 01-25 (Fig. 7) trends S–N and extends through the Kiatak Basin. It starts in the area between BoL and SP 280 in the faulted/folded sediment section already discussed. From SP 280 to SP 600 the main part of the Kiatak Basin is encountered. The sediment thickness exceeds 1.0 s TWT. The rather continuously, well-bedded strata are slightly displaced by steep faults. From SP 600 to EoL the reflectors indicate folded strata. All major unconformities are present and the sea floor again forms a major erosional surface.

Line NARES 01-29

This line is subparallel to line NARES 01-25 about 30 km farther east. It traverses three structural units (Fig. 8). The segment from BoL to SP 250 is interpreted as Thule Super Group. The Kiatak Basin is ~35.5 km wide and highly asymmetric. In the basin itself, all four major sedimentary units are present. On top of unconformity KT2, the young succession of sediments, also present on line NARES 01-24, reaches its greatest thickness. The total thickness of the Kiatak Basin in this area is >2 s TWT. From SP 960 to EoL a unit with some low frequency reflecting elements is interpreted again as Thule Super Group.

LINKS WITH ONSHORE GEOLOGY

The set of faults bounding halfgrabens in the Thule Super Group (Dawes 2006) apparently continues offshore (Fig. 10), subparallel to the NW–trending Prudhoe Land coast. The Archean basement SE of the Itilleq Fault on Steensby Land finds its equivalents on Northumberland Island and offshore NE of the Northwater Basin (Fig. 9). For some distance, the NE boundaries of the Kiatak and the Steensby Basins appear to be bound by extensions of the Granville and Moltke faults. The basin axes, however, trend more NW–SE. The important point from onshore is the different trend of the Thule halfgrabens (WNW–ESE) from the trend of the Kiatak and Steensby Basins (NW–SE).

STRUCTURAL MAP DERIVED FROM NEW MCS DATA

From the results obtained by the new MCS data in combination with existing reflection profiles in the western part of the northern Baffin Bay from the 1970s and especially with the onshore geological maps we were able to produce a new structural map of the investigated area (Fig. 10). It shows three sedimentary basins: (i) the Northwater, (ii) the Kiatak and (iii) the Steensby Basins. These basins were combined in various ways in the early publications. But a single-channel seismic line along the axis of Steensby and Kiatak Basin (across the gap in our data) shows a basement high between the two (Ross & Falconer 1975). Another high between Northwater and Kiatak Basins is indicated on the early lines (Jackson et al. 1992a), although the character of the rocks in the intervening gap is open.

The eastern basins (Kiatak, Steensby) strike in a NW–SE direction, whereas the Northwater Basin strikes N–S. A fourth, small basin is indicated further north, on lines NARES 01-04 and 01-26. The basins are surrounded by the Palaeozoic Thule Super Group. In the central southern part, a basement high is formed by the gneissic basement block of the Carey Islands. A similar high is present at the northern tip of the Kiatak Basin.

DISCUSSION OF THE SEDIMENTARY BASINS

The Northwater Basin has already been described earlier from the seismic lines 74-15, 74-16 and 74-18 (Jackson at al. 1992a). The new lines double the longitudinal extension of the basin. The sediments are between 1.5 s TWT (Fig. 2) and 1.0 s TWT (Fig. 4a) thick. Compressional folding and faulting occurred after deposition in the narrow fault-bounded segments. We interpret the fan-like arrangements of the faults on lines NARES 01-04, 01-02, 01-03 (Figs. 2, 3, 4a) as a negative flower structure which suggests an interpretation as trace of a strike-slip fault. Comparison with the narrow onshore basins following the Wegener Fault on the west side of northern Nares Strait (Judge Daly, Cape Back and Cape Lawrence Basins) shows a similar size and tectonic style.

The Kiatak Basin has already been traversed by an early seismic survey in the area (Keen & Barrett 1973), but it was never named. It was later combined with the Northwater Basin (Ross & Falconer 1975, Newman 1982). The deep basin is crossed by four of our seismic lines (Figs. 2b, 6, 7, 8). On the SW-side it is bounded by a steep fault against Thule Super Group rocks and against a marked zone of deformed sediments. A major part of the sedimentary sequence is folded (Fig. 2b) and faulted (Fig. 7) in the area indicated on the map. (Fig. 9). To the NE of the fault a thick, well-bedded sequence of NE-dipping, rather continuous sedimentary layers allows a provisional seismostratigraphy and indicates a depocentre more than 2.5 s TWT deep. A peculiar feature, two synclines with an intermediate high occur towards the top of the sequence (Figs. 7, 8) above KT2.

The Steensby Basin has first been recognized from magnetic anomalies (Keen & Barrett 1973). It was modified by Ross & Falconer (1975) based on one seismic line. The name Steensby Basin was first used by Newman (1982). The bowlshaped basin, traversed by two seismic lines (Figs. 4b, 4c, 5), is only weakly deformed.

AGE OF THE BASINS

In the absence of any kind of ground truth (wells, samples, etc.), the only indicators for the formation age of Northwater

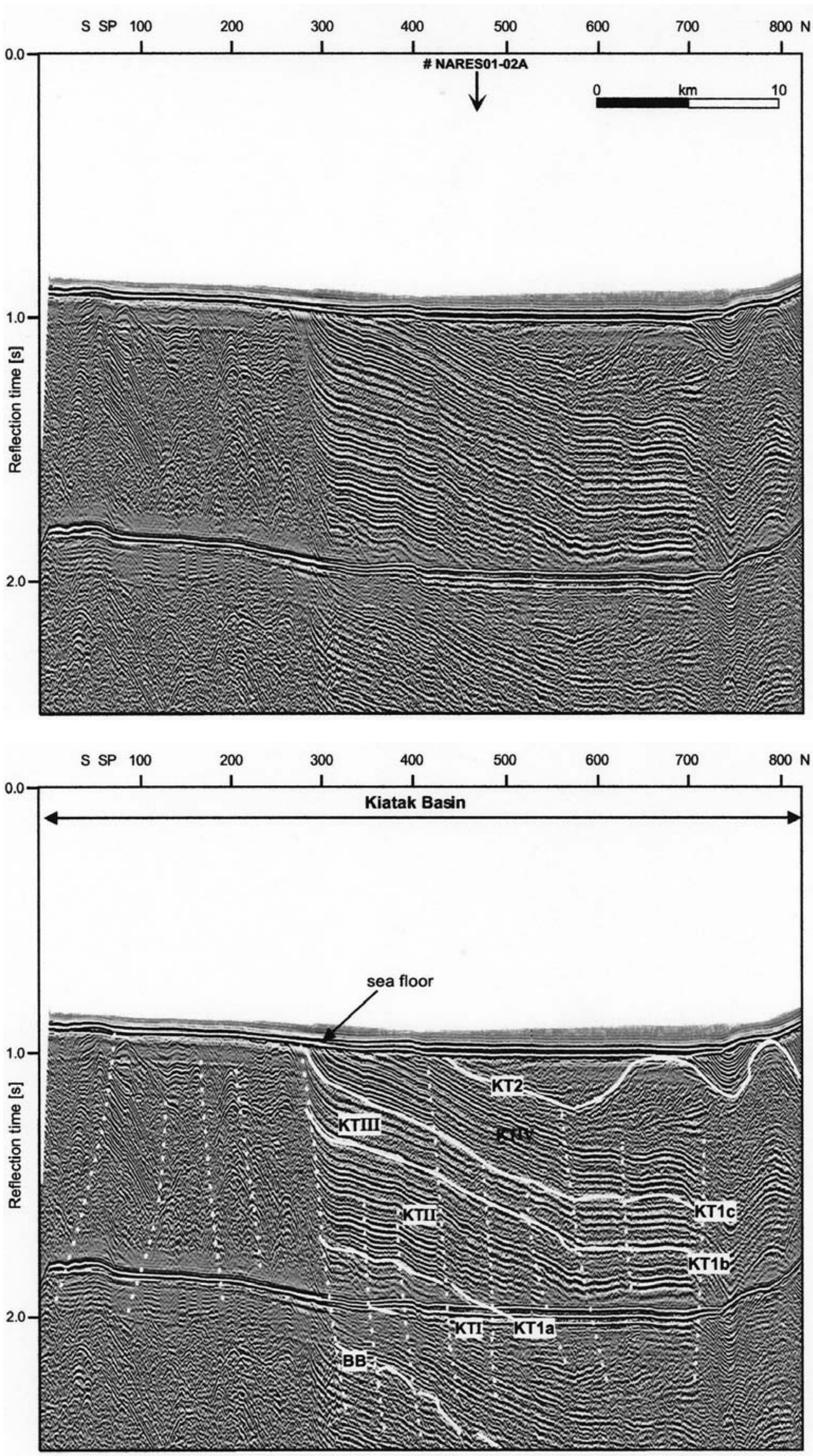


Fig. 7: Stacked seismic section of line NARES 01-25 (SP BoL-800). The section covers the Kiatak Basin. The basin shows three different areas. A strongly folded and disturbed area in the south (SP BoL-280), a section with well stratified sediments between SP 280 and 700 and another area where the sediments are affected by folding. For location see Figure 1b.

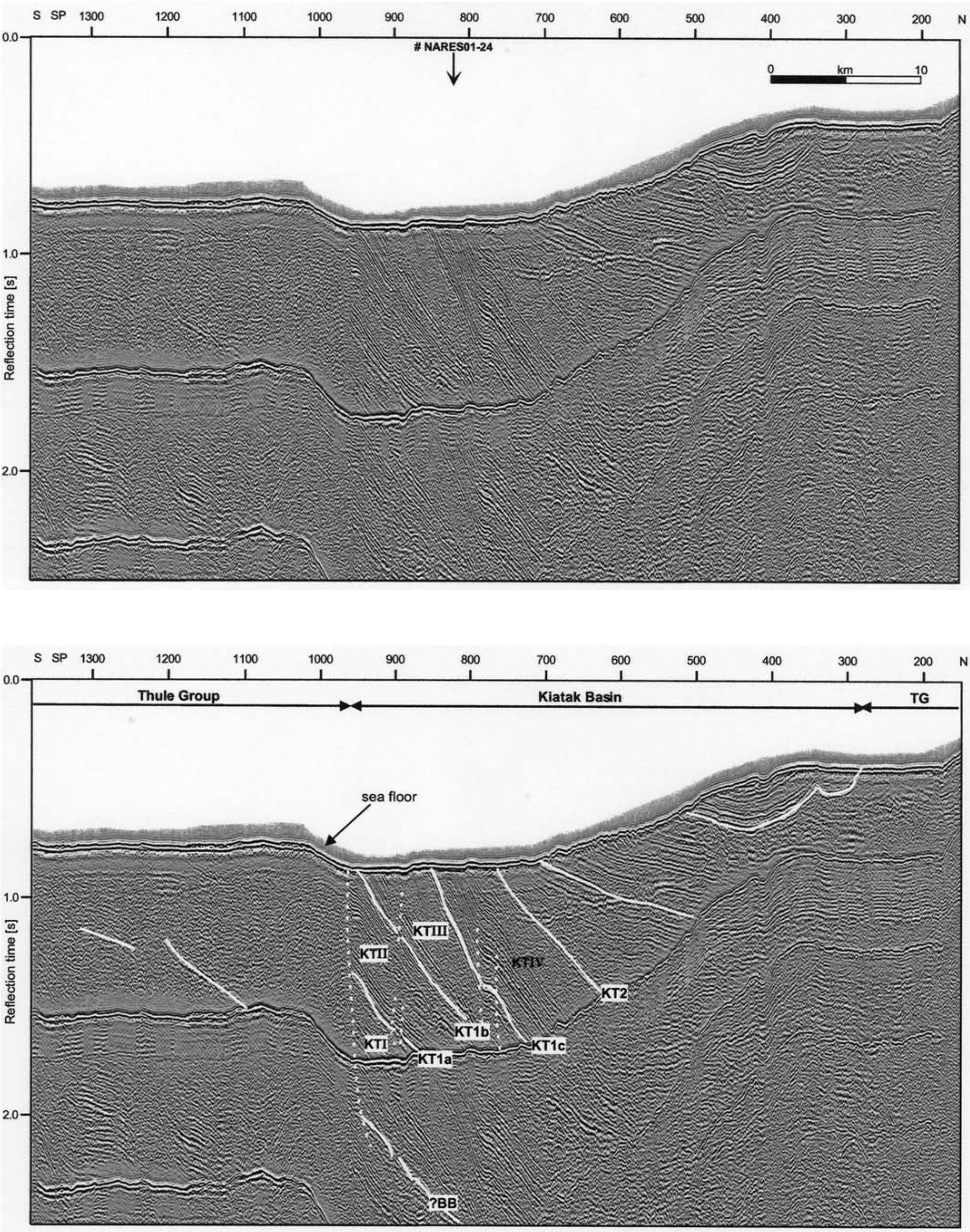


Fig. 8: Stacked seismic section of line NARES 01-29 (SP 150-1400). The section extends from the Thule Super Group (TG) in the north over the Kiatak Basin into the Thule Super Group in the south again. The sediments in the basin were tilted and uplifted and the sea floor in the basin forms a major erosional unconformity. For location see Figure 1b.

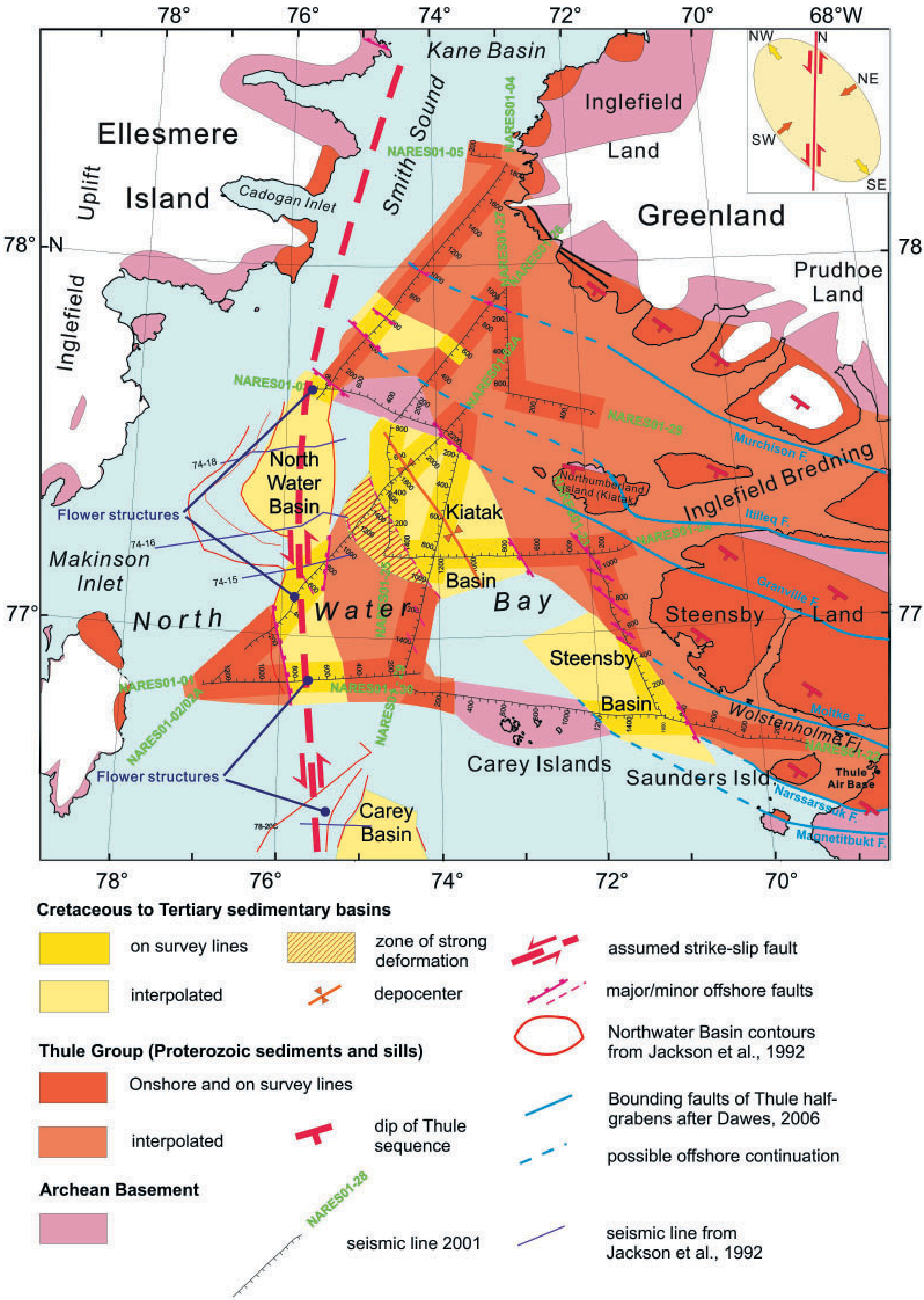


Fig. 9: Schematic structural map for the Northern Baffin Bay derived from new multi-channel seismic data.

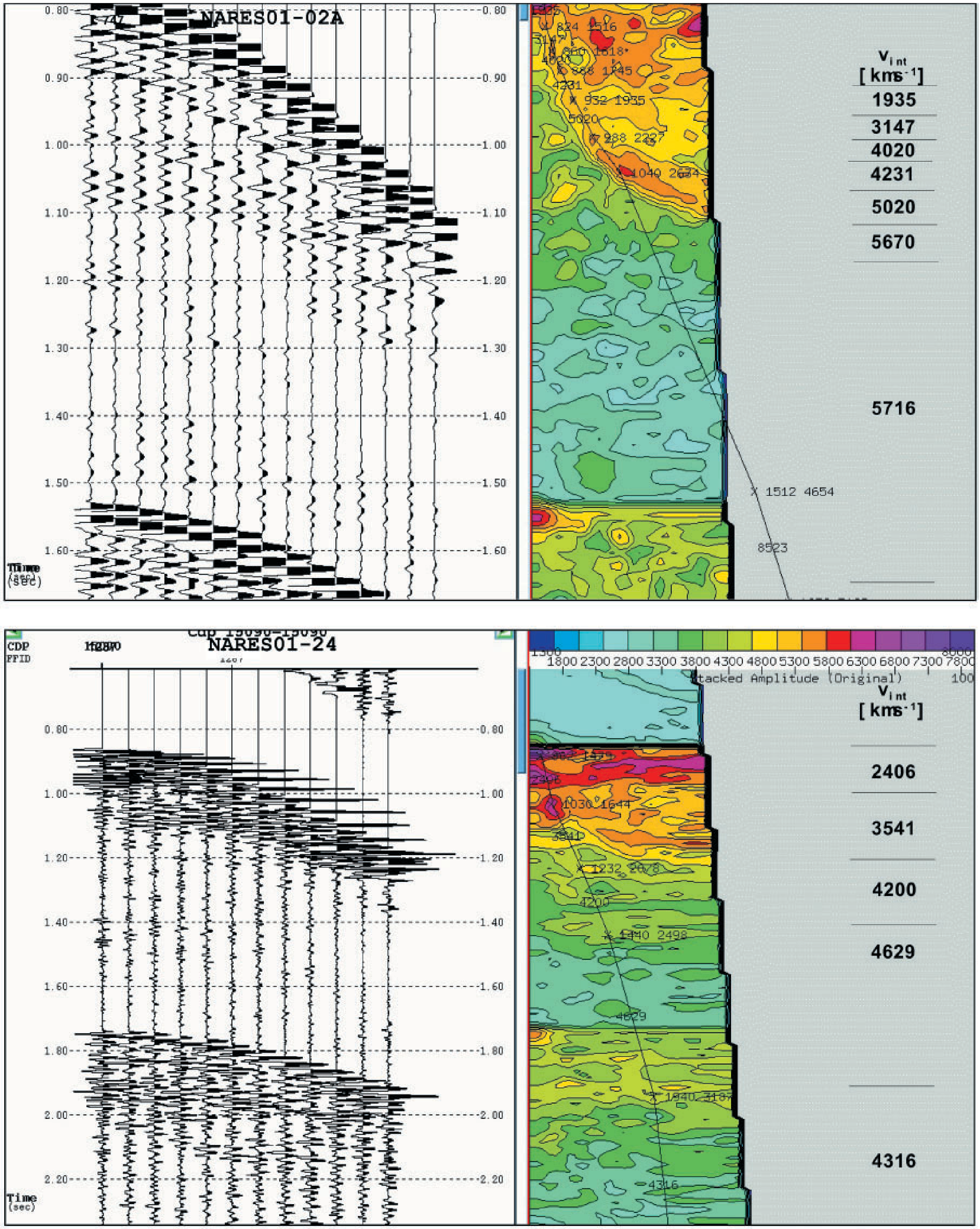


Fig. 10a: Examples of semblance velocity analysis from lines NARES 01-02A (SP 747) and NARES 01-24 (SP 1287). Both locations are from the inferred Late Cretaceous / Early Tertiary sedimentary basins. The uppermost sediments show rather low interval velocities between 1.9 and 2.4 km s^{-1} indicating younger deposits. For location see Figure 1b.

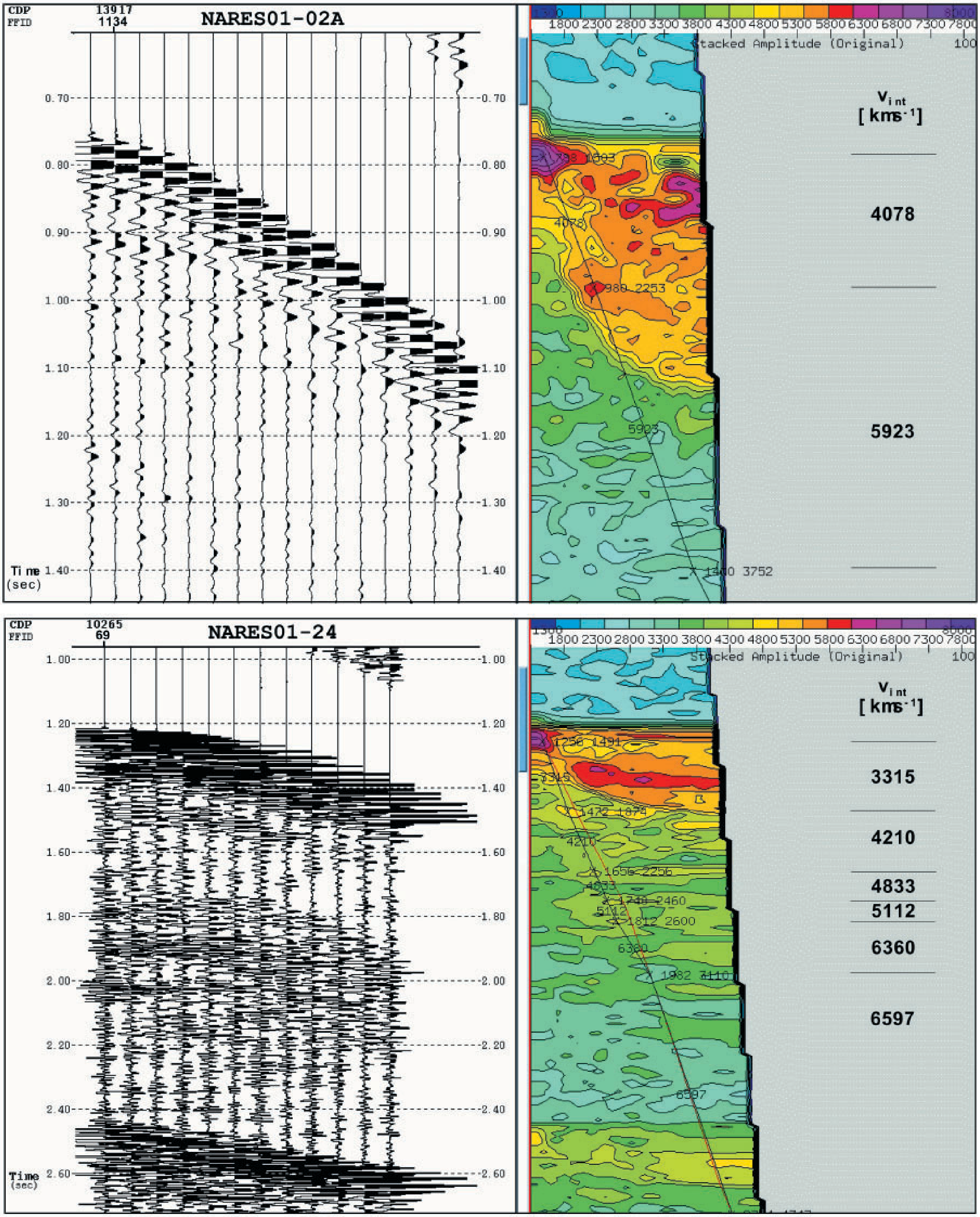


Fig. 10b: Examples of semblance velocity analysis from lines NARES 01-02A (SP 1134) and NARES 01-24 (SP 69). Both locations are from the inferred Thule Super Group. The uppermost interval velocity values are rather high between 3.3 and 4.0 km s-1. For location see Figure 1b.

Basin and Kiatak Basin are the reflection characteristics of the internal basin reflectors, the interval velocities derived from V_{rms}-velocities and the adjacent onshore geology. In the southern part where lines NARES 01-01, 01-22 and 01-30 form a transect the additional velocity information of the refraction/wide-angle data from line 3 can be used - although of less resolution for the upper part - to distinguish between the different crustal units.

In Figure 10a two examples of semblance velocity analysis are shown from the Northwater Basin (line NARES 01-02A) and the Kiatak Basin (line NARES 01-24). The analysis yields values between 1.9 and 2.4 km s^{-1} for the uppermost sequences in the basins. This indicates younger material of a low degree of compaction/diagenesis. In contrast to this the analysis in the areas of the inferred Thule Super Group yield considerably higher interval velocity values. In Fig. 10b two examples of semblance velocity analysis from these areas are shown. For the basement high on line NARES 01-02A (upper panel) high interval velocities (v_p ~4 km s^{-1}) were estimated directly below the sea floor indicating a very hard material. The derived interval velocities for the area between Northumberland Island and the Greenland coast (lines NARES 01-23 and 01-24) show values of ~3.5 km s^{-1} (Fig. 9b below) for the uppermost layers. The reflection characteristics differ as well: Low frequency reflectors characterize the eastern part (Northumberland Island), the area around Carey Islands and the northern part of line NARES 01-04 (inferred Dundas Formation) whereas higher frequency reflectors and fine stratified units are found in both the Northwater Basin and the Kiatak Basin. From these totally differing parameters we infer a much younger age for the Northwater Basin and the new found Kiatak Basin, i.e. Late Cretaceous to Early Tertiary.

TECTONIC INTERPRETATION

The analysis of ~780 km newly acquired MCS data from north of the Baffin Bay yielded important information about the tectonic evolution in the Nares Strait along the Wegener Fault. The largest part of the Northwater area is underlain by a few highs of Archean basement and overlying sediments of the Proterozoic Thule Super Group. On this basement, several small sedimentary basins are filled with low velocity sediments of most probably Cretaceous or Tertiary age. The basins differ fundamentally in direction, sedimentary infill and structural deformation. The North Water Basin has a clear N–S orientation, whereas the newly mapped Kiatak Basin and the Steensby Basin show a NW–SE direction. The Kiatak Basin is the deepest and the only one in which a seismic stratigraphic sequence could be worked out. The strata are steeply dipping and there is some evidence for inversion in the form of synclinal and anticlinal structures near the top. Offsetting faults in this basin are rare or absent on the investigated lines. The Steensby Basin is comparatively shallow and undeformed. Contrary to these NW–SE oriented basins, the Northwater Basin has a thinner sedimentary infill, but is affected by a fan-like system of steep, narrow-spaced faults.

If related to the Late Cretaceous to Paleocene transform movement on the Wegener Fault, the Northwater Basin appears to be a negative flower structure, follwing the main trend of the fault. The sediments filling of the basin would be slightly earlier or contemporaneous with the time of transform movement as derived from marine anomalies, i.e. Late Cretaceous to Paleocene.

The two other basins are oriented in the direction of least stress in the deformation ellipsoid (NW-SE). The folds and other compressive structures lie in the direction of maximum stress, all in relation to the main transform fault. However, the structures which are present in the seismic records of the Northwater and Kiatak Basins resemble those of the Sisimut and Nuussuaq Basins (Chalmers & Laursen 1995). These basins are situated at the Greenland continental shelf further to the South and were drilled (Rolle 1985). The major parts of the sedimentary units are of Middle/Late Cretaceous to Early Tertiary age. There, youngest deformed and eroded sediments are of Eocene age.

In detail we propose a four phase evolution of Kiatak and Steensby Basin which could best be determined from the seismostratigraphy in the Kiatak Basin.

- Phase 1: Pull-apart type opening of the basin (reflector BB) related to earliest rifting (ocean crust production) in the Labrador Sea.
- Phase 2: Deformation of the western part of the basin and uplifting of the sediments probably due to wrench tectonic (strike slip) as result of parallel spreading between America and Greenland in the Labrador Sea and Greenland and Eurasia in the Norwegian-Greenland Sea.
- Phase 3: Erosion of the deformed sediments because of sea level low-stand and cessation of rifting in the Labrador Sea.
- Phase 4: Renewed sedimentation (units younger than KT IV)

The relative thickness of basin sediments supports the assumption that basin formation in the Northwater area may have taken place a little later than in the Kiatak Basin.

ACKNOWLEDGMENTS

The 2001 Nares Strait Geoscientific Cruise was co-funded by the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Germany and the Geological Survey of Canada (GSC), Dartmouth, Canada. We are indebted to the master and crew of Canadian Coast Guard (CCG) icebreaker "Louis S. St. Laurent" for the help during the cruise. Intense discussions with K. Hinz and D. Franke helped to improve the interpretation. Helpful comments to the interpretation came from numerous colleagues from Canada (C. Harrison, R. Jackson) and Denmark (J. Chalmers, P. Dawes, Th. Funck, I. Reid).

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