Overturn of anoxic deep ocean happened at ~551 Ma – Evidences from isotopes and trace elements

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In the Ediacaran Period a large dissolved organic carbon (DOC) reservoir [1] prevented deep ocean from oxidation and potentially retarded evolution of metazoan, although atmospheric O_2 concentration had progressively rosen since the Neoproterozoic glaciations. Three negative $\delta^{13}C_{carb}$ excursions of the Doushantuo Formation (635–551 Ma) of South China [1, 2] may reflect complicated oxidation processes and redox fluctuations of the Ediacaran oceans.

The most prominent negative $\delta^{13}C_{carb}$ excursion occurred at the near Doushatuo-Dengying boundary (~551 Ma). At the Tianjiayuanzi-Jijiapo section in the Yangtze Gorges area, the negative $\delta^{13}C_{carb}$ excursion exceeds 15‰, with a decrease from +4‰ of the upper Doushantuo Formation down to −13‰ of the Doushantuo-Dengying boundary and then an increase to +5‰ of the lower Dengying Formation. Interestingly, the $\delta^{34}S_{CAS}$ (carbonate associated sulfate) values show a synchronous negative excursion of exceeding 40‰ and extraordinary negative values less than −10‰ at the base of the Dengying Formation. The synchronous negative $\delta^{13}C_{carb}$ and $\delta^{34}S_{CAS}$ excursions suggest the oxidation of both DOC and H_2S produced by BSR, accompanying the upwelling of euxinic deep water. Redox-sensitive elements in sedimentary carbonate, U, V, Mo, Cu, Ni, Cd, Zn, and Mn, also show a rapid variation at or beyond the Doushatuo-Dengying boundary that their concentrations (normalized by PAAS) increased first and then followed by a decrease. Furthermore, $(Ce/Ce^*)_{SN}$ (normalized by PAAS) generally exceeds 1.0 at the the Doushatuo-Dengying boundary, proving that anoxic and sulfidic water had arrived at shallow shelf at ~551 Ma due to an overturn of deep ocean.

Post-glacial stratified ocean, high biologic productivity, and atmospheric O_2 increase may sustain anoxia and higher H_2S concentration of deep ocean. Our data document that an overturn of deep ocean happened in the Doushantuo-Dengying transition period, suggeting that the overturn of deep ocean may play a major role to reduce DOC reservoir and attain oxidation of the Ediacaran oceans.

[1] McFadden *et al.* (2008) *PNAS* **105**, 3197-3202. [2] Zhou *et al.* (2007) *Chem. Geol.* **237**, 89-108.

Geochemistry of nitric thermal springs of the Far East Russia

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Geochemical data of alkaline nitric thermal springs, occurring on the continental margin of the Far East Russia (Primorye, Khabarovskii and Kamchatka regions) are presented. There are two geochemical groups of thermal waters. On Kamchatka (Paratunka basin) waters are mainly Na-SO_4, whereas in Primorye and Khabarovskii regions Na-HCO_3 type is predominant. Behavior and sources of chemical elements, including REE are discussed in respect to water-rock interaction, residence time, and heat flow. $^{87}Sr/^{86}Sr$ ratio as well as others geochemical tracers allowed to estimate flow pathways and distinguish different groundwater bodies in studied springs. Thermodynamic calculations show that studied thermal waters are oversaturated with respect to albite, adularia, zeolites, clay minerals, and calcite. Most main cations form complexes with HCO_3 (Primorye and Khabarovskii territories) and some of them with SO_4 in the case of Kamchatka. $\delta^{18}O$ and $\delta^{2}H$ ratios indicate that geothermal waters have meteoric origin. In gas phase atmospheric nitrogen is predominant. $^{3}He/^{4}He$ ratio is low in Primorye and Khabarovskii springs, but in Kamchatka this ratio is higher and 23% of helium has mantle origin.

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