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The Formation and Propagation of Stylo-Fractures

Zvi Karcz, Ovunc Mutlu, Rich Albert, and Jim DeGraff
ExxonMobil Upstream Research Company, Houston, Texas, United States (zvi.k.karcz@exxonmobil.com)

Stylolites are dissolution surfaces that are common in various rock types, and are especially prominent in carbonates. Their distinct rough morphology forms when rocks on either side of the stylolite penetrate into each other by dissolution. The stylolite itself is lined by insoluble particles, primarily clays and oxides, which form a layer up to several centimeters thick. This layer of insolubles, and the common formation of a cement halo around the stylolite where porosity is occluded to near zero, make stylolite units effective baffles to flow in some reservoirs.
Although stylolites form through the non-brittle deformation mechanism of dissolution-precipitation creep, they are commonly associated with secondary brittle structures such as fractures and veins. Most of these secondary brittle structures form after the stylolite is well developed, but it is not clear what controls their formation and propagation.
In this study we focus on small extension fractures that emanate from stylolite surfaces in an un-named Middle East reservoir. These stylo-fractures form on well developed stylolites with amplitudes up to several centimeters and thicknesses up to 2 centimeters, which occur in fine-grained, limy, wackestone to packstone units. The stylo-fractures are sub-vertical hairline fractures filled with organic matter and calcite cement.
We used standard finite element modeling and FEM/DEM techniques to interrogate parameters that may control the formation and propagation of these stylo-fractures. We explored the importance of stylolite geometry, the mechanical properties of the stylolite fill and its contrast with the surrounding rock, as well as the stress regime. Preliminary results indicate that the thickness of the stylolite fill, and the material property contrast between the stylolite fill and the host rock have a primary role in determining whether stylo-fractures will form, and on their morphology. Furthermore, we find that relatively low ratios of horizontal to vertical stress imposed as external loading conditions, favor the formation of stylo-fractures. We simulated burial and uplift cycles with varying material properties to elucidate the timing of stylo-fracture formation in geologic settings.