

Re-Os Systematics in Diagenetic Pyrite from Continental Sedimentary Rocks: Potential for Geochronology and Isotopic Tracer Studies

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To test the feasibility of Re-Os geochronology and isotopic tracer studies in continental sedimentary environments, we have analyzed two pyrite samples from the Mariano Lake uranium deposit, hosted by the Upper Jurassic Morrison Formation in the Grants uranium region, New Mexico, USA. Analyses of two splits of a pyrite separate from a single hand sample, and a single analysis of a pyrite separate from another sample (Table 1), reveal strikingly high Re and Os concentrations.

Table 1: Preliminary Re-Os analyses of pyrite from Mariano Lake uranium ores.

Run #	Sample	Re, ppb	Os, ppb	¹⁸⁷ Os/ ¹⁸⁸ Os	¹⁸⁷ Re/ ¹⁸⁸ Os
M2	M-20-1	223.7 (1)	3.48 (1)	1.753 (7)	375 (1)
M3	M-20-1	229.3 (2)	3.56 (1)	1.745 (7)	376 (1)
M4	M-14-1	572 (3)	28.98 (5)	1.332 (4)	110.0 (6)

Blanks are Re = 0.048 ppb, Os = 0.003 ppb, and ¹⁸⁷Os/¹⁸⁸Os = 0.4943. Values in parentheses are uncertainties (2σ) in the last digit indicated.

Two samples, M-14-1 and M-20-1, were collected several hundred feet apart from a primary tabular ore body in the Mariano Lake deposit. Both are medium-grained arkosic sand-stones in which pyrite is intimately intermixed with organic material and fills pore spaces between detrital quartz and feldspar. In both cases, the pyrite occurs as clusters of subhedral to euhedral grains. In M-20-1, clusters of one to several large grains, averaging about 0.2 mm in diameter, are partially surrounded by smaller grains. In M-14-1, the average grain size is notably smaller, less than 0.1 mm, and grains are mostly subhedral.

The data yield an isochron age of 94 ± 21 Ma, with an initial ¹⁸⁷Os/¹⁸⁸Os of 1.16 ± 0.11 (Model 3, Ludwig, 1999), in good agreement with an estimated 100 Ma age for the primary ores of the Grants uranium region (Ludwig et al., 1984). Although the isochron is effectively based on two points, the age is reasonable.

The preliminary analyses document high initial ¹⁸⁷Os/¹⁸⁸Os for mineralizing fluids. If we assume an age of 100 Ma, and calculate the initial ¹⁸⁷Os/¹⁸⁸Os from samples M-20-1 and M-14-1, the results are 1.13 ± 0.01 and 1.15 ± 0.01, respectively, within analytical uncertainty of each other and of the initial ratio from the isochron. The fluids transporting the Os were clearly well mixed, and the initial ratio was relatively constant throughout the deposit. These values are reasonable for relatively young, evolved crustal rocks, about mid-way between reported estimates of average sea

water (~1.0; Sharma et al., 1997) and currently eroding continental crust (~1.25; Sharma and Wasserburg, 1997). The most likely source of the Os is the sediment of the Morrison Formation itself, especially the abundant and readily leached volcanic ash. Because the ash is derived from young arc volcanoes, the initial ¹⁸⁷Os/¹⁸⁸Os is within the expected range. Thus, the preliminary results from the Morrison Formation, though still relatively uncertain, are perfectly reasonable.

In nature, the +4 and +7 oxidation states of Re predominate (Morgan, 1999). Under oxidizing conditions in near-surface environments (e.g. seawater, surface or groundwaters) the perrhenate oxyanion (ReO₄⁻) is highly soluble and stable over a wide range of pH. Under anoxic conditions, however, Re is removed from solution. Removal of Re from the pore waters and fixation in the sediment may be aided by adsorption on mineral surfaces. Williams et al. (1997) also note that Os may be very particle reactive. This is supported by the observations of Sharma and Wasserburg (1997), who report lower concentrations of Os in river water samples that were transported back to the lab without treatment, compared to those that were filtered and acidified in the field. Our data corroborate these ideas; both Re and Os concentrations are significantly higher in sample M-14-1 than in M-20-1, despite their spatial proximity and mineralogical similarity. The average grain diameter in M-14-1 is at least a factor of 2 smaller than that of M-20-1, yielding a 4-fold increase in surface area for the same mass of pyrite. Alternatively, the extremely fine-grained organic material present in both samples may be a more important control on scavenging of Re from groundwaters.

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