Re-Os geochronology of lacustrine organic-rich sedimentary rocks: Systematics and implications

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The Re-Os geochronometer is widely utilised to determine precise depositional ages of marine organic-rich sedimentary rocks (ORS). However, Re-Os systematics have not been fully evaluated in lacustrine ORS. Lacustrine sedimentary rocks provide an invaluable archive of continental geological processes responding to tectonic, climatic and magmatic influences. The lack of marine biostratigraphic constraints in lacustrine sedimentary rocks means that correlation to global geological phenomena requires accurate and precise geochronological frameworks.

Here we apply the Re-Os geochronometer to the Eocene Green River Formation (GRF), the world's largest succession of lacustrine ORS representing a classic model of lacustrine deposition. We present two precise Re-Os ages of 48.5 ± 0.6 Ma and 49.2 ± 1.0 Ma from the Uinta basin that are in excellent agreement with Ar/Ar and U/Pb dates of interbedded tuffs within the GRF. An additional Re-Os age of 47.8 ± 9.9 Ma has a higher uncertainty attributed to a smaller spread in $^{187}Re/^{188}Os$ ratios. This third age is from a section suggested to have been deposited in the deepest lake setting. It possesses higher TOC that exhibits more significant correlation with Re, Os and trace elements than the sections which yield precise ages. The redox sensitive trace elements are used to assess Re-Os systematics in lacustrine ORS and suggest deposition from an oxic-dysoxic water column.

In addition to geochronology, the initial $^{187}Os/^{188}Os$ (Os_i) of the GRF (~1.4-1.5) has implications for the understanding of global ocean Os fluctuations. The Os_i is similar to continental runoff today (~1.54), suggesting that the $^{187}Os/^{188}Os$ of continental runoff into the ocean has not changed since the Eocene. Global ocean $^{187}Os/^{188}Os$ has evolved from ~0.56 during the Eocene to a modern day value of 1.06. This study suggests that global ocean Os evolution has been driven by a decrease of unradiogenic Os flux rather than an increase in radiogenic Os from continental runoff.

Geochemical and isotopic insights into the development of a large caldera-forming eruption, Atitlan Caldera, Guatemala

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How do large volumes of rhyolitic magma accumulate prior to the eruption of large caldera-forming eruptions? Rhyolitic magmas are proposed to originate either from rhyolitic pods that are the result of rapid differentiation, through assimilation of crustal melts, or a combination of the two. High magma flux rates are required to sustain an eruptable crystal-melt reservoir. These issues are evaluated at Atitlan Caldera, Guatemala where eruption of the ~300 km^3 Los Chocoyos rhyolitic ignimbrite and air fall occurred at 84 ka. Eruption of a compositionally zoned ignimbrite recorded the presence of rhyodacite and high silica rhyolite in the proportions of 1:4. The rhyodacite displays trace element ratios similar to the basaltic andesite enclaves found in early Los Chocoyos fall deposits, as well as, stratocone lavas erupted around the caldera boundary before and after the Los Chocoyos. In particular, the rhyodacite displays higher Sr/Y, La/Yb and Ce/Y than the high silica rhyolites. Generation of rhyolitic magmas by exclusive melting of old granitic crust is inconsistent with trace element models and Sr isotopic data. Sr isotopes for the rhyodacite and high silica rhyolite are slightly elevated from the mafic enclave and unlike the Sr isotope ratios for the more evolved granite. The rhyodacite can be modeled to form via batch partial melting of the mafic enclave, assumed to reflect the least differentiated end member, with garnet in the residuum. The high silica rhyolite can be modeled from 70% fractional crystallization of the basaltic andesite and 15% assimilation of 15.2 Ma granitic pluton exposed along the caldera boundary. Thus, partial melting and differentiation of basaltic andesite stalled in the crustal plumbing system with minor addition of granitic crustal melts can account for the formation of rhyolitic magmas at Atitlan Caldera. Thermal models project that a flux rate of 10^{-2} km^3/yr is required to provide enough heat to form large volume rhyolitic eruptions. Stratocone eruption rates of basaltic andesite at Atitlan Caldera since the Los Chocoyos are 4 x 10^{-3} km^3/yr. Assuming a 3:1 intrusive:extrusive ratio, current magma flux rates at Atitlan Caldera are at least 1.2 x 10^{-2} km/yr and able to sustain the formation of large volume rhyolitic magmas.