Carbon chemostratigraphy of the Paleoproterozoic Belcher, Nastapoka, and Richmond Gulf Groups

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The Paleoproterozoic Lomagundi $\delta^{13}C_{carb}$ excursion between 2.22 and 2.06 Ga corresponds to the most significant period of atmospheric oxygenation and is referred to as the "Great Oxidation Event" (GOE). Large $\delta^{13}C_{carb}$ excursions are often followed by periods of accelerated biological evolution, suggesting that rocks deposited immediately after 2.06 Ga might preserve changes in environmental chemistry and microbial communities after the GOE. The poorly studied rocks of the Belcher, Nastapoka, and Richmond Gulf Groups, along the northwestern margin of the Superior Craton, Canada, have been dated between 2.03 and 1.870 Ga (Chandler and Parrish, 1989; Hamilton et al., 2009), and thus represent ideal rocks to investigate the evolution of microbial communities and of the carbon cycle in a higher redox state. These Paleoproterozoic successions contain exceptionally well-preserved carbonates with abundant and diverse stromatolites. The Belcher Group preserves three successive transgressions of a drowning carbonate platform between two major volcanic episodes (Ricketts and Donaldson, 1989). Progressive transitions from green/gray to red argillites/mudstones and the development of beds of carbonate concretions indicate a progressive oxidation of fine-grained marine sedimentary rocks and organic matter near the end of the second and third megacycles (Tukarak and Costello-Laddie Fms.). Data from the McLeary and Kasegalik Fms. in the Belcher Group show uniform $\delta^{13}C_{carb}$ values around +0.1‰ and $\delta^{13}C_{org}$ values between -26.1‰ and -22.1‰. Current work is focused on completing the carbon isotope chemostratigraphies to establish geochemical correlations between the entire Belcher Group and the correlative Richmond Gulf and Nastapoka Groups.

Formation and evolution of cratonic lithospheric mantle in central Siberia

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Degrees, depth, settings and age of partial melting

A major reason why various models for the formation of cratonic mantle continue to be debated [1] is that the modal and chemical composition of initial melting residues, hence melting conditions, remain poorly constrained. Spl harzburgite xenoliths (Mg# 0.92-0.93) from the Udachnaya kimberlite in the central Siberian craton, unlike most published data on cratonic peridotites, form clear trends on major oxide plots and based on experimental results [2] are residues of 35-40% fractional partial melting of upwelling fertile mantle over a broad depth range (7-1 GPa). By contrast, the majority of garnet peridotites from Udachnaya show metasomatic enrichments in Fe, Ti etc. relative to the residual harzburgites. Dunites (melting degrees >40%) are extremely rare.

Unmetasomatized spl harzburgites yield isochron Lu-Hf age of 1.8 Ga and Sm-Nd age of 2.0 Ga [3]. The early Proterozoic formation of the Siberian lithospheric mantle is also indicated by Re-depletion ages for coarse peridotites from this study [4] that range from 1.5 to 2.6 Ga (av. 1.8 Ga). The Re-Os age range may reflect metasomatic overprinting rather than prolonged craton creation. Garnet peridotites yield Hf- and Nd-isotope WR-isochron ages of 0.7 Ga, apparently dating a major metasomatic event [3].

O-isotope data and the origin of opx-rich peridotites

We report laser-fluorination O-isotope data for olivine and opx from 32 Udachnaya peridotites. Average δ18O for the olivines is 5.18 ± 0.26‰ (2σ), i.e. identical to the mantle olivine average of 5.18 ± 0.28‰ [5]; the opx are on average 0.5‰ heavier than coexisting olivine. Calculated bulk compositions are similar for spl and coarse and sheared garnet peridotites (~5.3‰) and show no relation to modal or major oxide abundances. A sub-group of Udachnaya spl harzburgites have too much opx (31-43% vs. 7-22% in 'normal' harzburgites) to be melting residues. The high opx in Siberian and other cratonic peridotites are commonly attributed to hydrous melting or post-melting silica enrichments in subduction zones. Bulk O-isotope compositions of the opx-rich spl harzburgites are similar to those for all other Udachnaya peridotites. There is no evidence that processes producing opx-rich (or metasomatized) cratonic peridotites impart distinctive O-isotope characteristics; their links to subduction settings remain unsupported by chemical or isotope data. The opx-rich rocks could form by mineral segregation in unconsolidated residues, crystallization of pockets of trapped residual melt etc. We find no evidence that intitial melting residues were dunites later refertilized to harzburgites in subduction zones.

[1] Pearson & Wittig (2008) *J Geol Soc* **165**, 895-914. [2] Herzberg (2005) *J Petrol* **45**, 2507-2530. [3] Doucet *et al.* (2012) *This volume.* [4] Doucet *et al.* (2011) *Miner Mag* **75**, 777. [5] Mattey et al. (1994) *EPSL* **128**, 231-241.