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Anisotropic scaling of stylolite morphology: influence of the stress-field orientation?

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We investigate the morphology of stylolites which have formed under a stress field with its largest principal stress direction being (sub-) horizontal. We study samples from two different tectonic settings, from (a) southern Germany where flat-lying Jurassic limestones exhibit vertical stylolites caused by a North-South compression and (b) Jurassic to Cretaceous limestones from NE-Spain, which were deformed by a Cretaceous to Tertiary fold and thrust-belt which exposes stylolites that formed synchronously to folding.

We compare them to bedding parallel stylolites (from Cirque de Navacelles, France [Ebner et al., EPSL 2008]). The oriented samples were opened along the stylolite interface to examine the complex 2D topography of the surface. To quantify the surface topography we use optical profilometry that is based on laser triangulation of the surface without any contact. The topographic information is analysed using a 2D Fourier spectral approach. Bedding parallel stylolites have been successfully described as self-affine fractals with two scaling regimes on small and long scales, respectively. These scaling regimes are characterized by two distinct roughness exponents at small and large scales. They are separated by a well defined crossover length scale (L) which is a function of a stress component σ during formation of the stylolites, as $L \sim \sigma^{-2}$. Compared to bedding parallel stylolites which display an isotropic circular shape of the 2D power spectra of the topography, the samples from bedding non parallel stylolites, exhibit an elliptic shape with varying degree of ellipticity, i.e. two independent crossover-lengths L_1 and L_2 for the vertical direction in the plane of the stylolite and the horizontal direction in plane, respectively.

Since these directions coincide with the intermediate (vertical) and the smallest (horizontal) principal stress direction we conclude that the scaling anisotropy observed in bedding normal stylolites is caused by the non axisymmetric 3D nature of the stress-field during formation.