

Developing the comminution age technique: Isolating the detrital minerals

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The uranium-series isotopes can be used to quantify the timescales on which Earth-surface processes operate; this is essential before we can begin to try to understand how the erosion of the Earth's surface responds to climate change.

The traditional uranium-series methodology analyses the isotopic composition of the bulk sediment; however, this requires complex modelling to account for the variable isotopic composition of authigenic phases, such as carbonates and organic material [1]. The accuracy of the calculated ages can be improved by focussing on the isotopic evolution of only the detrital minerals. One such example is the emerging *comminution age* technique which calculates a radiometric age by relating the (²³⁴U/²³⁸U) of the detrital minerals to the surface area [2].

Sequential extraction procedures are currently used to remove the non-detrital fraction but these procedures are unreliable and suffer from a lack of reproducibility and completeness. To overcome this, the isolation of the detrital minerals can be monitored by analysing the (²³⁴U/²³⁸U) of the sediment throughout the procedure. This is possible as there are three domains of (²³⁴U/²³⁸U) in sediment: 1. (²³⁴U/²³⁸U) = 1 for the inner-core of detrital minerals, (²³⁴U/²³⁸U) < 1 in the outer-rind (ca. 50 nm) of sediment due to the effects of alpha-recoil, and (²³⁴U/²³⁸U) > 1 for the non-detrital fraction [3]. The minimum (²³⁴U/²³⁸U) of the sediment therefore represents the optimum isolation of the detrital minerals.

This study evaluates existing sequential extraction procedures and proposes an *optimised* procedure based on the above methodology. This will be presented in addition to the implications of the results upon ages calculated using the comminution age technique.

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Fayalite oxidation processes at Obsidian Cliffs, Oregon

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Fayalite Fe₂²⁺SiO₄, the ferrous end-member of olivine, is present in terrestrial rocks and in primitive meteorites [1]. A ferric fayalite, laihunite Fe²⁺Fe³⁺₂□(SiO₄)₂, has also been reported in terrestrial [2, 3, 4, 5] and martian [6] samples. In order to constrain the oxidation processes of fayalite, we have studied crystals found in lithophysae from the Obsidian Cliffs rhyolite using EMPA and SAED+EELS on a TEM, and made thermodynamic modelling.

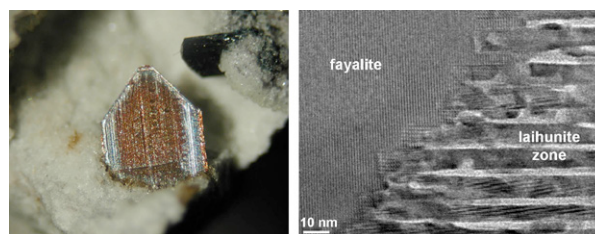


Figure 1: (a) picture of an oxidized fayalite crystal (approx. 1.6 mm tall) (©B.Lechner) (b) HRTEM image of the fayalite/laihunite interface.

Fayalite crystallized at 800-900°C and low p_{H₂O}. Temperature decrease to 650°C induced the oxidation of fayalite into a "laihunite" zone Fe²⁺Fe³⁺₂□(SiO₄)₂ composed of nano-lamellae of various oxidation phases (Fig.1). Further cooling, H₂O exsolution from rhyolite lava and/or infiltration of meteoric water caused the oxidation of the "laihunite" zone into an "oxyfayalite" zone Fe²⁺_{0.26}Fe³⁺_{1.16}□_{0.58}(SiO₄) also made of nano-lamellae.

Fayalite oxidation reactions can be used to constrain the emplacement and cooling history of the lava flow. Our data also hint at the existence of a ferric fayalite phase that is more oxidized than laihunite.

[1] Jogo *et al.* (2009) *EPSL* 287, 320-328 [2] *Laihunite* Research Group (1982) *CJG* 1, 105-115 [3] Schaefer (1983) *Nature* 303, 325-327 [4] Kitamura *et al.* (1984) *AmMin* 69, 154-160 [5] Shen *et al.* (1986) *AmMin* 71, 1455-1460 [6] Noguchi *et al.* (2009) *JGR* 114, E10004.