Isotopic evidence for mid-Archean anoxia

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The presence of nonzero $\Delta^{33}S$ and $\Delta^{36}S$ in the Archean and earliest Paleoproterozoic sedimentary rock record is considered to provide the strongest line of evidence for an anoxic early atmosphere. Low atmospheric oxygen is required both for production and transfer of the signal to the geologic record (Farquhar *et al.*, 2000; Farquhar and Wing, 2003, 2005; Pavlov and Kasting, 2002). Temporal trends of sulfur isotopes in the Archean record reveal periods of large amplitude non mass-dependents signals (Early and Late parts of the Archean), and others when the signal was attenuated (Middle Archean) (Ono *et al.*, 2003; Ohmoto *et al.*, 2006), and some workers argue that this interval lacks a non mass-dependent signal and records an early, transient oxygenation of Earth's atmosphere (Ohmoto *et al.*, 2006).

We have investigated this interval and present new analyses of samples from the mid-Archean record (ca. ~2.8 and ~3.0 billion years ago (Gya)) that demonstrate the presence of an unambiguous non mass-dependent signal and is inconsistent with an oxygenated mid-Archean atmosphere. Our results for $\Delta^{33}S$ and $\Delta^{36}S$ indicate however that the character of the non mass-dependent signal is different for this interval in Earth history and provides evidence for changes in the pathways for non mass-dependent chemistry in this interval. This may reflect a change in the chemical composition of the atmosphere and may also be related to the observation of an attenuated $\Delta^{33}S$ signal at this time.

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Incipient eclogite facies metamorphism in a granulite recorded by inclusion pattern and compositional zoning in garnet

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Garnet with prograde zoning in the mesosome of a migmatitic granulite gneiss from the Moldanubian Zone, Bohemian Massif, was studied for PTt evolution using multicomponent diffusion modelling. Garnet in the leucosome has preserved an eclogite facies core, with a granulite facies rim having low Ca and high Fe, Mg and Mn. Both the mesosome and leucosome garnets show partial resorption indicated by inward zoning of Mn and variable Sm/Nd ratio at the garnet rims. Diffusion modelling of the interface between eclogite and granulite facies garnet suggests that modification of the compositional gradient occurred mostly during the granulite facies conditions, above 600-650 ^{o}C. Based on the inferred PT path, heating to the granulite facies conditions of 800 ^{o}C/2GPa with isothermal decompression to 0.8 GPa followed by cooling to 600 ^{o}C would require ~ 1.6 Ma for heating and cooling and ~ 2.4 Ma for relaxation and decompression. This corresponds to heating and cooling rate of 250 °C/Ma which was calculated for the Mn zoning in the garnet rim, and a vertical exhumation rate of ~ 1.7 cm/a. An increase of temperature to 850-900 ^{o}C for the same heating/cooling and exhumation rate would homogenize the garnet, which is the case in most felsic granulites in the Moldanubian Zone. Previous Sm-Nd dating of the prograde zoned garnets constrains their minimum crystallization age to 354 Ma, that is ca 10-20 Ma older than ages recorded by U-Pb system in zircon in felsic granulites. Recognition of two discrete metamorphic events and the calculated PTt path for the granulite may explain the compositional homogenization of garnets in felsic granulites and the reported age differences between eclogites/garnet peridotites and granulites in the Bohemian Massif.