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Deformation record in and around boudinaged dykes – high finite strain examples from Spitz (Austria)

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Analog and numerical models of the progressive evolution of boudinage have shown that the main factors controlling the development and final shape of boudins are the flow regime, orientation and spacing of the inter-boudin surface, viscosity contrast and the layer orientation and thickness. Variation of these parameters can cause complex behavior of boudin separation and rotation of the boudin segments inducing complex perturbation strain in the host rocks.

The former quarry Fehringer nearby Spitz an der Donau (Austria) represents an excellent natural laboratory to study the influence of the geometry of interboudin surfaces, viscosity contrast and layer thickness on boudin evolution at high finite strain. Geologically the exposed rocks belong to the central European Variscan orogeny. The rocks including amphibolites, quartzites, paragneiss, schists and marbles of which the latter represent the main unit within the quarry. The highly deformed rocks have experienced metamorphic conditions of around 700-800 °C at 8 kbar and have been syntectonically intruded by pegmatitic and aplitic dykes. During continuous top-to-the SE shearing, dykes have been rotated into the shear direction resulting in stretching, boudinage and rotation of boudin segments. Interestingly, the observed boudins preserve various shapes including pinch and swell, fish mouth but also blocky geometries suggesting a progressively changing viscosity contrast possibly resulting from local metamorphic or chemical induced rheological weakening or cooling.

The aim of this study is to analyze the deformation mechanisms within boudin segments and their surrounding matrix. Using space for time, the changing deformation mechanisms and flow patterns are characterized for the host rock marbles and the aplitic dykes.

Based on the great variety of boudin types found at the outcrop, it was decided to compare two different boudin end-members (1) blocky and (2) pinch-and-swell, to deduct common or discerning processes that would allow for a better understanding of these structures.

In both types, the grain size of the marble host rock is decreasing with increasing proximity to the aplitic dyke, accompanied by a more distinct shape preferred orientation of the calcite grains, both likely due to a localization of deformation around the aplite.

Intracrystalline distortion has been analyzed via electron backscatter diffraction (EBSD) mapping allowing for a quantification of the misorientation in different localities throughout these samples. EBSD analysis revealed increased crystal plasticity, either within calcite grains located at the aplite-host rock boundary or in quartz grains within the aplite center depending on boudin type. In general, all aplite dykes are surrounded by a metasomatic halo of diopside. Only where late cracks occur this halo is missing, instead we observe precipitations of quartz and less common calcite.

Geodynamically, it stands to reason that after the intrusion of the dykes they were later rotated or boudinaged mainly depending on their orientation and aspect ratio. The occurrence of both compressional and extensional structures, which can be observed in a multitude of samples, might be due the rotation of dykes into the fields of instantaneous stretching/shortening and the consequential varying behavior of these dykes.