Direct ventilation of the North Pacific did not reach 2300 m during the last glacial termination

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It has recently been argued that the North Pacific circulation during HS1 (18-14.6 kyr) was distinct from both the LGM and the warmer intervals that followed, with a greater formation of 'deep waters' sinking to 2500-3000 m. This intriguing conjecture appears to be inconsistent with a number of geochemical proxies measured at multiple North Pacific core sites from this depth range.

'Ventilation' involves the input of atmospherically-equilibrated waters to the ocean interior. Well-equilibrated waters have high concentrations of oxygen and relatively low concentrations of dissolved carbon dioxide. Bottom waters with high oxygen concentrations inhibit the diagenetic enrichments of some redox-sensitive trace metals in underlying sediments, while low concentrations of carbon dioxide (relative to alkalinity) produce high carbonate ion concentrations, encouraging preservation of calcium carbonate ($CaCO_3$) microfossils in sediment. Thus, poorly ventilated bottom waters are likely to show both sedimentary authigenic U enrichments and poor $CaCO_3$ preservation. Measurements at sites from the NW Pacific and in the Bering Sea show that, at 2393 m and 2209 m water depth, respectively, these twin hallmarks of poor ventilation reigned throughout the LGM and HS1, to finally disappear after ~15 ka. This sequence of change is consistent with a poorly ventilated deep ocean throughout this interval that extended from the abyss to within < 2500 m of the surface. The assembled evidence does not appear to provide an opening during the deglaciation during which the North Pacific water could have pumped oxygenated waters into the deep.

A new starting point for the mantle's geochemical reservoirs

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The present-day terrestrial mantle, as sampled by melts that erupt at the surface, is chemically and isotopically heterogeneous. The discovery of a surviving portion of the early-formed silicate Earth that existed immediately after formation of the core—referred to as primitive mantle—would place constraints on the earliest chemical evolution of the Earth. Such a discovery would also provide a starting point to understand the origin and long-term evolution of the various geochemically-distinct mantle reservoirs that now make up Earth's interior. Earth's primitive mantle has long been thought to be compositionally similar to primitive chondrites, at least for the refractory, lithophile elements. However, the recent discovery that modern terrestrial lavas have $^{142}Nd/^{144}Nd$ ratios ~18 ppm higher than chondrites suggests that the Earth's primitive mantle has a Sm/Nd ratio that is ~5% higher than chondrites [1], and that all modern terrestrial mantle and crustal reservoirs ultimately were derived from this reservoir with superchondritic Sm/Nd. Today, the $^{143}Nd/^{144}Nd$ of the primitive (albeit non-chondritic) reservoir would be ~0.5130, a ratio that is closer to the depleted MORB mantle than to chondritic. In order to extract the continents from the non-chonditic primitive mantle, the depleted mantle reservoir must comprise > 50% of the mass of the mantle, thus extending into the lower mantle. Another implication of a non-chondritic Earth is that it provides a new reference for the composition of primitive mantle (e.g. $^{143}Nd/^{144}Nd$ = 0.5130), and reservoirs that were once considered depleted relative to chondritic (e.g. HIMU, with $^{143}Nd/^{144}Nd$ = 0.51285) are actually enriched relative to the postulated non-chondritic mantle. The observation that the most frequently-occurring $^{143}Nd/^{144}Nd$ ratio (0.5130, PREMA) in ocean island basalts (OIB), including lavas with high $^{3}He/^{4}He$, overlaps with the value suggested for a non-chondritic mantle (0.5130) suggest that large portions of the mantle sampled by OIB remain little-modified with respect to $^{143}Nd/^{144}Nd$. If the Earth's primitive mantle is not chondritic and a portion has survived in the deep Earth to the present-day, we consider the best candidate to be the mantle reservoir sampled by lavas with the highest $^{3}He/^{4}He$.

[1] Boyet and Carlson, *Science*, (2005).