MIF of S, oölitic ironstones, redox sensitive elements in shales, and the rise of atmospheric oxygen

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Farquhar et al., 2000 discovered that mass independent sulfur isotope fractionation (MIF) defined as $\Delta^{33}S=\delta^{33}S-0.513\delta^{34}S\neq0.0$ is present in sediments >2.45 Ga, and that it is absent in rocks <1.9 Ga. The origin of the MIF was attributed to isotopic effects during gas-phase photodissociation of S species in an O_2-free atmosphere.

We have confirmed the presence of MIF in pyrites from the 2.71 Ga fresh water Ventersdorp Sgr. (Rietgat and Kameeldoorns fms.), the 2.64 Ga marine Schmidtsdrif Gr. (Lokamonna Fm.) both in South Africa, and the ~2.74 Ga Michipicoten Greenstone Belt, Canada. The slope of the best fit line through our data on a $\delta^{33}S$-$\delta^{34}S$ plot is 0.725; the scatter about this line is probably due to a combination of atmospheric processes and biological sulfate reduction.

Pyrites from the marine ~2.3 Ga upper Rooihoogte and lower Timeball Hill fms., Pretoria Gr., South Africa, which are sandwiched between two glacials, fit on the $\delta^{33}S=0.511\delta^{34}S$ slope with almost no scatter. Their $\delta^{34}S$ values range from –34.7 to –23.9‰. These are the oldest known sedimentary sulfides with modern sulfur isotope systematics. The overlying quartzite of the Timeball Hill Fm. contains hematitic oölites and pisolites. The absence of MIF and the presence of ironstone indicates that at least some O_2 was present in the atmosphere ~2.3 Ga. The Duitschland Fm. in South Africa is a time equivalent of the Rooihoogte Fm. The upper Duitschland Fm. contains carbonates with $\delta^{13}C$ values as high as +10.1‰, suggesting that oxygenation of the atmosphere had started by that time.

Black shales from the 2.1–2.0 Ga Lower Albanel Fm., Canada and from the Kainuu Belt, Finland contain pyrites with _$\Delta^{33}S$ _≤0.5 that fit tightly on the $\delta^{33}S=0.510\delta^{34}S$ slope. It is not yet clear whether this apparent tail of MIF is real, and – if so – whether it is relevant to the oxygen content of the atmosphere at that time.

We have found no correlation between the carbon content and the Mo, U, Re, and V content of the 2.1-2.0 Ga Francevillian black shales in Gabon. This correlation seems to exist in slightly younger (~2.0 Ga) black shales in Finland and is well established in the 1.7 Ga black shales of the McArthur Basin, Australia. There is apparently a significant time lag between the disappearance of the MIF signal for sulfur and the appearance of the correlation between the concentration of carbon and the redox trace sensitive elements in black shales.

The Early Evolution of the Solar Nebula with Implications for the Formation of Primitive Material

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I will present a review of our understanding of the early evolution of the solar nebula especially as it bears on the formation of primitive meteorites. Although my emphasis will be on the results of theoretical studies, I will also summarize some of the observational evidence supporting these conclusions. In particular, I will summarize our current best deductions about midplane temperatures and densities of the solar nebula and about both long-term and episodic evolution.