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Stylolite formation: dissolution patterns in disordered granular rocks

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Stylolites are pressure-dissolution surfaces forming naturally in sedimentary rocks. By laboratory charactrization, we show that their morphology displays a self affine scaling. Their surface is described by a Hurst exponent $\zeta_1 \approx 0.5$ at large scale, and $\zeta_2 \approx 1.2$ at small scales, with a clear cutoff scale experimentally determined around $\L_c=1$˜mm in limestones. This morphology is modeled theoretically, describing the growth of a stylolitic interface by a Langevin equation for the dissolution of a disordered elastic solid in contact with a fluid pocket: this process is dominated by a competition between stabilizing long range elastic interactions at large scales or local surface tension effects at small scales and a destabilizing quenched material disorder. This model renders for the observed morphology. Molecular dynamic models incorporating elastic interactions, granular disoredered properties and pressure dependent dissolution rates also display this type of features. The cutoff scale is thus shown to be a fossil stress measure.