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Scaling of natural and simulated stylolites and their use as stress gouges

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Stylolites are rough dissolution pairs of surfaces that are generated by stress induced solution. These irregular structures can be found in various rock types and are mainly filled with fine-grained insoluble material. Stylolites are known to represent self-affine structures that have characteristic statistical properties (Schmittbuhl et al., 2004). We therefore investigate the scaling behaviour of natural (tectonic) and simulated stylolites, which allows comparing properties like roughness, width and saturation of the interface.

For our numerical models, we used the *Elle* software package. Simulations reveal: (i) An initial non-linear growth of roughness and a following saturation of its amplitude. (ii) Two scaling regimes in space with different roughness exponents separated by a well defined crossover that correspond to surface and elastic energy dominated regimes, respectively. (iii) A clear dependence of the scaling on quenched noise that influences roughness and saturation.

We compare our simulations to vertical stylolites from the Schwäbische Alb that crop out in Jurassic interbedded strata composed of marl and limestone. Stylolites confined within single calcareous beds are investigated after image analysis of 2D sections using a height-height correlation function. The results show a crossover length scale similar to that of the numerical examples. Further, the natural interfaces are also saturated implying that the structures lost the memory of the entire strain accommodated by the stylolite.

The saturation of the natural example and the simulation shows that both belong to

the same universality class of growth phenomena. The reason for saturation is in both cases a direct dependency on the system size due to long-range correlations in the system. The numerical simulations show a direct relation between the position of the crossover in the correlation function and the stress that acts during stylolite growth in accordance with the analytical prediction by Schmittbuhl et al. (2004). Using this relation we present how tectonic stresses can be calculated from natural stylolites.

Schmittbuhl, J., Renard, F., Gratier, J.-P., Toussaint, R., 2004. The roughness of stylolites: Implications of 3D high resolution topography measurements, *Phys. Rev. Lett.*, 93, 238501.