Provenance of Lower Cretaceous sediments from Svalbard and NE Greenland: A detrital zircon study

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Upper Jurassic – Lower Cretaceous sedimentary successions in the Wandel Sea Basin of North Greenland have previously been shown to correlate stratigraphically with similar aged formations on Svalbard, including the mainly fluvial Helvetiafjellet Fm (Dypvik *et al*., 2002). Detrital zircons from Lower Cretaceous sedimentary formations from the Wandel Sea Basin (Kilen and Peary Land) and Svalbard (the Helvetiafjellet Fm.) have been dated by U-Pb and analysed for Lu-Hf isotopes by laser ablation plasma source mass spectrometry (LAM-ICPMS). Samples from all three areas display a similar range of U/Pb ages, with significant zircon populations at 1.0 – 1.2, 1.8 – 2.0 and 2.6 – 2.8 Ga. Major hiati occur between 2.1 and 2.4 and from 0.48 to 0.91 Ga. Low initial $^{176}Hf/^{177}Hf$ ratios indicative of recycled older crust are predominant in Caledonian-aged zircons, in the Palaeoproterozoic 1.8 – 2.0 Ga populations, and among late Archean zircons. Other U/Pb age populations in the studied samples are dominated by zircons with positive ε_{Hf} values, indicating a significant contribution of mantle-derived material. There is commonly a narrow range of ε_{Hf} values seen within the various U/Pb age population, and the values seen in the different samples are in general correlated with the different age populations. One exception is the 1.8 – 2.0 Ga population where variations suggest variable sources for this age group. The U/Pb data indicate that Greenland could be the sole source of the studied sandstones, which to a large extent is supported by Lu/Hf data. However, concordant ages in the range 1.0 – 1.1 Ga are generally infrequent in the published record from Greenland, and no large terrane of this age have as yet been discovered in Greenland. This mismatch suggests the presence of a source outside the Greenland subcontinent.

The sedimentological link between Mesozoic sediments on Svalbard and North Greenland has been known for some time. This work demonstrates that the two areas most likely had the same areas of provenance, documented by near identical U/Pb age and Lu/Hf isotope signatures of detrital zircons.

References

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Metal saturation in the upper mantle

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The uppermost mantle represented by samples and partial melts appears to be quite oxidized at oxygen fugacities (fO_2) around the FMQ equilibrium. However, whether the oxidation states found in shallow mantle regions are representative for the entire upper mantle remains unclear. There is evidence for reduction with depth. Thermodynamic model calculations and analyses of natural garnet peridotite samples indicate that fO_2 in the upper mantle decreases with increasing pressure [1]. In addition, experiments have shown that phases stable in the transition zone (400 to 670 km) and the lower mantle (670 to 2900 km) can incorporate so much Fe^{3+} that an Fe–rich metal phase is likely to be stable [2,3].

To simulate redox controls in the upper mantle experimentally, we have equilibrated Fe_2O_3–free synthetic fertile mantle material in metallic Fe capsules between 1 and 14 GPa and 1220 to 1650°C. fO_2 at run conditions, approximated from the FeO content of the silicates, are IW – 0.5 to –1.2. Analyses of pyroxene and garnet with Electron Energy Loss Spectroscopy (EELS) show that above 7 GPa, subcalcic pyroxenes and majoritic garnets incorporate so much ferric iron that a mantle composition with 8 wt.% FeO and 2000 ppm Fe_2O_3 will be within metal saturation. Hence, the earth's upper mantle at > 250 km depth is likely to be saturated with an (Fe,Ni) metal phase.

It was proposed [3] that the high ferric iron concentrations noted in experimental transition zone and lower mantle phases may be derived by disproportionation of ferrous iron components in silicates, according to $3FeO = Fe° + Fe_2O_3$. If this was the case for the upper mantle, the $Fe°–Fe_{1-x}O–Fe_3O_4$ triple point in the Fe–O system (at ~ 570°C at 10^5 Pa) should be shifted to higher temperature with increasing depth. An in–situ determination of the wuestite–magnetite phase transition between 0.5 and 5 GPa in the presence of metallic Fe in the MAX80 high pressure device, using white synchrotron radiation, shows that the disproportionation reaction has a negative slope in P–T space. Therefore, to relate the high ferric iron concentrations in upper mantle pyroxene and garnet to pressure–induced FeO disproportionation alone seems a simplistic view.

References

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