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Modelling heat budget and heat transfer in supra-detachment basins: example from the Solund Devonian basin of western Norway

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The continental Devonian basins of western Norway were formed in the hangingwall of the large scale extensional Nordfjord Sogn Detachment. This detachment postdates the main contraction stage of the Caledonian orogeny in Scandinavia and was mainly active in the Lower to Middle Devonian. The thermo-chronological development of the footwall of the Nordfjord Sogn Detachment Zone (NSDZ) has been the focus of many studies that have argued for a rapid denudation and exhumation of the Caledonian root, eventually leading to the exposure of the (U)HP rocks in the Western Gneiss Region. However, the prograde low-grade metamorphism imprinted on the adjacent Devonian basins during the post-orogenic extension has received much less consideration.

The Solund basin is the second largest of the Devonian basins along the west coast of Norway and is dominated by coarse conglomerates with subordinate sandstones indicative of rapid and immature sedimentation processes. The western and basal parts of the basin rest with depositional unconformity on the Caledonian nappes, whereas the southeastern margin of the basin is in direct contact with the ductile extensional mylonites formed in the upper parts of the NSDZ.
The sediments of Solund expose a low-greenschist facies metamorphism with an estimated temperature of approximately 300˚C and represent the deepest burial level ($\geq$10 km) of all the Devonian basins of the area, suggesting a relatively high regional geotherm during the burial of the sediments. In addition to the regional low-grade metamorphism in the basin, we observe important and locally very intense fracture-related net-veining within the sediments with an increasing frequency toward the contact with the detachment mylonites. These veins are probably reflecting the fluid activity at a relatively deep level in the basin during metamorphic conditions.

In this study, we developed a set of 2D FEM models to investigate the different heat processes contributing to the thermal state of sedimentary basins formed above major crustal detachments. We modelled the large-scale effect of the shear heating caused by the localized ductile deformation in the mylonitic shear zone of the NSDZ. We argue that this process may increase the temperature at the base of the Solund basin by 50˚C and contribute to the high geotherm observed in the area. We consider the fluid flow processes with two approaches: (1) with a continuum porous flow model where we assess the critical conditions necessary for natural convection to develop at the basin scale, and (2) with a discrete fracture network to model the heat transfer caused by the intense net-veining at the vicinity of the detachment.