Reaction-induced fracturing during silicate weathering and carbonation

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Silicate weathering under acidic conditions occurs in a wide range of scenarios, including volcanic environments, soils subjected to acid rain or acid mine drainage sites. Moreover, the study of the processes occurring under these extreme conditions contributes to the understanding of the conditions for hosting life in other planets. From a technological point of view, these pH conditions are relevant for geological CO_2 storage in rocks. The rate-limiting step for this process is considered to be the release of divalent cations from the silicate structure. In this experimental study we show how during acidic weathering and carbonation of different silicates (wollastonite, augite and diopside), extensive etch pit formation takes place, where cracks can initiate and propagate by stress corrosion. Crack propagation may as well be facilitated by the confined growth of amorphous Si-rich phases and/or carbonates within fractures and pores formed during dissolution. Although the precipitation of an amorphous material is not expected to exert much stress due to the low critical supersaturation reached in the system and thus the low crystallization pressure, it may contribute to fracture propagation, as it has been suggested for the case of amorphous proto-serpentine phase formed during serpentinization of olivine (Plümper et al., 2012). All in all, this mechanism leads to intensive fracturing that generates fluid pathways to facilitate dissolution along the fracture surfaces. Fracture formation and propagation is essential to this process, as it facilitates the transport of fluids within an otherwise impermeable material and increases the fluxes of Ca and Mg released to the solution. Finally, we provide some insight on the effect of the hydrodynamic conditions and the compositional differences of the dissolving silicates on the mechanisms of silicate acidic weathering and carbonation.

References

Plümper, O., Royne, A., Magraso, A., and Jamtveit, B., 2012, The interface-scale mechanism of reaction-induced fracturing during serpentinization: Geology, v. 40, p. 1103–1106