Anomalously high chromium isotope ratios in shelf bottom waters of the Bering and Chukchi Seas

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Previously, we reported the heaviest observed $\delta^{53}Cr$ isotope signatures ($\delta^{53}Cr$ = 3.85‰, 4.15‰) and low [Cr concentrations [Cr] (1.5 nmol/kg) from two samples from the oxic bottom waters of U.S. GEOTRACES Arctic Ocean GN01/HLY1502 station 61 (72.8°N,159.6°W) on the Chukchi Sea shelf within the Arctic Basin [1]. These samples fall far above the linear $\delta^{53}Cr$-ln[Cr] relationship that encompasses most seawater Cr isotope data including those from the western Arctic Ocean. In order to further investigate the chemical and isotopic modification of Cr as Pacific water flows into the Arctic Ocean via the shallow Bering Strait and the Chukchi Sea, we have obtained chromium stable isotope data from three GN01 stations south of the Bering Strait: 1(60.2°N,179.1°W), 2(62.2°N,171.6°W),and 3(64.0°N,166.6°W).

Slope edge Stn 1 is presumed to reflect the source waters for the Pacific inflow. Surface water Cr concentrations [Cr] and $\delta^{53}Cr$ signatures at Stn 1 (3.2 nmol/kg; 0.99‰) are similar to those observed at 30°N 140°W North Pacific station SAFe [2] (3.2 nmol/kg; 1.01 ‰). Surface waters at shelf Stns 2 and 3 nearer the Bering Strait are lower in [Cr] (1.7, 2.3 nmol/kg) and higher in $\delta^{53}Cr$ (1.47‰, 1.30‰), probably due to biological removal along the flow path. Oxic bottom waters of two samples each from these stations near the Bering Strait have very low [Cr] and high $\delta^{53}Cr$ (Stn 2: 1.5 nmol/kg, $\delta^{53}Cr$ 2.97‰, 2.55‰; Stn 3: 1.9 nmol/kg, $\delta^{53}Cr$ 2.30‰, 3.12‰). These Bering Shelf samples triple the number of anomalously high $\delta^{53}Cr$ values in this region. Based on observation of significant [Fe^{2+}] in Stn 61 bottom waters (Maia Heller, personal communication) and high total dissolved [Fe] at all three stations (Mariko Hatta, personal communication), we suggest that Cr reduction by Fe^{2+} diffusing out of reducing sediments may be responsible for the anomalous Cr isotope fractionations. Both the surface waters of the Bering Strait and of the Chukchi Sea are highly productive, the resulting elevated organic matter respiration within the sediments depletes their pore waters of oxygen, and Fe^{2+} is known as an efficient reductant for chromate.

[1] Moos & Boyle, Goldschmidt Abstract 2018. [2] Moos & Boyle (in press), Chemical Geology