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Tracing oxidative weathering of rock organic carbon through geological time using rhenium isotopes

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The release of CO_2 from the oxidative weathering of rock-derived organic carbon (OC_{petro}) is now understood to be an important component of the long-term carbon cycle. However, it is difficult to quantify how this flux has changed throughout Earth's history, making it challenging to assess carbon cycle-climate linkages in the geological past. Due to the close association between the trace element rhenium (Re) and OC_{petro}, Re isotopes (^{185}Re and ^{187}Re, reported as $\delta^{187}Re$) are a promising system for investigating oxidative weathering. In modern river sediments, whole rock $\delta^{187}Re$ decreases as Re is lost during weathering, possibly due to the preferential oxidation of isotopically heavy phase(s). This leads to release of Re with higher $\delta^{187}Re$ to the dissolved load of rivers [1]. Rivers are the main source of Re to the oceans. Therefore, if changes in oxidative weathering intensity and flux alter river $\delta^{187}Re$ values, any shift in seawater Re isotopic composition may be recorded in the authigenic component of marine sediments.

To explore the magnitude of seawater $\delta^{187}Re$ shifts associated with changing oxidative weathering intensity on land, we use an isotope mass balance model. We find that realistic increases in oxidative weathering can drive resolvable variation in seawater $\delta^{187}Re$ over relevant timescales. We investigate signals preserved in the sedimentary record using Jurassic mudstones and shales from the Llanbedr (Mochras Farm) borehole, Wales. These samples were reanalysed recently as part of the Jurassic Earth System and Timescale (JET) project, and record continuous deposition in an unrestricted marine setting [2,3]. We focus on samples spanning the Toarcian Oceanic Anoxic Event (T-OAE). During this period, there is evidence for carbon cycle perturbations, and increased hydrological cycling and silicate weathering [3,4]. Therefore, it is likely that oxidative weathering rates were also elevated. We investigate the magnitude, direction and controls on Re isotope variations over the T-OAE, and consider what Re isotopes can tell us about oxidative weathering of OC_{petro} throughout Earth's history.

[1] Dellinger et al. (2021), *EPSL* 573, 117131
[2] Storm et al. (2020), *PNAS* 117, 3974-3982
[3] Xu et al. (2018), *EPSL* 484, 396-411
[4] Percival et al. (2016), *Geology* 44, 759-762