Weathering resistant surfaces in naturally polished carbonate rocks from fault zones

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Many fault surfaces have a polished, glossy appearance that is due to the presence of a thin layer of particles that forms during slip. Such layers are often less than 1 micron thick, and calculations based on the reaction rates for carbonate minerals indicate that these layers should weather away over relatively short times scales of months or years. However, in many cases polished fault surfaces are much older than this, suggesting that they could be resistant to weathering. In this study, we use atomic force microscopy experiments to determine the dissolution rates and patterns of polished fault surfaces. Our results demonstrate that these natural "fault mirrors" do in fact dissolve more slowly than artificially polished surfaces prepared from the same bulk rock. Furthermore, naturally polished surfaces dissolve by horizontal peeling, in contrast to the artificially polished samples that dissolve perpendicularly to the surface. Transmission electron microscopy and Rutherford backscattering spectrometry reveal that the layer is typically 150-600 nm thick, and comprises a mixture of nano-scale particles comprising carbonate minerals and silica, and possibly clays and Fe-oxides as well. Our results suggest that such natural nano-composites could play an important role in controlling the weathering rates of rocks under field conditions, and might even be used to constrain the timing of seismic activity along faults.