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Stylolite morphology, stress and strain markers

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Stylolites are ubiquitous pressure-solution seams found in sedimentary rocks. Their morphology is shown to follow two self affine regimes: analyzing the scaling properties of their height over their average direction shows that at small scale, they are self affine surfaces with a Hurst exponent around 1, and at large scale, they follow another self affine scaling with Hurst exponent around 0.5.
We show theoretically the influence of the main principal stress and the local geometry of the stylolitic interface on the dissolution reaction rate. We compute theoretically and numerically how it is affected by the deviation between the principal stress axis, and the local interface between the rock and the soft material in the stylolite. The free energy entering in the dissolution reaction kinetics is expressed from the surface energy term, and via integration from the stress perturbations due to these local misalignments. The resulting model shows the interface evolution at different stress conditions.
In the stylolitic case, i.e. when the main principal stress is normal to the interface, two different stabilizing terms dominate at small and large scales which are linked respectively to the surface energy and to the elastic interactions. Integrating the presence of small scale heterogeneities related to the rock properties of the grains in the model leads to the formulation of a Langevin equation predicting the dynamic evolution of the surface. This equation leads to saturated surfaces obeying the two observed scaling laws. Analytical and numerical analysis of this surface evolution model shows that the cross-over length separating both scaling regimes depends directly on the applied far-field stress magnitude. We develop the basis for the development of a paleostress magnitude marker.
We also show that for long stylolites, a third scaling regime is found with scale independent mode amplitude of the stylolite profile.
This method hence allows to evaluate total amounts of dissolution on long stylolites.
Eventually, on stylolites grown in anisotropic stress environments, we show how the teeth geometry allows to distinguish between the two stress magnitudes associated to the tangential components.
We discuss the impact of these measures on interpretations in terms of stress history, and possible associated datation techniques.