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Redox processes in igneous systems - *Science Innovation Award Lecture*

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Planetary core, crust, and atmosphere formation are influenced by the relative proportions of ferric and ferrous iron in planetary interiors. Quantifications of ferric/ferrous iron ratios in igneous systems and subsequent calculations of system oxygen fugacities (fO2) have surged in recent decades. Creative proxies for fO2 in systems that are not amenable to oxybarometry have also proliferated. To infer petrological and geochemical processes from this ever-expanding dataset, and to extrapolate these data to inaccessible environments (mantles, exoplanets, deep time), requires that we redouble our efforts to understand how ferric iron partitions amongst minerals and melts, how it couples with other redox sensitive species, and how it influences the activity-composition relationships that underpin thermodynamic models. In this presentation I will discuss the influence of solid phase assemblages on melt ferric iron concentration during melting and crystallization. I will discuss the promise and limitations of vanadium-based redox proxies. I will highlight areas in which the community might make strategic investments in the future.

Figure 1. Maps of redox data from across tectonic settings. Panel (a) displays average thermobarometric fO2 recorded by present-day volcanic rocks (circles) and mantle rocks (stars) relative to the quartz-fayalite-magnetite (QFM) buffer. Panel (b) displays V/V* (where V* is Sc^0.84*Yb^0.54) calculated for present-day basalts. As a proxy for mantle fO2, V/V* is less model-dependent than V/Sc due to the greater sensitivity of V/Sc to melting reactions and crystal fractionation; however, caution is warranted when applying any trace element as a proxy for thermobarometric fO2. Modified from Figure 1, Cottrell et al., *Nature Reviews Earth and Environment*, 2025.

Figure 2. Panel (a) compiles fO2 calculated in the literature from modelled vanadium partitioning between olivine and melt. Panel (b) display V/V* from eclogites and ophiolites as a function of time. There is no statistically significant temporal trend in fO2 in mantle-derived rocks since the Archaean using any vanadium-based redox proxy. Modified from Figure 5, Cottrell et al., *Nature Reviews Earth and Environment*, 2025.

Figure 1

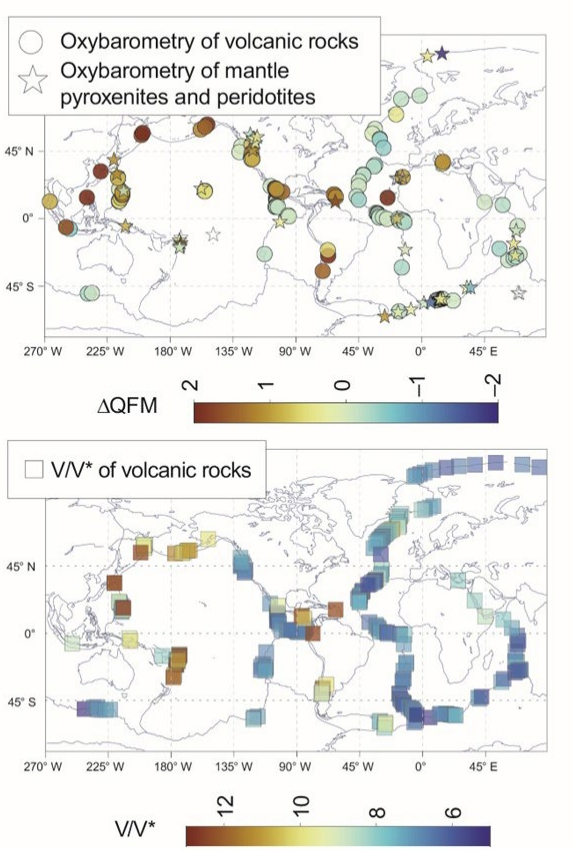

Figure 2

