An experimental perspective to oxidative biological weathering and its Archean origins

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Mineral weathering is fundamental to Earth's system evolution, driving biogeochemical cycles, soil genesis, ecosystem formation, and atmospheric composition. Research on biota-rock interactions has itensified in recent years and a more refined understanding of the biological constrains is christalizing. While modern Earth weathering is mainly an oxidative process driven by interactions among climate, bedrock, and complex overlying ecoystems, its evolution from a more primitive anoxic world and the associated geochemical fingerprints are still poorly constrained.

Our overarching goal is to contrast the effects of abiotic, and biological factors during incipient oxidative weathering of silicate rocks and compare it to an anoxic analogue of early Earth (Archean geological eon, 3.5 GA). Specifically, we assess the stoichiometric mobilization of major elements (Si, Al, Mg, Ca, Fe, Na, Ti, K, P and Mn) from granular basalt under abiotic, microbial, vascular plant and fungal effects, in modern-day oxygen levels in a mezocosm-scale column experiment. A similar suite of elements are analysed in weathering columns subjected to a mixture of microbes and cyanobacteria under modelled anoxic conditions of earrly Precambrian (98% N_2 – 2% CO_2).

Our study shows a strong effect from biotic developmet on the stoichiometry of different element groups. It also suggets the potential for a strong transition between anoxic and oxidative - dominated geochemical cycles. This is also reflected in geochemical biosignatures formed during incipient weathering, which could potentially be preserved in the sedimentary record. Our study allows for more clearly understanding of the local formation of geochemical biosignatures and the propagation of these signals to different Earth's surface reservoirs. We foresee that our results will better constrain planetary evolution models, particularly at the transition between different atmospheric compositions.