Persistence of early Archean style of crustal growth and near-chondritic mantle into the late Archean

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The Neoarchean Lewisian Complex of north-west Scotland is one of the most extensively studied TTG gneiss terranes on Earth. It has been used to propose and refine models of crustal evolution for over a century, from the early recognition of multiple phases of crustal reworking based on cross-cutting dykes [1] to the more recent "terrane models" proposed for crustal accretion [2]. Interpretation of both geochronology and isotopic data from the Lewisian, however, remains complicated (e.g. [3]) by polyphase metamorphism, which in places attains granulite facies.

In this study, we present cathodoluminescence image-guided ion microprobe U-Th-Pb geochronology and LA-ICP-MS Hf isotopes of zircon separated from representative TTG gneisses across the Scottish mainland and Outer Hebridean Lewisian outcrop. Applying a similar methodology to that outlined in [3], we assign a preferred magmatic protolith age to each zircon population and this age is then used to calculate $\varepsilon_{Hf}(t)$ values.

Over a wide range of protolith ages from > 3.1 Ga to 2.7 Ga, zircon $\varepsilon_{Hf}(t)$ values are, on average, only slightly super-chondritic and show relatively little variation with time. A possible explanation for this trend is that younger TTG magmas are increasingly influenced by recycling of older crust, although few older zircon cores are observed to support such an *ad hoc* interpretation. As an alternative, we propose a tectonic model for the Lewisian in which mafic precursors to the TTG magmas, generated from a mildly depleted to near-chondritic mantle, were rapidly recycled over a period of >400 Ma with little or no direct input of typical contemporaneous depleted-mantle. Similar tectonic scenarios, differing markedly from "modern-style" plate tectonics, have been proposed for the early Archean (e.g. [4]) and our observations from the Lewisian TTG gneisses suggest that, at least locally, similar processes, as well as near-chondritic mantle, may have persisted into the Neoarchean.

[1] Peach *et al.* (1907), *Mem. Geol Surv. GB*. [2] Kinny *et al.* (2005), *J. Geol. Soc. Lond.* 162, 175–186. [3] Whitehouse & Kemp (2010), *Geol. Soc. Lond. Spec. Publ.* **335**, 81-101. [4] Naeraa *et al.* (2012), *Nature* 485, 627-630.

Increasing greenhouse gas emissions in circumpolar regions due to climate change-induced permafrost retreat

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Thawing permafrost peatlands substantially influence northern ecosystems by changing the regional hydrology and mobilizing the vast carbon (C) reserves that results in increased greenhouse gas (GHGs) emissions to the atmosphere. With permafrost distribution controlled largely by topography and climate, our IPY study intensively monitored the local C-cycling processes and GHG fluxes associated with different hydrologic and permafrost environments at 4 sites along a latitudinal climatic gradient of mid-boreal, boreal, low and high subarctic ecoclimatic regions that extend south-north from the Isolated Patches Permafrost Zone (northern Alberta), to the Continuous Permafrost Zone (Inuvik, NWT). Each site encompasses a local hydrologic and vegetation gradient from upland forest and peat plateau to collapse scar.

Our multi-year measurements of peatland profiles and flux chambers for CH_4 and CO_2 concentrations and stable isotope ratios indicate processes, including methanogenesis, methanotrophy, transport and emission that control the distribution of these GHGs. These relationships are modulated by fluctuating local soil water and ecosystem conditions. The gas geochemistry shows that significant surface CH_4 production occurs by both hydrogenotrophic and methyl-fermentative methanogenesis in submerged, anaerobic peats, e.g., collapse scars, whereas methane oxidation is restricted to aerobic, drier environments, e.g., upland sites and peat-atmosphere interface. The most active methanogenesis and emissions are in the actively thawing permafrost sites contrasting with those under continuous permafrost. This degree of methanogenesis is being amplified by the increased rate of warming and the rapid retreat of permafrost in Canada's northern areas (ca. 2.5 km/yr).

For context, the present permafrost and GHG emission situation is compared with the rapid rises in temperature, CH_4 and CO_2 concentrations during the Younger Dryas-Preboreal transition (~11.5yBP). Our pCH_4 and $\delta^{13}CH_4$ work [1] on Pakitsoq, Greenland ice show that the rapid rise in pCH_4 during YD-PB is unlikely to have been due to massive marine gas hydrate release ('clathrate gun'), but that CH_4 from permafrost retreat after Last Glacial Maximum is a plausible explanation.

[1] Schaefer, *et al.* (2006) *Science* **313**, 1109-1112.

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