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Harnessing the Power of Carbonate Fault Rocks

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ABSTRACT

Carbonate-hosted faults are disproportionately responsible for seismicity and fluid migration in the shallow continental crust. Carbonate deformation is substantially different from deformation in silicate-dominated rocks. Calcite undergoes crystal plastic deformation at lower temperatures (<200°C), diffuses more readily than silicates and its high solubility supports the potential for rapid healing of fractures and hardening of faulted material. Dolomite is much stronger and brittle to higher temperatures (above ~500°C, similar to feldspar) but dolomite and calcite frequently replace one another through solution-precipitation processes leading to strength inversions throughout geologic time. Carbonate minerals recrystallize at shallow crustal conditions, sometimes overprinting the evidence for deformation history.

Identifying and describing fault rocks is challenging due to their significant variability. The existing fault rock nomenclature in broad use (gouge, cataclasite, breccia; Sibson, 1975) does not differentiate the majority of distinguishing features, observable in the field, in core, or in thin section, that differentiate deformed from undeformed rocks and provide evidence for healed fractures, past fault slip, and even paleo-earthquakes. We propose a flexible, holistic classification scheme for carbonate fault rocks, for use in outcrop, hand sample and core observations. The rock names are based on modifications of the familiar classification and incorporate the best elements of other schemes presently in use, except for one new proposed term, “tiganite”, to describe a rock with a strong surface fabric without detectable evidence of shear strain (the carbonate equivalent of a schist). We drop “cohesion” from the Sibson scheme as it is subjective and often related to weathering or post-faulting cementation, so does not support fault mechanism interpretation. Our scheme is based on a hierarchy of descriptive elements chosen for reproducibility of observations, and their relevance for interpretation of deformation history. Rock names are formatted similar to metamorphic rock naming, with a broad noun augmented by optional modifiers to be selected by the geologist according to their purpose. We present this scheme as a flow chart for easy field reference.

We hope that through adoption of a more nuanced, applicable and reproducible classification scheme for carbonate fault rocks, the scientific community will be able to communicate observations and interpretations more effectively to support the understanding of faulting and fault healing in carbonate terranes.

BIOGRAPHY

Prof. Christie Rowe is a field geologist focused on understanding geologic controls on the earthquake cycle, and the impacts of earthquakes on the geologic record, including fault slip and healing, fluid transport and ore formation, and the interaction between long-term and catastrophic events in rock deformation. She earned an AB (Geology) at Smith College and PhD (Earth Sciences) at UC Santa Cruz and worked at University of Cape Town before joining McGill University in 2011. She is the recipient of the Hutchison Medal of the Geological Association of Canada, Outstanding Publication Award from the Structural Geology and Tectonics Division of the Geological Society of America, the Birch Lectureship of the American Geophysical Union, and McGill's Outstanding Emerging Researcher Prize. Christie is the Executive Editor for Community at Seismica, a free-to-read, free-to-publish journal in seismology and earthquake science.