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Large scale field measurements of stylolites: stylolite lateral extent and roughness

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Stylolites are rough surfaces formed by localized dissolution, mostly in carbonates and sandstones. They reflect important diagenetic processes in sedimentary basins, such as local mass transfer, compaction, and porosity reduction. Understanding how, where and when they form can improve prediction of their occurrence and their effect on flow, and thus has appreciable geological and economical implications. In spite of their importance, fundamental issues concerning their structure and evolution are still debated.

Our field study was conducted on the "Blanche" cliff of the Ein El-Assad Formation (Lower Cretaceous) exposed in Northern Israel. The Blanche here is a $\sim$50m-thick biomicritic limestone, with very low porosity. It consists of well-developed bedding-parallel stylolites that can be traced through the entire outcrop ($>$1km), and most likely continue beyond the exposure. Such a tracing length for stylolites is remarkable, and is observed for the first time. It has implications for understanding scales of permeability units and their structural continuity.

We measured stylolite roughness in-situ using Ground-based LIDAR at 3-mm resolution. A single scan provides millions of points that may be interpolated to generate a topographic map or hundreds of profiles. Thus, the technique allows a statistical approach when calculating roughness. Our measured surfaces range in size from 0.9X0.4 m^2 to 9.3X2.8 m^2. Previous studies showed already that stylolite roughness is fractal over several orders of magnitude (Karcz and Scholz, 2003; Renard et al., 2004; Schmittbuhl et al., 2004; Ebner et al., 2009). However these previous measurements were performed at scales smaller than 0.3m. Here we report measurements of stylolite surface roughness at a scale larger than ever measured before (10^{-2}-10^{1}m), allowing observation of both the previously reported fractal roughness and of a previously unobserved upper limit for fractal behavior above $\sim$0.1m. Surface growth models of stylolites (Ebner et al., 2009; Koehn et al. 2009) suggest that this newly recognized upper limit may be used as a measure of the amount of dissolution along the stylolites. These growth models and their agreement with observations also support a physical model in which stylolites develop from existing surfaces rather than propagate in-plain as has been previously suggested for other case studies (e.g., Fletcher and Pollard, 1981; Raynaud and Carrio-Schaffhauser, 1992). The modeling aspects are presented in a companion talk.

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