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Constraints on strain rates during large-scale mid-crustal shearing: An example from the basal Vaddas shear zone, northern Caledonides

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The Caledonian orogen in Scandinavia is characterized by large-scale crustal nappe stacks which were emplaced east-/southeast-wards onto the Baltica shield. Whereas original thrust relationships are generally obscured by syn- to post-collisional extensional deformation in the southern and central Scandinavian Caledonides, several large-scale thrust systems are well-preserved in the northern Scandinavian Caledonides in Troms and Finnmark. One example is the mid-crustal Vaddas shear zone, which emplaced the Vaddas nappe on top of the Kalak nappe complex. In this contribution we present a structural, petrological and geochronological analysis of the rocks under- and overlying the Vaddas shear zone in northern Troms, in order to estimate the strain rate associated with thrusting along this major shear zone.

The Vaddas nappe above the investigated shear zone consists mainly of Upper Ordovician to Silurian metasediments, which were deposited in a marine environment and which were intruded by voluminous gabbroic intrusions, before they were sheared off from their substratum and transported on top of the Kalak nappe complex during the Caledonian orogeny. *PT* conditions from one of these gabbroic bodies indicate that the body intruded the metasediments at ∼9 kbar (Getsinger et al., subm to G3), which corresponds to a depth of ∼34 km. U-Pb SIMS dating of zircons from this gabbro indicate that intrusion occurred at 439±2 Ma. The Vaddas nappe is separated from the Kalak nappe by an at least ∼150 m thick, amphibolite-facies shear zone with a subhorizontal fabric and top-to-the-SE shear sense. It has developed within the lowest part of the Vaddas nappe as well as the upper part of the Kalak nappe complex and *PT* calculations indicate that final shearing occurred at ∼450°C and ∼6 kbar (depth of ∼23 km). U-Pb TIMS dating of titanites, which grow parallel to the shear fabric in the Kalak nappe complex, gives ^{206}Pb/^{238}U ages ranging from 442±1 to 429±1 Ma, indicating that shearing probably commenced right after intrusion of the Vaddas gabbros and continued over a period of ∼10 m.y.

Assuming an original dip of the Vaddas shear zone of 30°, the horizontal displacement would be ∼23 km as the most conservative assumption (i.e. for a highest thrust angle) for the depth difference of 11 km between intrusion of the gabbro and late shear deformation. Given the thickness of the shear zone of 150 m and the time for the shearing of ∼10 m.y., a strain rate of ∼5*10^{-13} s^{-1} can be estimated. As suggested, this is a conservative estimate, so that strain rates may well have been faster. These strain rates appear to be similar to those of Alpine nappes, so that it is suggested that Caledonian nappe stacking has probably taken place at the same rates or even faster than Alpine ones. Given the fact that the transport distances in the Caledonides are far greater than in the Alps, this would suggest that the Caledonian orogeny has taken place over a longer period of time than in the Alps.