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Stylolites: barriers or conduits?

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Stylolites are planes of dissolution that commonly form a distinct indentation and play an important role in fluid circulation during carbonate deformation. They are formed by a pressure solution processes that dissolves the soluble particles and leads to an enrichment in insolvable, non-carbonate particles (NCP) along their planes.
Although they seem macroscopically planar, stylolites have an extremely variable shape from the meso- to microscale, with variable porosity and permeability. Therefore, stylolites may have a strong effect on regional fluid flow and the formation of reservoirs in the upper crust, can act as barriers or conduits for flow, and can change this role in the course of time. The main aim of this project is to investigate how this happens, how stylolites control dissolution in rocks, and to what extent. For this, we use a combination of different chemical, petrographic and physical analyses on selected samples with key examples of various types of stylolites.
Chemical and petrographic (SEM and FTIR) analysis allow us to characterize the mineral content and submicroscopic arrangement of stylolite structures to determine which role the NCP and the distribution of pores in and around the stylolites have on fluid circulation. Because the investigated stylolites are relatively narrow, (around 30-50 μm) we also applied Micro XRD and Micro XRF. Micro XRD helps in high resolution determination of the mineral composition and structures of NCP, supported by initial micro XRF to obtain the internal element distribution. Micro CT analysis characterizes the spatial distribution of the voids in and around stylolites and visualizes which pores are connected. A database has been set up to classify the different shape and composition of stylolite structures.
All stylolites show a sharp contact between matrix and NCP, usually with small pores, (less than 5 μm) in the boundary zone. Pores are rounded and commonly interconnected. Pores are relatively abundant inside stylolites but not outside, supporting the idea that stylolites act as pathways for fluid migration.
Despite the different provenance and composition of analyzed limestone samples, NCP are mostly kaolinite, palygorskite and illite in all stylolites. Besides indicating a local strong hydration, these clay minerals, especially palygorskite, have a very high specific surface, enhancing preferential pathways for fluid inside NCP zones. To investigate this further, we are planning 14C-PMMA analysis that it will allow us to visualize all pores from 0.1μm diameter around stylolites. This we will permit to show the flow path of fluids in stylolites in detail.