Stylolite Networks as a Primary Control on the Geometry of Massive Diagenetic Alterations in Carbonates

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Abstract

Bedding-parallel stylolites are ubiquitous rough dissolution surfaces that act as either barriers or conduits to fluid flow. Stylolite networks can determine fluid pathways, thus controlling the location and petrophysical properties of diagenetic alterations, like fault-associated dolomitization. This reaction takes place when fluids typically hotter than host rocks are advected through faults and replace limestones. The resulting geometries range from dolostone patches around faults to stratabound bodies that extend long distances away from faults. It has been historically assumed that such geometries are the result of depositional facies distribution, and pre-dolomitization diagenesis and fractures. However, very few studies have addressed the impact of stylolite networks on these systems, and no systematic analyses have been made. The Benicassim outcrop analogue (Maestrat Basin, eastern Spain) is a world-class example of hydrothermal stratabound dolomitization. In this area, seismic-scale stratabound dolomitized bodies extend for several kilometers away from large-scale faults, replacing syn-rift Aptian-Albian shallow-marine carbonates. Field and petrographic data indicate that grain-dominated facies are preferentially replaced while mud-rich facies are less frequently dolomitized. However, grainstones and packstones also crop out between dolostone layers, suggesting that not only the depositional facies determined which rocks were dolomitized. Most of the beds contain dense networks of sedimentary (i.e. layer-parallel) stylolites, as well as several sets of meter-scale fractures of different ages. Dolomitization fronts are always very sharp, and the vast majority of them weave up and down following consecutive stylolites. This suggests that stylolites acted as vertical barriers to fluid flow, and constrained the reaction to only one side of them. Stylolite density and teeth height does not dramatically change between the different layers. However, high-amplitude stylolites are found in certain muddy layers, creating anastomosing networks that acted both as vertical and horizontal barriers to fluid flow, thus constraining dolomitization.

Complementary advection-diffusion numerical simulations illustrate how fluids can be channelized depending on the geometry and connectivity of stylolite networks. We suggest that these structures can be a major control on diagenetic processes like dissolution, cementation and replacement, therefore determining reservoir quality.