The strontium stable isotope composition of seawater during glacial intervals

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The strontium ($^{88}Sr/^{86}Sr$) stable isotope composition of seawater reflects input from continental weathering and hydrothermal exchange at mid-ocean ridges, and output in carbonate sediments. It has been suggested that increased weathering of shelf carbonates accompanying the low sea levels during the last glacial maximum (LGM) will have enhanced the flux of light Sr (from carbonates) to the oceans. However, temperature and species dependent fractionation of Sr stable isotopes during incorporation into marine carbonate has to be quantified in order to accurately reconstruct past seawater compositions.

This study presents high-precision $\delta^{88}Sr$ data, obtained using double-spike TIMs technique. Present-day seawater yields a $\delta^{88}Sr$ composition of 0.356±0.007 ($2\sigma_m$) with no resolvable difference between Pacific, Atlantic and Indian Oceans. *Globigerinoides sacculifer* from sites in the South Atlantic, covering a temperature range of ~10°C, show no systematic variation with temperature. Both *G. sacculifer* and *G. menardii* show systematic variations with growth rate (shell size) with heavier compositions in the larger size fractions. By contrast, *G. aequilateralis* and *G. ruber* show with no systematic variation with shell size. Preliminary $\delta^{88}Sr$ data for *G. ruber* covering the last 70 kyr indicate that there was no resolvable change in the $\delta^{88}Sr$ composition of seawater across the LGM and deglaciation. In this case the postulated enhanced weathering of shelf carbonates during glacial intervals [1], delivering light Sr isotopes to the ocean may not have been as significant as predicted [2] or else was offset by increased production and preservation of carbonates, driving seawater to heavier $\delta^{88}Sr$ values. Alternatively the very long residence time of Sr in the oceans may simply buffer the changes in input or output such that no changes are resolved at the level of precision of this study.

[1] Stoll, H. M. & Schrag, D. P. (1998) *Geochim. Cosmochim. Acta* **67**, 1107–1118. [2] Krabbenhoft *et al.* (2010) *Geochim. Cosmochim Acta* **74**, 4097–4109.

Pb and Sr isotopes and the provenance of the painting materials in 19th century Canada

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Introduction

Cornelius Krieghoff was a 19th century Canadian artist (1815-1872) of winter landscapes and depictions of aboriginal and rural Quebec life. Like many pre-20th century artists, Krieghoff used a pigment known as lead white composed of a synthetic analogue of hydro-cerussite, often with lead carbonate impurities. Krieghoff used lead white in the preparation layer on the canvas and as a white pigment (either alone or in mixtures to lighten other colours). Calcium carbonate was often added as an extender. Samples of lead white and other Pb-bearing pigments of 15 Krieghoff works painted between 1844 and 1871 were also analysed for Pb and Sr isotopes to provide constraints on pigment sources.

Results

The bulk of the lead isotope data yield isotopic compositions that are consistent with data obtained from lead white in European paintings of the same or earlier periods [1, 2]. However, a few samples yielded lead isotope compositions that were more suggestive of a North American origin. The Sr isotope ratios of the samples range from values consistent with Palaeozoic carbonates to values in excess of present day seawater.

[1] Keisch & Callahan (1976) *Archaeometry* **18**, 181–193. [2] Fortunato *et al.* (2005) *Analyst* **130**, 898–906.