The relationship between $\Delta^{14}C$ and $\delta^{13}C$ of DIC in the LGM Ocean

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Reconstructed atmospheric radiocarbon activities ($\Delta^{14}C$) during the last glacial period were higher than can be explained by ^{14}C production rates, seemingly requiring reduced ventiliation of the glacial deep ocean relative to the preindustrial ocean. Estimates of glacial deep ocean $\Delta^{14}C$ generally support this prediction; though large uncertainites exist in deep ocean paleo-$\Delta^{14}C$ reconstructions due to the paucity of records, generally low sedimentation rates in the deep ocean, bioturbative mixing of foraminifera of differing ages, and uncertain surface reservoir ages. Due to these uncertainties there is currently no consensus regarding the spatial extent or the degree of ^{14}C depletion in the glacial deep ocean. The lack of a strong decrease in $\delta^{13}C$ in the glacial deep Pacific Ocean has been used as an argument against the existance of a large ^{14}C-depleted water mass. However, the distributions of ^{14}C and ^{13}C of dissolved inorganic carbon are not strictly analogous. For example, in the modern ocean, differences in the depths of organic carbon remineralization vs water mass aging cause the slope of the relationship between $\delta^{13}C$ and $\Delta^{14}C$ to increase with water depth.

We explore the relationship between $\delta^{13}C$ and $\Delta^{14}C$ during the Last Glacial Maximum (~19-23 kyr BP) using a global compilation of published measurements. Despite the uncertainties listed above, there is credible evidence that deep waters in the North Atlantic, Southern Ocean and Eastern Equatorial Pacific were depleted in ^{14}C during the LGM. The decrease in deep Pacific $\Delta^{14}C$ with little associated change in $\delta^{13}C$ is equivalent to a steepening of the $\delta^{13}C$ - $\Delta^{14}C$ relationship. We suggest that this steepening may be explained by reduced organic carbon remineralization rates in the glacial deep Pacific and/or changes in preformed $\delta^{13}C$ and $\Delta^{14}C$ values. We discuss the evidence for such changes and the implications for reconstruction of the glacial ocean carbon cyle.

Rollback-enhanced decompression melting of a volatile-rich mantle: The ancient lavas of Mt. Etna

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Mount Etna, Europe's largest and most active volcano, sits above a complicated tectonic setting near the intersection of the Tyrhennian, African and Ionian plates. Geophysical evidence suggests that the large volumes of mafic lavas at Etna and the neighboring Hyblean plateau are due to enhanced melting caused by perturbations in mantle convection associated with the oversteepened Ionian slab. Here, we present new Sr-Nd-Hf-Pb data on ancient Etna basalts. We use these data, together with new major/trace element and literature data, to constrain the source lithologies responsible for early Etnean magmatism. Our sample suite includes basal tholeiites followed (at ~ 200 ka) by lavas of dominantly transitional and alkaline compositions. Major and trace element trends within the tholeiitic and alkaline series can separately be modeled by fractional crystallization, but processing through crustal magma bodies cannot satisfactorily explain the links between these two compositional series. Isotopic data are distinctive between the two groups, with the tholeiitic lavas bearing less radiogenic Sr ($^{87}Sr/^{86}Sr < 0.7032$) and Pb ($^{206}Pb/^{204}Pb < \sim 19.6$, $^{208}Pb/^{204}Pb < \sim 39.3$) when compared to the alkaline lavas ($^{206}Pb/^{204}Pb \sim 20$, $^{208}Pb/^{204}Pb > \sim 39.5$). Nd and Hf isotopic signatures define narrower ranges, with shifts of $< 2\ \varepsilon$ units across this compositional boundary and markedly more radiogenic compositions than modern Etna lavas. We interpret the isotopic data to signify mixtures of MORB mantle and enriched mantle (defined as where MORB and OIB mantle compositions generally intersect). Major element modeling using compositions of the most magnesian basalts from early Etna lavas, as well as those from the associated Hyblean plateau, indicates that these lavas represent melting from relatively fusible lithologies (volatile-rich peridotites and pyroxenites) with lower solidi than ambient asthenospheric mantle. The prevalence of fusible lithologies coupled with enhanced convection due to the unique tectonic setting, gives rise to the voluminous volcanism in the Etna /Hyblean region.