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Stylolite compaction and stress models

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Stylolites are rough dissolution seams that develop during pressure solution in the Earth's crust. Especially in limestone quarries they exhibit a spectacular roughness with spikes and large columns. They are visible as dark lines of residual clays and other non-dissolvable components in the white limestone. The roughening phenomena seems to be universal since stylolites can also be found in quarzites, mylonites and all kinds of rocks that undergo pressure solution. The genesis of stylolites is not well understood even though they have been used to estimate compaction and to determine the direction of the main compressive stress. We have developed a numerical model to study the dynamic development of the roughness and its dependence on stress. Based on the model we present estimates of finite strain and depth of burial.

The numerical stylolites are studied in two ways: the temporal evolution of the roughness on one hand and the fractal characteristics of the roughness on the other hand. In addition we vary the noise in the model and illustrate the importance of the grain size on the roughening process.

Surface energies are dominant for small wavelengths and the initial stylolite growth is non-linear and as slow as a diffusive process. However, once a critical wavelength is reached the elastic regime becomes dominant and the growth is still non-linear but not as strong as in the surface energy dominated case. The growth of the roughness speeds up and teeth structures develop. Depending on the system size the growth will reach a third regime where saturation is reached and the roughness stays constant. We will present a scaling law based on these findings that can be used to estimate finite strain from natural stylolites.

The roughness of the stylolite itself is self-affine with two different roughness exponents. The switch from one exponent to the other is dependent on stress. We show how stylolites can thus be used as palaeo-stress-gauges. A variation of the initial noise in the system does only change the stylolite growth significantly, if the absolute size of the noise is changed, for example the grain size in a sample. The roughness exponents do not change but the switch from slow to fast growth comes earlier so that the finial stylolite will look different.