The early formation of the continental crust: constraints from zircon Hf-isotope data

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A worldwide database of >16,000 U–Pb and Hf-isotope analyses of zircon, largely from detrital sources, has been interogated to analyse the processes of crustal evolution on a global scale, and to test existing models for the growth of continental crust through time. At any timeslice, most zircons have ε_{Hf} well below the Depleted Mantle (DM) growth curve, reflecting later reworking of originally juvenile material. To quantitatively estimate the proportion of juvenile material added to the crust at any given time during its evolution, it is necessary to correct for this effect. "Crustal" model ages are calculated assuming the zircon-bearing magmas were generated from the average continental crust ($^{176}Lu/^{177}Hf = 0.015$); zircons with non-juvenile Hf are projected back to the DM growth curve using this ratio. Juvenile magmas are defined as having $\varepsilon_{Hf} \geq 0.75$ times the ε_{Hf} of the DM at the time of genesis. The distribution of corrected model ages can then be used to model the true crustal growth rate over the 4.56 Ga of Earth's history. The modelling shows that there was little episodicity in the production of new crust, as opposed to peaks in magmatic ages. The distribution of age-Hf isotope data from zircons worldwide implies that at least 60% of the existing continental crust separated from the mantle before 2.5 Ga, and has been variably reworked since then. However, taking into consideration new evidence coming from geophysical data, and correcting for the geographical biases in database, the formation of most continental crust still earlier in Earth's history (at least 70% before 2.5 Ga) is even more probable. Thus, crustal reworking has dominated over net juvenile additions to the continental crust, at least since the end of the Archean. Moreover, the juvenile proportion of newly formed crust in any timeslice decreases stepwise through time: it is about 70% in the 4.0–2.2 Ga time interval, about 50% in the 1.8–0.6 Ga time interval, and possibly less than 50% after 0.6 Ga. These changes may be related to the formation of supercontinents.

Applications of the Arctic sea ice proxy IP_{25}: Quantitative versus qualitative considerations

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Background

The presence of the sea ice diatom biomarker IP_{25} in Arctic marine sediments has been used in previous studies as a proxy for past spring sea ice occurrence and as an indicator of wider palaeoenvironmental conditions for different regions of the Arctic over various timescales [e.g. 1, 2]. Recent attempts have also been made to make the interpretations of the IP_{25} data more quantitative by comparison of IP_{25} (and other biomarker) concentrations with known sea ice conditions (3). However, the extent to which such calibrations can be extrapolated for longer timescales and for different Arctic regions remains unclear.

Current work

This presentation will focus on recent results, with particular emphasis on the importance of accurate analytical methods for the quantification of IP_{25} in marine sedments and a consideration of the factors that likely influence whether IP_{25}-based interpretations can be considered as qualitative or quantitative. Recent case studies to illustrate these points will be taken from different geological epochs (including modern times, the Holocene and the Younger Dryas) and from a diverse range of Arctic and sub-Arctic regions including the Canadian Arctic and the Nordic Seas. The outcomes of these analyses not only provide important information on past Arctic sea ice conditions, but also help identify areas of research that still require attention.

[1] Belt et al. (2007) *Org. Geochem.* **38**, 16-27. [2] Vare et al. (2009) *QSR* **28**, 1354-1366. [3] Müller et al. (2011) *EPSL* **306**, 137-148.