The Keisarhjelmen detachment records Silurian-Devonian extensional collapse in Northern Svalbard by A. Braathen, P.T. Osmundsen, H. Maher and M. Ganerød

Comment by Winfried Dallmann[1] and Karsten Piepjohn[2]

[1] Institute of Geosciences, UiT The Arctic University of Norway, P.O.B. 6050 Langnes, NO-9037 Tromsø, Norway
[2] Federal Institue for Geosciences and Natural Resources, Stilleweg 2, DE-30655 Hannover, Germany

The discussed area has been investigated since the 1960s. Scientists of the Norwegian Polar Institute, the Cambridge scholar environment, the University of Münster and others have mapped, described, interpreted and contributed to the discussion through decades. Very little of this is reflected in the paper by Braathen et al. (2017). A discussion of previous models is absent.

We appreciate the introduction of a new model inspired by the authors' knowledge of Devonian basins in southern Norway and other places. It may certainly contribute new aspects. We react, however, to the way these new aspects are presented, claiming to fundamentally replace earlier models, without a thorough documentation and without discussing the wealth of previously available data.

Here, we would like to point out some key issues.

Stratigraphy and timing

There seems to be some confusion about the stratigraphy, which has led to the assumption of a very long activity period of the detachment. All strata overlying the postulated detachment (Siktefjellet and Red Bay groups) are of ?latest Silurian to Lochkovian age. The Andrée Land Group in the eastward adjacent Andrée Land Basin starts in the Pragian and is confined to the Pragian in near-by areas (Kapp Kjeldsen unit; Murašov and Mokin 1979).

Earlier work attributes major sinistral strike-slip only to the latest Silurian and Lochkovian development of the Siktefjellet and Red Bay groups, not the entire Old Red of Svalbard (e.g. Gee 1972; Friend et al. 1997).

There is a major angular unconformity between the Siktefjellet and Red Bay groups (Gee and Moody Stuart 1966), which demands a major tectonic readjustment at that time (Haakonian Phase; Gee 1972).

The sedimentary transport direction in the Red Bay Group is generally from south to north, however, there has not been documented primary thinning of individual formations. To postulate a supradetachment basin, the existence of growth faults, or faults fading out in younger strata should be documented.

The base of the Devonian is a depositional, angular unconformity in many areas, also south of Liefdefjorden (Fig. 1). In many places, the basal Devonian overlies a weathered paleo-karst surface developed in the Mesoproterozoic marbles (Piepjohn 1997), which possibly might be confused with a brittle fault contact.

Faults and geological boundaries

Figure 4a in Braathen et al. (2017) shows the mountains Litoppen and Gneisfjellet looking towards SW from Flyvengen (location should be indicated). The outline on the western side (right) shows the position of the postulated detachment, while on the eastern side (left) it shows a lithological boundary within the Bockfjorden Anticline. The actual boundary with the Devonian is situated in the

straight ravine to the east (left) of it and is a down-to east normal fault (Dallmann et al. 2005), which defines most of the boundary between the Bockfjorden Anticline and the Devonian strata to the east (Fig. 1).

It cannot be observed that any of the E-W trending faults defining the rotated extensional blocks root in an underlying detachment. Some of the faults could be interpreted as such. However, not only one but many of them cut through the postulated detachment and displace the basement to the west. Some of them even cut through the Bockfjorden Anticline (Fig. 1). These observations suggest at least a major post-detachment reactivation of the entire fault system, which has been ascribed to sinistral strike-slip during the Monacobreen Phase (Lochkovian/Pragian; McCann 2000). Fig. 3 in Braathen et al. (2017) is highly interpretative; many important structures are omitted.

The Bockfjorden Anticline does not dip below a detached hangingwall north of Liefdefjorden; it is bounded by the steep Hannabreen Fault against another basement terrane, the Biscayarhuken Terrane. The Hannabreen Fault is interpreted as a strike-slip dominated fault during the Haakonian Phase (lower Lochkovian; Gee 1972).

The detachment

The migmatitic unit in the core of the anticline is separated by a ductile, mylonitic thrust zone (so far assigned to Caledonian age) from the overlying Mesoproterozoic metasediments (Piepjohn and Thiedig 1995). During several long field seasons, we have not seen any transition from those mylonites into the brittle faults that locally occur between basement and Devonian.

N-S trending lineations occur in the mylonites, but also in other Caledonian deformed rocks, e.g. in the Biscayarhuken Terrane and even far east in Ny-Friesland. They could have a Caledonian age.

The observation of consistent sinistral shear in the east, dextral shear in the west and dip-slip, top-north shear on top of the anticline is a crucial statement that needs proper documentation.

Conclusion

We do not reject the basic idea of an extensional detachment, which is responsible for the formation of a core complex (Bockfjorden Anticline). However, much better documentation is needed. The possible detachment should be limited to latest Silurian – Lochkovian. It has interacted with other movements and is overprinted by younger structures. To our opinion, the detachment model does not – like claimed – fundamentally replace earlier interpretations, but may modify and refine them.

References

Braathen, A., Osmundsen, P.T., Maher, H. and Ganerød, M. (2017). The Keisarhjelmen detachment records Silurian-Devonian extensional collapse in Northern Svalbard. *Terra Nova*, 2017, 1-6. DOI: 10.1111/ter.12305

Dallmann, W. K., Piepjohn, K., McCann, A. J., Sirotkin, A. N., Ohta, Y. and Gjelsvik, T. 2005a. Geological map of Svalbard 1:100,000, sheet B5G Woodfjorden. *Norsk Polarinstitutt Temakart*, 37, Tromsø.

Dallmann, W. K. (ed.), 2015. Geoscience Atlas of Svalbard. *Norwegian Polar Institute Report Series*, 148. Norwegian Polar Institute, Tromsø. 292 pp.

Friend, P. F., Harland W. B., Rogers, D., Snape, I. and Thornley, S. 1997. Late Silurian and Early Devonian stratigraphy and probable strike-slip tectonics in Northwestern Spitsbergen. *Geological Magazine*, 134, 459-479.

Gee, D. G., 1972. Late Caledonian (Haakonian) movements in northern Spitsbergen. *Norsk Polarinstitutt Årbok*, 1970, 92-101, Oslo.

Gee, D. G. and Moody-Stuart, M. 1966. The base of the Old Red Sandstone in central north Haakon VII Land, Vestspitsbergen. *Norsk Polarinstitutt Årbok*, 1964, 57-68, Oslo.

McCann, A. J. 2000. Deformation of the Old Red Sandstone of NW Spitsbergen; links to the Ellesmerian and Caledonian orogenies. In: New Perspectives on the Old Red Sandstone (Friend, P. F. and Williams, B. P. J., eds.) *Geological Society, London, Special Publications*, 180, 567-584.

Murašov, L. G. and Mokin, J. I. 1979. Stratigraphic subdivision of the Devonian deposits of Spitsbergen. *Norsk Polarinstitutt Skrifter*, 167, 249-261; Oslo.

Piepjohn, K., 1997. Erläuterungen zur Geologischen Karte 1:150.000 des Woodfjorden-Gebietes (Haakon VII Kand, Andrée Land), NW-Spitzbergen, Svalbard. *Münstersche Forschungen zur Geologie und Paläontologie*, 82, 15-37.

Piepjohn, K. and Thiedig, F., 1995. Tektonische Entwicklung des kristallinen Basements im Liefdefjorden-Gebiet, NW-Svalbard. *Münstersche Forschungen zur Geologie und Paläontologie*, 77, 1-25.

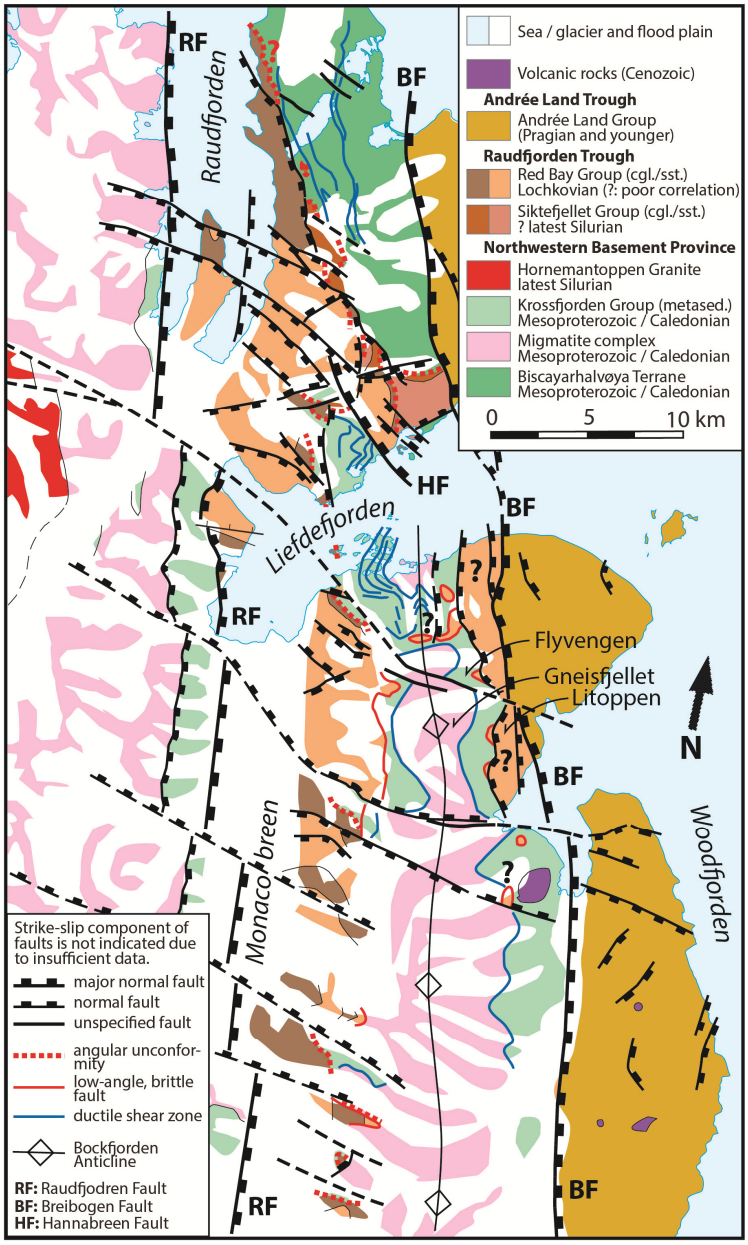

Figure 1: Geological map of the area around the Red Bay Trough generalized from the Norwegian Polar Institute's map sheets (Dallmann 2015), with some key issues of the present discussion outlined.