Preliminary structural cross-sections across Fosheim Peninsula and Axel Heiberg Island, Arctic Archipelago

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Abstract

Partially balanced structure cross-sections have been drawn through the Eurekan orogen of west-central Ellesmere Island (Fosheim Peninsula) and central Axel Heiberg Island. Most of the horizontal shortening depicted in the cross-sections is taken up by slip along the Otto Fiord Formation detachment (evaporites); about 55 km (25-30%) of shortening occurs between Parrish Glacier Thrust and the hanging wall of the Stolz Fault Zone. A pair of ramps beneath Princess Margaret Range is inferred to explain the transfer of slip from an Ordovician detachment to the Otto Fiord detachment. The effect of Eurekan deformation on the lower Paleozoic Franklinian strata beneath Axel Heiberg Island and the northern half of Fosheim Peninsula is unknown.

Résumé

On a tracé des coupes structurals epartiellement équilibrées à travers l'orogène eurékien de la partie ouest-centrale de l'île Ellesmere (péninsule de Fosheim), et la partie centrale de l'île Axel Heiberg. La majeure partie du rétrécissement horizontal apparaissant dans les coupes de terrain est due à un glissement le long du décollement de la formation d'Otto Fiord (évaporites); on observe un rétrécissement d'environ 55 km (25-30 %) entre le charriage de Parrish Glacier et la lèvre supérieure de la zone faillée de Stolz. Pour expliquer la propagation du mouvement de glissement, à partir du décollement de strates ordoviciennes jusqu'au décollement des strates d'Otto Fiord, on a suggéré qu'il existait un couple de rampes au-dessous du chaînon Princess Margaret. On ignore l'effet de la déformation eurékienne sur les strates frankliniennes du Paléozoïque inférieure au-dessous de l'île Axel Heiberg et de la moitié nord de la péninsule de Fosheim.

INTRODUCTION

Complete analysis of sedimentary basins requires that the paleogeographic limits of depositional sites, facies and sediment source areas be palinspastically restored. Structural cross-sections have been constructed for Fosheim Peninsula, and from Fosheim Peninsula to west Axel Heiberg Island (Fig. 37.1), as part of an ongoing study of the evolution of the Eureka Sound Group basins. Upper Cretaceous and Paleogene strata of the Eureka Sound Group (Ricketts, 1986; Miall, 1986) represent the last phase of sedimentation in Sverdrup Basin and upon adjacent Franklinian bedrock. In a general way, Eureka Sound Group sedimentation can be viewed as taking place in two distinct phases: deposition of deltaic, shallow marine, estuarine and related facies prior to the principal tectonic events of the Eurekan Orogeny; and deposition in orogenic foredeeps during folding and thrusting, the main phase of deformation occurring from Middle to Late Eocene, possibly extending into the early part of the Oligocene (Ricketts and McIntyre, 1986). Thus, palinspastic reconstructions are a necessary prerequisite to establishing basin limits and changing sediment source areas during the different stages of foredeep evolution. The structural sections presented here (Figs. 37.2, 37.3) are a first attempt to solve

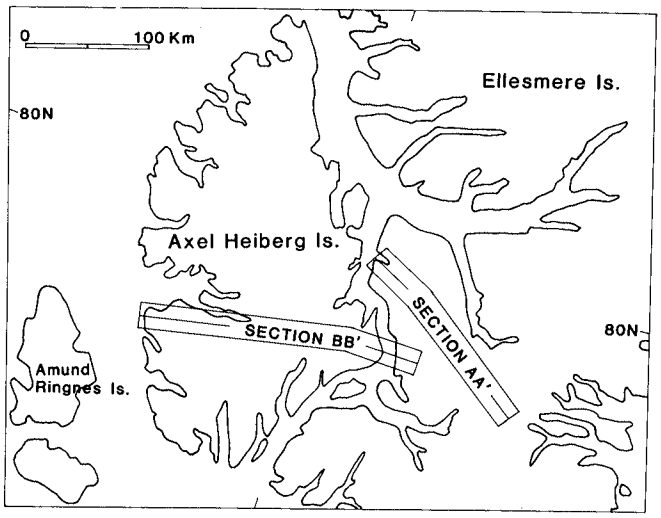


Figure 37.1. Index map of Ellesmere and Axel Heiberg islands showing locations of map strips and lines of section.

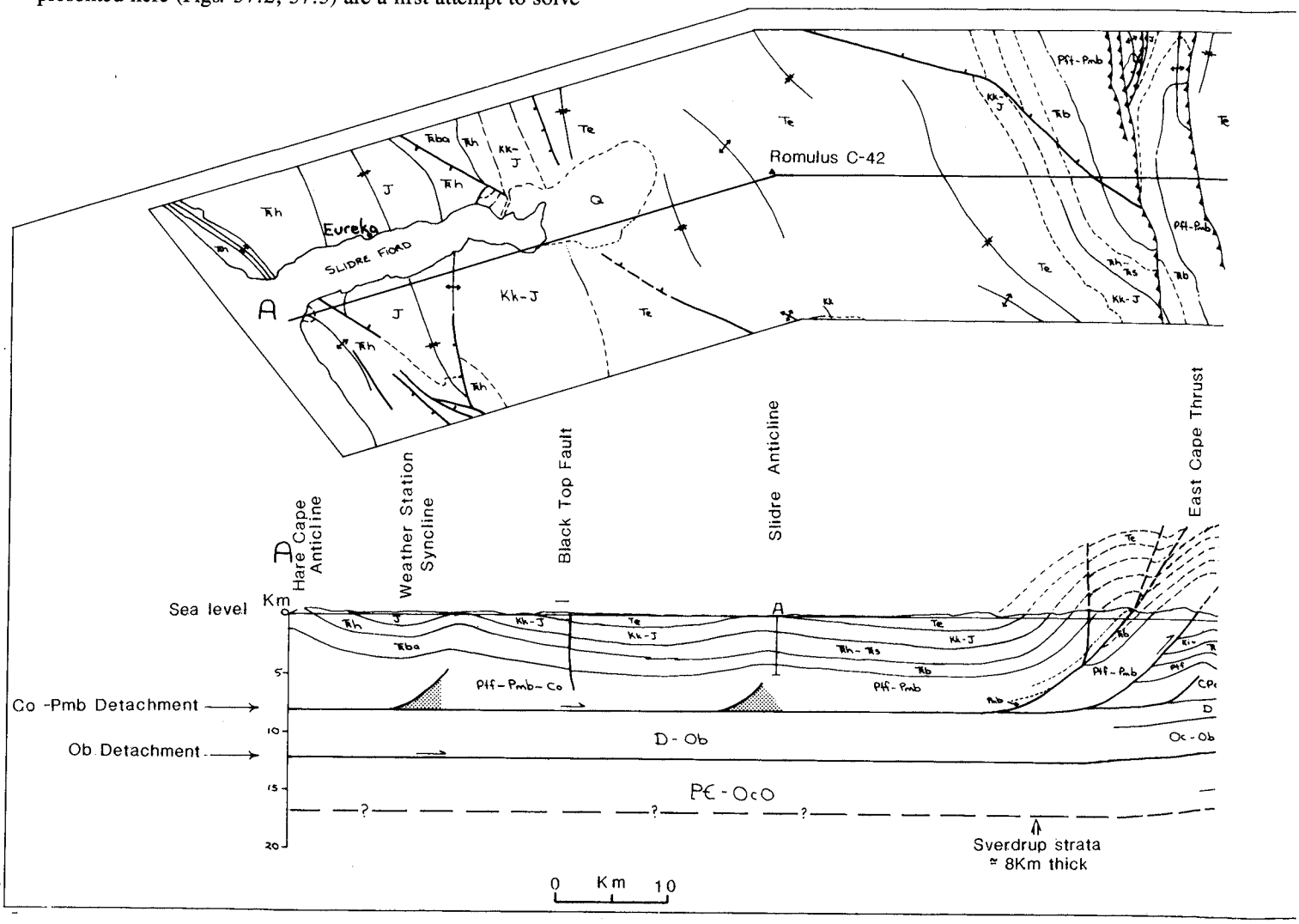
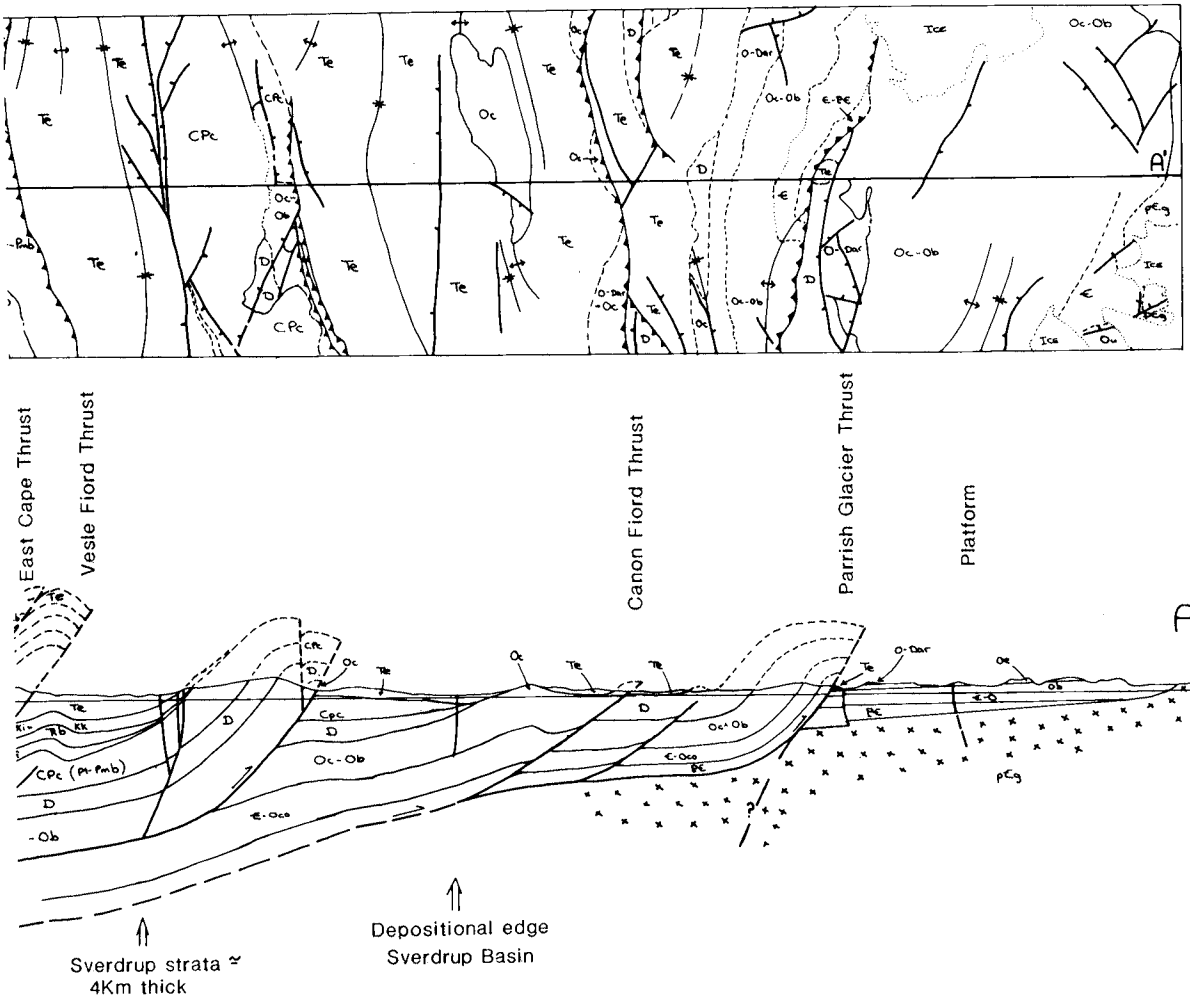


Figure 37.2. Structural cross-section AA' and geology of map strip through Fosheim Peninsula. Geology from Thorsteinsson (1971d; 1972a; 1972c); and unpublished data. Stippled pattern represents region of (Otto Fiord Formation) evaporite addition and doming, possibly associated with blind thrusts. However, the temporal relationship between thrusting and diapirism is uncertain. No vertical exaggeration in scale.

Stratigraphic designations are as follows:

Te	= Eureka Sound Group	D	= Devonian undivided
Kk-J	= Kanguk Fm. (Kk), Hassel Fm. (Kh), Christopher Fm. (Kc), Isachsen Fm. (Ki), Jurassic undivided (J)	O-Dar	= Ordovician to Lower Devonian undivided
		Oc-Ob	= Cornwallis Group to Baumann Fiord Fm.
		Oe	= Eleanor River Fm.
Trh-Trs	= Heiberg Fm. to Savik Fm.	ϵ-OcO	= Cambrian to Copes Bay Fm.
Trb-Trba	= Bjorne Fm. to Blaa Mountain Group	ϵ-Pϵ	= Cambrian to Upper Precambrian
Ptf-Pmb	= Trold Fiord Fm. to Mount Bayley Fm. (includes Assistance and Tanquary fms.)	Pϵ-OcO	= Upper Precambrian to Copes Bay Fm. undivided
CPc	= Upper Carboniferous to Permian undivided	Pϵ-g	= Gneissic basement



some of these problems, and provide a starting point for regional interpretations. Conclusions regarding structural style, structural shortening and levels of detachment for example, are likely to change as new studies are undertaken.

ACKNOWLEDGMENTS

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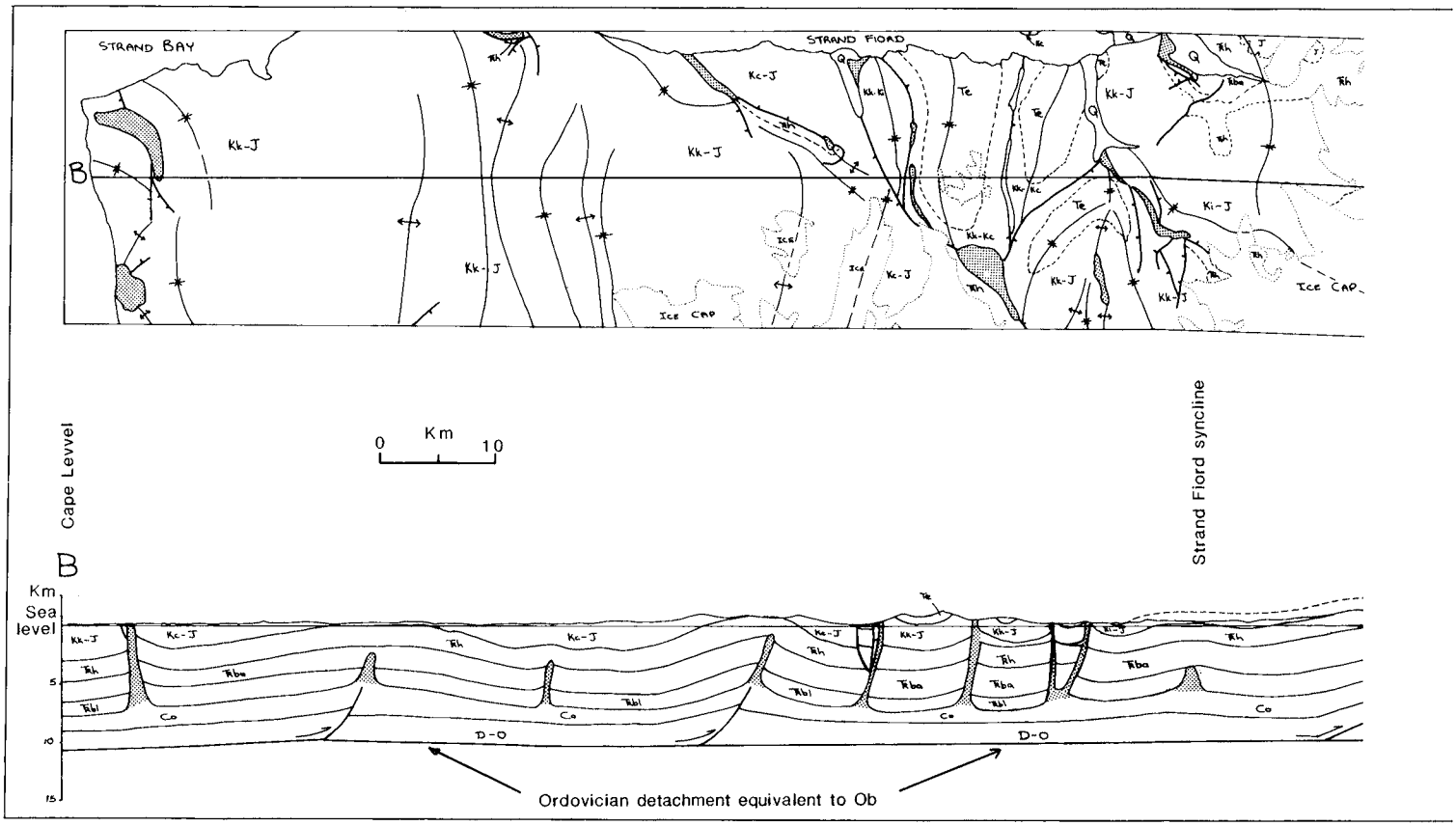
CONSTRAINTS

The lower Paleozoic platform and Precambrian basement southeast of Parrish Glacier Thrust are regarded as fixed relative to the thrust and fold belt in section AA' (through Fosheim Peninsula, Figure 37.2). Although Precambrian gneisses are exposed between Bache Peninsula and Bay Fiord, the depth to this basement elsewhere on Fosheim Peninsula and Axel Heiberg Island is unknown. Furthermore, the thickness of lower Paleozoic strata west and northwest of Vesle Fiord Thrust is also unknown.

Only some of the Ellesmerian structures in the Franklinian rocks have been included in section AA'; the most obvious example is the broad, antiformal structure immediately northwest of Canon Fiord Thrust, where Eureka Sound strata (Expedition Formation – in this area mostly Lower Paleocene, possibly as old as Maastrichtian) overlap eroded Cornwallis Group rocks (Ordovician). Furthermore, Ellesmerian folds (and possibly faults) in Devonian and Ordovician strata probably occur in the footwall of the Canon Fiord thrust and also are overlain by the Eureka Sound Group. Some of the Eurekan thrusts may represent reactivated Ellesmerian faults. For example, "A" Canon Fiord Thrust (Fig. 37.2) is an Ellesmerian structure which placed Ordovician Cornwallis Group on Devonian strata. It was rejuvinated during the Eurekan Orogeny, thrusting Ordovician strata over Tertiary. For the purpose of calculating shortening in the Franklinian rocks resulting from Eurekan deformation, only those structures between Parrish Glacier and Vesle Fiord thrusts have been taken into account (Fig. 37.2). Elsewhere in the two sections, the effect of Eurekan deformation on lower Paleozoic rocks is unknown.

Most of the shortening occurs as a result of thrusts and associated folds. Doming of Sverdrup Basin strata because of salt intrusion is known to have taken place sporadically since the Late Carboniferous (Balkwill, 1978). Several of the anticlinal structures on western Ellesmere and central Axel Heiberg islands are cored by evaporites (Otto Fiord Formation); for example, the Mokka Fiord, Depot Point and Fosheim anticlines. Jackson and Halls (1985) have demonstrated, in the case of Mokka Fiord, that doming occurred prior to the



main phase of Eurekan deformation. However, for the purpose of this investigation, the amount of horizontal shortening is not considered to be great. In fact, some extension might be expected where the diapirs have breached the anticlines.

DISCUSSION

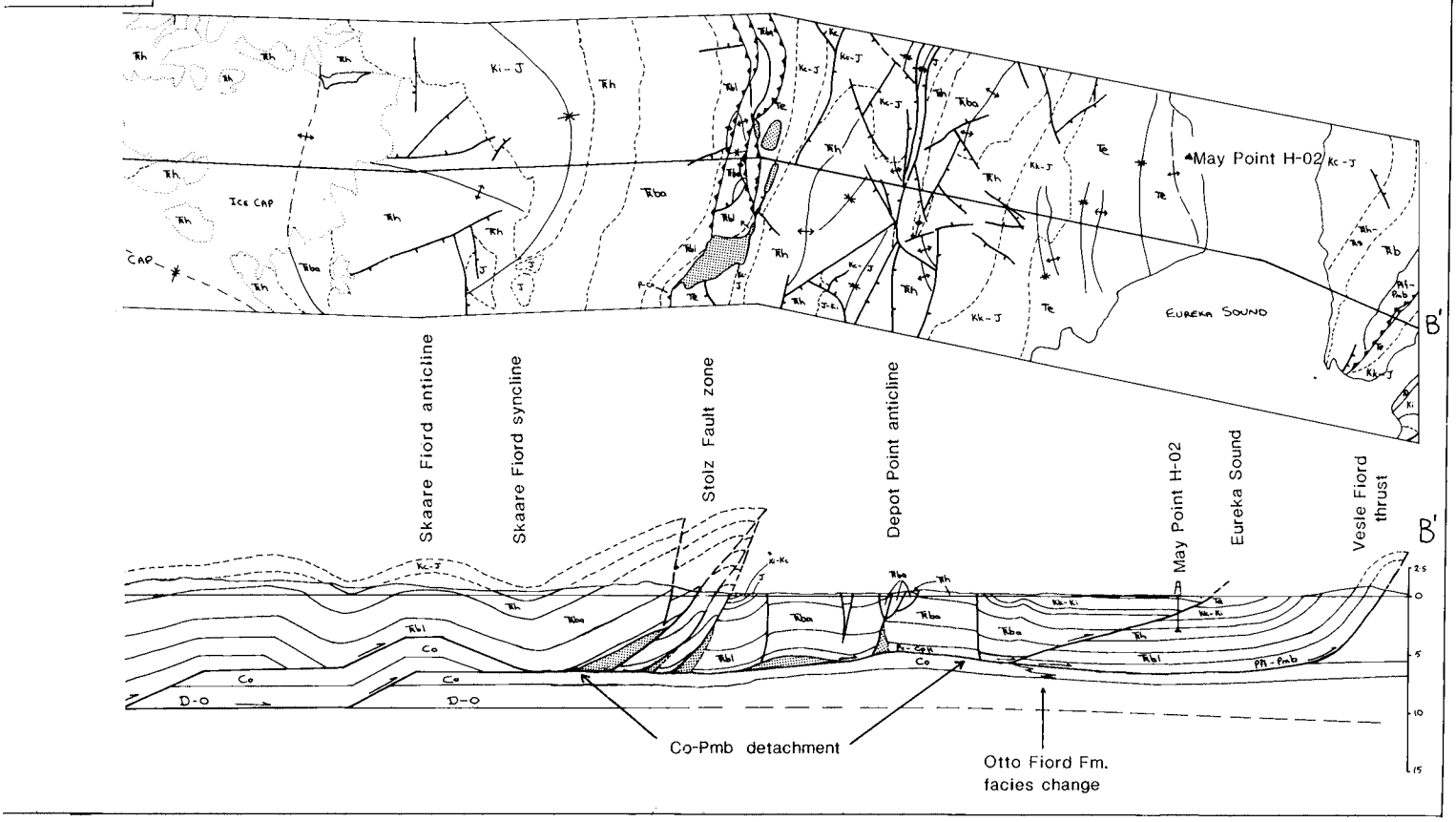
The sections have been constructed showing three levels of detachment.

1. A basement detachment exposes Upper Precambrian-Cambrian strata in the hanging wall of the Parrish Glacier Thrust. The thrust surfaces approximately at the lower Paleozoic platform – shelf margin (Trettin and Balkwill, 1979), and may reflect reactivation of an older basement structure. There appears to be a considerable change in stratigraphic thickness in the lower Paleozoic sequence across this fault. The depth to basement along Fosheim Peninsula, assuming constant thickness of lower Paleozoic and upper Precambrian strata, is about 15 to 18 km, and corresponds reasonably well to depths calculated along a transect through Devon and Ringnes islands on the basis of geophysical parameters (Sobczak et al., 1986).
2. A major detachment occurs in the Lower Ordovician Baumann Fiord Formation evaporites, and is found locally in the hanging wall of an unnamed thrust between Canon Fiord and Vesle Fiord thrusts, as well as in the Canon Fiord Thrust. Beneath western Axel Heiberg Island, this detachment is assumed to occur in stratigraphically equivalent basin shale (Fig. 37.3).

Figure 37.3. Structural cross-section BB' and geology of map strip from Vesle Fiord Thrust, due west across central Axel Heiberg Island. Geology from Thorsteinsson (1971a; 1971b; 1971c; 1972a; 1972b; 1972c); van Berkel et al. (1984); unpublished data. Stippled areas represent Otto Fiord evaporites that have been added to the section as diapirs or domal thickenings. No vertical exaggeration in scale.

Stratigraphic designations are as follows:

Te	= Eureka Sound Group	Trba	= Blaa Mountain Group
Kk-J	= Kanguk Fm. (Kk), Hassel Fm. (Kh), Christopher Fm. (Kc), Isachsen Fm. (Ki), Jurassic undivided (J)	Trbl	= Blind Fiord Fm.
		Ptf-Pmb	= Trold Fiord Fm. to Mount Bayley Fm.
Trh	= Heiberg Fm.	Co	= Otto Fiord Fm.
		D-O	= Devonian to Ordovician undivided



3. The third and uppermost detachment is here drawn at the contact between the Lower Triassic Blind Fiord Formation and Upper Carboniferous Otto Fiord evaporites. Most of the shortening illustrated in Figures 37.2 and 37.3 takes place along this detachment. At its eastern limit near Vesle Fiord Thrust, this detachment occurs in the slightly younger Mount Bayley Formation (Lower Permian). A facies change occurs in the Carboniferous strata approximately between Depot Point anticline and May Point (section BB'), where Otto Fiord evaporites grade into nonevaporitic rocks (see Nassichuk and Davies, 1980, Figure 11). At section BB, slip along the detachment is transferred to the Lower Permian Mount Bayley Formation, which occurs locally in the hanging wall of Vesle Fiord Thrust.

In considering the transfer of slip from the Otto Fiord to the Ordovician detachment beneath Axel Heiberg Island, two possible scenarios are suggested. In the first, the upper detachment (Co = Otto Fiord evaporites) continues west of Axel Heiberg Island with a ramp to the Ordovician detachment (above D-0) located somewhere offshore. The alternative scenario, depicted in Figure 37.3, shows a pair of ramps beneath the Princess Margaret Range, coinciding with an anticline – syncline fold pair in the hanging wall of the Stolz Fault Zone. One problem with this explanation is the possible requirement for a lateral ramp from the Otto Fiord detachment to the Ordovician detachment between sections AA' and BB'.

SHORTENING

The sections have been balanced only to the upper (Otto Fiord) detachment level by comparing lengths of units (the top of the Blind Fiord Formation was used here). The volume of evaporite in the Otto Fiord Formation cannot be assumed to be constant because of salt withdrawal from some areas and addition to halokinetic structures in others. The temporal relationship between thrusting and diapirism remains uncertain. Most of the Sverdrup Basin strata also thin along the lines of section, from the basin depocentre near Strand Fiord to the basin margin east of Vesle Fiord Thrust (see Figure 37.2). Particularly noticeable is the rapid thinning of units like the Blaa Mountain Formation and Blind Fiord Formation east of the Stolz Fault Zone in Figure 37.3 (BB'), and east of Vesle Fiord Thrust in Figure 37.2 (AA').

Shortening along the Ordovician detachment and basal detachment between Vesle Fiord Thrust and the Franklinian platform is about 14.5 km. Elsewhere along these surfaces, the amount of shortening due to Eurekan deformation is unknown. About 10 km (40%) of shortening has taken place at Stolz Fault Zone. The total amount of shortening between the Paleozoic platform and the hanging wall of Stolz Thrust is about 55 km, or 30 per cent. Vergence is to the east and southeast, that is, toward the craton. Between 25 and 50 per cent shortening was estimated by Okulitch (1982) for sections constructed along southern Ellesmere Island, although this value includes both Ellesmerian and Eurekan structures.

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