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# A recipe to create nano-grains on dolomite

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Advances in imaging techniques in recent years have allowed for easy microstructure visualization at nano-resolution, and many studies have observed nano-grains in different materials, including rocks. An important example in geological systems is their seemingly ubiquitous occurrence on so-called mirror-like slip surfaces, produced in natural and experimental earthquakes of both carbonate and silicate rocks. It is, however, not yet clear whether these nano-grains can indeed be used as a reliable indicator of seismic slip. Since carbonates are prone to decarbonation at temperatures exceeding 550 – 600 °C, nano-grain formation may be formed due to heating rather than shear.

In this study, we have investigated the effect of elevated temperatures on carbonate fault rocks. We used hand-polished mirror-like dolomite protolith, as well as natural fault mirror surfaces, obtained from the Foiana Fault Zone from the Southern Alps in Italy. The samples were heated to 200 to 800 degC in a ∼5 hour heating cycle, followed by slow cooling (∼12 h) to room temperature. Subsequently, we imaged the samples using SEM and AFM. Nano-grain formation on the surfaces of hand-polished samples starts around 400 ° C, and is pervasive at and above 600 ° C. Fault mirror samples are initially coated with naturally formed nano-grains and only very local patches on these surfaces display obvious morphological changes due to heating. Exposing both types of sample heated to 600 °C to DI water under the AFM shows rapid recrystallization and the formation of a more porous and blade-like crystal layer on the entire surface. This happens both in hand-polished and naturally polished surfaces. Fault mirror samples that have not been heated do not change when exposed to water.

We have shown that nano-grains can form as a result of heating without shear, but that samples that have experienced high shear strain have a water- and heat-resistant coating composed of otherwise morphologically indistinguishable nano-grains. These results show that caution is needed when interpreting laboratory and field microstructures, since there is more than one way to cook up a nano-grain.