Tectonic Stylolites As Reliable Paleopiezometers

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ABSTRACT

Understanding the numerous effects of tectonic stress on rocks during long-term contraction is challenging and requires tools that reliably reconstruct both stress orientation and magnitude. At sub-seismic scale, few structures have been successfully used to reconstruct paleostress tensor so far, these structures being striated fault planes (to access paleostress orientation) and calcite twins (that also give an access to the maximum magnitude of the differential stress). Recent understandings of the morphogenesis of stylolites - pressure-solution features commonly linked with fracture networks in sedimentary rocks - stated that a stylolite can fossilize the stress field during its growth [1]. This stress signature is due to the competition of small-scale surface energy and large-scale elastic fluctuation regime that control the roughness of the stylolite. Consequently, a frequency analysis of the roughness signal shows the length scale for which the switch from small-scale to large-scale energy regime occurs: the crossover length, which is linked to the applied stress [1]. So far, this property has mainly been applied to bed-parallel isotropic stylolite populations in order to reconstruct maximum burial depth in shallow strata.

This contribution presents for the first time a natural case study where an anisotropic tectonic stylolite population described in deeply deformed strata is used to access the principal stress magnitude that prevailed in rocks during distinct tectonic stages. The Monte Nero Anticline (Northern Apennines, Italy) is a fault-related arcuate anticline where a fracture-stylolite network extensively developed, mainly related to the stress field that led to the folding. Five successive fracture sets and three related tectonic stylolite sets were discriminated in the microstructure population, and were used as a tectonic relative calendar for the area. The 3-D roughness of the stylolites was analysed and reconstructed based on 2-D profiles and periodicity properties [2] and principal stress magnitude were calculated for several steps of the deformation. In order to better understand the results of this inversion process, a paleostress study has been carried out on the fracture population using the established calcite twinning paleopiezometer. Results highlight that the tectonic stylolite roughness inversion is a reliable and user-friendly way to access paleostress. Used in combination with calcite twinning paleopiezometry it adds great details when reconstructing the natural evolution of stress during deformation, which is promising to better illustrate and so understand the interplay between stress and rock during deformation.

References

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