Supplementary material for: Koehl J.-B. P. & Allaart L. 2021. The Billefjorden Fault Zone north of Spitsbergen: a major terrane boundary? *Polar Research 40*. Correspondence: Jean-Baptiste P. Koehl, Centre for Earth Evolution and Dynamics, University of Oslo, PO Box 1028 Blindern, NO-0315 Oslo, Norway. E-mail: jean-baptiste.koehl@uit.no.

Expected seismic character of the Billefjorden Fault Zone north of Wijdefjorden

This supplement is dedicated to discussing seismic evidence expected in the study area (north of Wijdefjorden) should the Billefjorden Fault Zone continue north of Wijdefjorden. Several reactivation scenarios are considered.

If the Billefjorden Fault Zone formed as an east-dipping Ellesmerian thrust and was not reactivated (e.g., Harland et al. 1974), the fault would create a moderately to steeply east-dipping zone of contact between relatively dense basement rocks of the Atomfjella Antiform and less dense Devonian sedimentary rocks, with basement rocks thrust over Devonian sedimentary strata. This would result in a major, east-dipping negative seismic reflection (trough) north of the mouth of Wijdefjorden. Major seismic reflections north of Spitsbergen dip gently to the west (Fig. 3, **Fel! Hittar inte referenskälla.**Supplementary Figs. S1, S2).

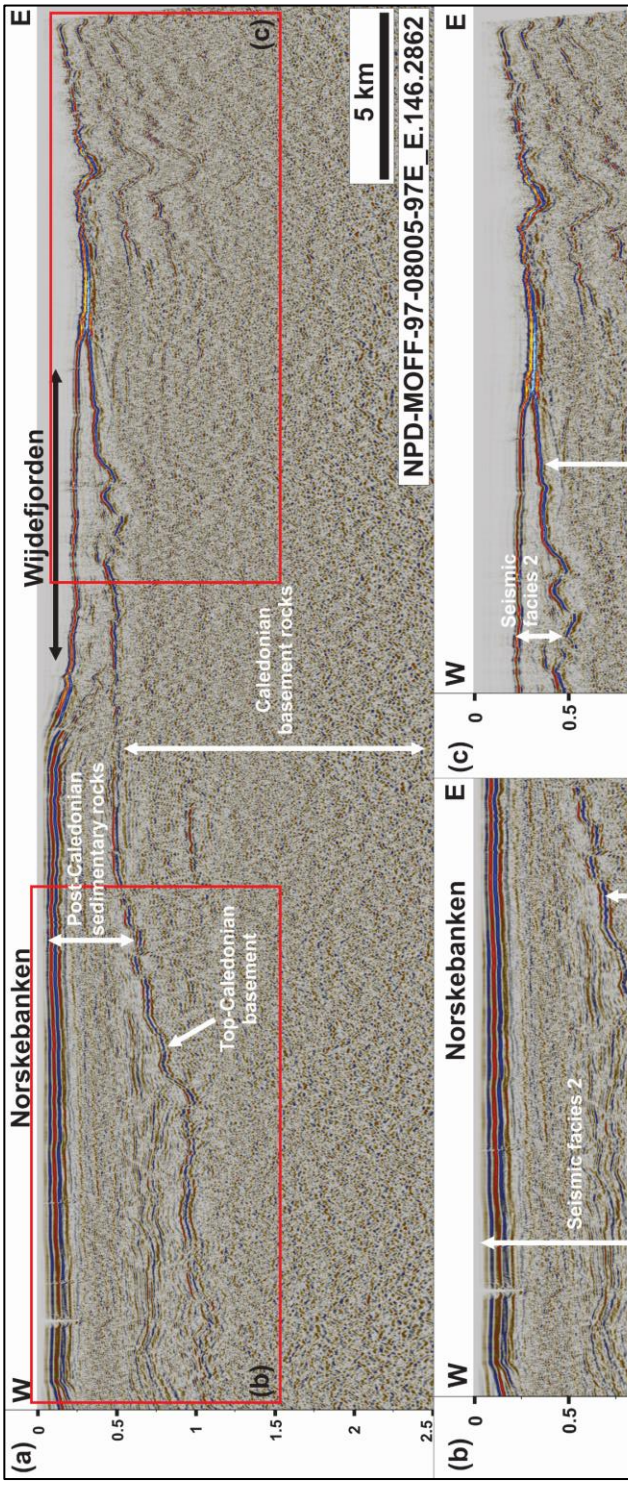
If the Billefjorden Fault Zone formed as a high-angle, west-dipping, normal fault bounding the Devonian Graben (e.g., Manby & Lyberis 1992), the fault would have downthrown Devonian sedimentary rocks to the west and represent a major disruption surface below the seafloor, juxtaposing eastwards-thickening Devonian sedimentary rocks against denser basement rocks of the Atomfjella Antiform. The expected result would be a major moderately to steeply west-dipping disruption surface, possibly associated to a positive seismic reflection (peak). Instead, the top-basement reflection north of Spitsbergen gently deepens westwards and, conversely, Devonian sedimentary rocks thicken westwards (Fig. 3, Supplementary Figs. S1, S2).

If the Billefjorden Fault Zone had been reactivated as an east-dipping Carboniferous normal fault (e.g., Braathen et al. 2011), the fault would have downthrown (Devonian–Carboniferous) sedimentary rocks to the east, thus generating abrupt depth variations for the top-basement reflection. This is not the case. Instead, the top-basement reflection north of Wijdefjorden deepens gently westwards, showing gentle up and down bending interpreted as post-Caledonian folds (Fig. 3, Supplementary Figs. S1, S2).

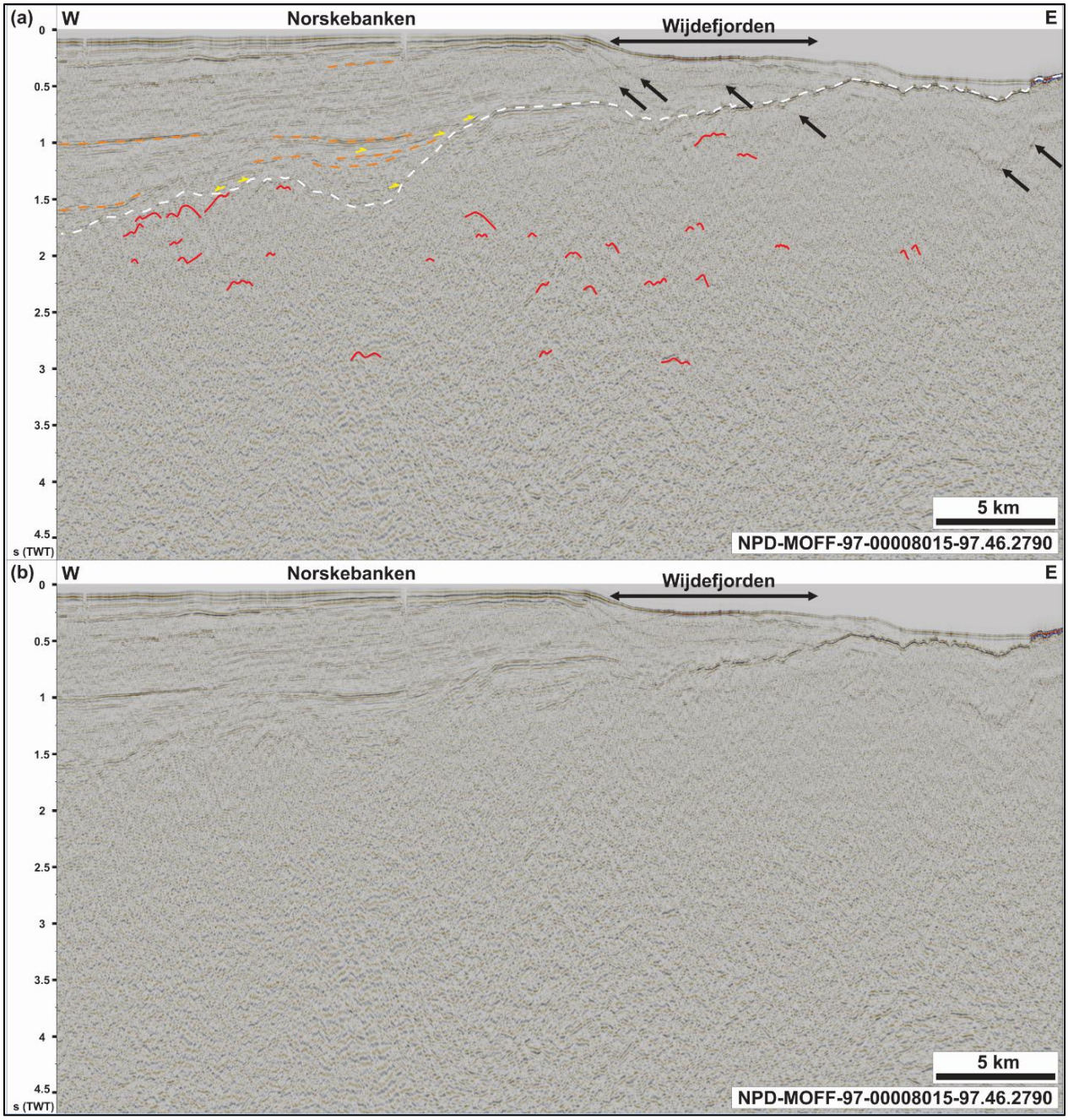
If the Billefjorden Fault Zone had been reactivated as a top-west Eurekan thrust (Major & Nagy 1972), the fault would be associated to a major seismic trough because it would juxtapose relatively denser, shallow basement rocks of the Atomfjella Antiform over less dense sedimentary rocks. This is not the case either (Fig. 3, Supplementary Figs. S1, S2).

Based on previous field studies in central Spitsbergen, the estimated thickness of Devonian sedimentary rocks in the footwall of the Billefjorden Fault Zone ranges from a few hundred metres to ca. 9 km (Murascov & Mokin 1979; Friend et al. 1997; Piepjohn & Dallmann 2014). Using an averaged seismic velocity of 5.65 km/s for Devonian rocks (Gernigon et al. 2018), expected offset of the top-basement reflection across the Billefjorden Fault Zone in northern

Spitsbergen (if it is present) should be of 0.2 to 3.2 seconds (TWT). There is no such offset on the presented seismic data (Fig. 3, Supplementary Figs. S1, S2).



Supplementary Fig. S1: Uninterpreted version of Fig. 3.



Supplementary Fig. S2: Supplementary east–west-trending seismic section north of Wijdefjorden. See Fig. 2 for location and Fig. 3 for symbols and explanations.

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