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Timing of porosity destruction related to pressure-solution in limestones

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Among effects that affect sedimentary rocks during diagenesis, pressure-solution has a very strong impact on the physical properties of rocks such as porosity and permeability. Intergranular pressure-solution results in rough or wavy surfaces called stylolites, which are very common in sedimentary basins, especially in limestone. According to the opening of the system, dissolved material can precipitate locally, leading to the destruction of the porosity around the stylolite. That can namely occur during the development of sedimentary stylolites, when no fracture of fault can allow dissolved material to flow away before precipitating again. This contribution aims at unravelling the depth at which the material dissolved during compaction precipitated in the open porosity, adding new data to discuss when pressure-solution starts to be an efficient mechanism of deformation in limestone during strata burial in sedimentary basins.

We report the results of the study of cements that fill the fractures developed at the tips of stylolites in a sample of dolostone from the Jurassic Calcare Massiccio formation, coming from the Umbria-Marche area (Italy). The fractures developed from stylolite-induced stress, and the filling cements' oxygen and carbon isotopic values range between 10.6‰ to -6.1‰ PDB and -8.2‰ to -0.6‰ PDB, respectively. Considering a closed system, we use fractionation equations to convert δ18O values into temperature, which shows that the material put in solution during pressure-solution precipitated at a temperature ranging from 18°C to 39°C. Temperature range and geothermal gradient estimates suggest that the mechanism of pressure-solution actually was primarily active at depth as low as 1 km. In the studied sample, up to 18% of the original volume has been dissolved on stylolites, and that volume loss would have occurred in the first 2 km of the burial history. This natural example feeds the growing body of evidence that stylolites can start developing at a very low depth level. Our results suggest that the porosity in sedimentary rocks can be destroyed very early during burial, both by dissolution and by precipitation, which make the pressure-solution mechanism's impact on fluid flow in basin likely to be underestimated.