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Channelised stress-related outbreaks through micro fractures: combining geophysics, geomechanics and mineralogy

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The Collisional Orogeny in the Scandinavian Caledonides (COSC) drilling project, co-funded by the ICDP, focusses on understanding the structures and geological processes that formed the Paleozoic Caledonian mountain belt, with analogies to modern collisions such as the Alpine-Himalaya belt [1]: the paleocontinent Baltica under thrusted Laurentia, as India underthrusts Asia.

In this study, we focus on the 2.3 km deep COSC-2A drill core, which was drilled ca. 20 km to the east of COSC-1 borehole and from which ca. 2.2 km core was retrieved out of ca. 2.3 km drilling. The borehole intersected, from top to the bottom, turbiditic (meta)greywackes of Ordovician age, continued through early Cambrian arkose, conglomerates and (meta)greywackes before penetrating in ca. 1.3 km through Baltican basement ignimbrites and silicic porphyry rocks of latest Paleoproterozoic age (ca. 1.66 Ga). The latter are intruded at ca. 1.6-1.9 km by ca. 1.47 and 1.27 Ga old dolerite flat-lying dikes or sills [2-3: and references therein].

An extensive set of geophysical logs [4] was acquired and alongside rock samples taken for mineralogical and structural investigations. We focussed on the flat-lying dolerite intrusions in which stress-related breakouts are concentrated. These samples show highest grain (ca. 2.99 g/cm3) and bulk density (2.93 g/cm3) [5]. Accordingly, the mineralogy of these rocks is distinctive compared to all other rocks showing pyroxenes, plagioclase and amphibole. Subordinately, K-feldspar, mica, apatite and sulfides occur. The occurrence of chlorite and epidote could be interpreted as secondary overprint or LT/LP metamorphism. Both minerals appear solely at the contacts between the dolerite intrusion(s) and the silicic porphyry host rocks pointing to pathways in which fluid flow and elemental exchange have occurred. Reflected in the lowest tensile strengths (19-21 MPa) and lower unconfined compressive strengths than the surrounding porphyries [5] µm-scale fractures in these dolerites, refilled with water-bearing minerals, likely reduce the rock strength. Such alteration-related weakening could promote stress localization and contribute to borehole failure more readily than in softer sedimentary or silicic porphyry rocks.

References

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