Syn-kinematic porosity evolution during nucleation and growth of stylolites (Eilean-Dubh limestone, NW Scotland)

Zhaoliang Hou¹, Florian Füssel², Martin Schöpfer¹, and Bernhard Grasemann¹

¹Department of Geology, University of Vienna, Vienna, Austria (zhaoliangh99@univie.ac.at)
²School of Geosciences, University of Edinburgh, Edinburgh, UK (florian.fusseis@ed.ac.uk)

Stylolites are common microstructures in rocks, where mineral dissolution in a fluid localises in more or less discrete seams. Stylolite formation strongly affects rock porosity, pore connectivity and thus fluid flows. However, details of porosity evolution associated with stylolite nucleation, propagation and growth remain unclear, leading to the debate whether stylolites are conduits or barriers for fluids.

In this contribution, we use an exceptionally large high-resolution SEM-BSE mosaic (102,600 × 18,239 pixels, 0.17µm/pixel) to investigate the detailed microstructures of stylolites from the Eilean-Dubh limestone of the NW Highlands in Scotland. Advanced image analyses indicate that porosity self-organises systematically around stylolites suggesting a four-stage growth process for stylolites: In stage 1, primary pyrites in the rock matrix concentrate stress and dissolution, leading to the formation of porosity. In stage 2, the dissolution porosity self-organises, triggering a chemical-hydraulic-mechanical feedback loop that facilitates further dissolution. In stage 3, the porous zones enlarge and grow along the direction of the smallest principal stress (process zone), concentrating the synkinematic precipitation of pyrites from an external fluid in the core (core zone). In stage 4, the isolated domains connect forming a stylolite with a core zone in the center (highest porosity) surrounded on both sides by a process zones (higher-than-matrix porosity), suggesting a conduit phase during stylolite formation. Since the stylolite-hosting Eilean-Dubh limestones were episodically imbricated below the Ullapool thrust and the stylolites formed sub-parallel to the internal thrust planes, we speculate that synkinematic fluids during the stylolite formation were pumped episodically into the rock during activity of the Ullapool thrust. The detailed stylolite microstructures and the proposed process for stylolite growth suggest that stylolite in carbonate may act as a conduit for a fluid flow.