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Tectonic basement slices in the décollement of the Scandinavian Caledonides: transition from thin-skinned to thick-skinned tectonics in collisional orogens

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The Scandinavian Caledonides are characterized by predominantly thin-skinned tectonics in the foreland fold-and-thrust belt and thick-skinned deformation in the hinterland nappe stack. A sequence of laterally extensive Cambrian to Ordovician (meta)pelites (known as phyllites) makes up the primary décollement throughout the orogen. Similar spatial changes in tectonic style is known from many orogens, and several mechanisms have been suggested to explain this first order observation, including changes in décollement thickness and strength, and reactivation of old basement structures. In any case, critical to the formation of thin-skinned thrusting is the presence of a mechanically weak décollement layer. The question in place is: if the décollement is laterally extensive and mechanically weak, as it is in the Scandinavian Caledonides, why does deformation at some point (in time and space) localize into the underlying basement?

We present new structural and geochronological (U–Pb and Ar/Ar) results from the Caledonian nappes in Stavanger, southwesternmost Norway, that provide new constraints on the transition from thin- to thick-skinned tectonics. In the Lower Allochthon Buadalen Nappe, the décollement phyllites contain some 1 to 50 m thick layers of mylonitic granitic gneiss interpreted as tectonic slices derived from the Baltica basement. The tectonic basement slices carry a well-developed sub-horizontal NW–SE mineral lineation and abundant field kinematic indicators consistently showing overall top-to-the SE thrusting, identical to the general Caledonian transport direction. Preliminary microstructural work confirms top-to-the SE sense of shear and indicates medium-grade deformation conditions with dynamical recrystallization of quartz primarily by sub-grain rotation. The overlying Middle Allochthon Storheia Nappe consists of granitic gneiss corresponding in age and chemistry to both the tectonic basement slices and the Baltica basement. Mylonites developed within these rocks display SE–NW trending mineral lineations, top-to-the SE kinematic indicators and medium-grade conditions, identical to that observed in the underlying tectonic basement slices.

The results show that deformation localized into the basement during Caledonian shortening and caused the imbrication of tectonic slices into the overlying décollement. Similar tectonic basement slices can be found at several places along a zone extending northeastwards from Stavanger, roughly parallel to the Caledonian orogenic front. Based on this, we speculate that the transition from thin-skinned to thick-skinned tectonics, as observed in the Scandinavian Caledonides, is a function of increasing temperature at the décollement level, causing the transition from predominantly frictional slip in the thin-skinned foreland to predominantly viscous creep towards the hinterland. Thus, the high contrast in mechanical strength that may exist between the décollement and the basement in the brittle deformational field is gradually reduced and eventually cancelled out as crystal-plastic deformation become dominant.