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Atmospheric $\delta^{13}CO_2$ and $\delta^{13}C$ in planktonic foraminifera during the last 150 kyr reconciled by simulations including the carbonate ion effect on isotopic fractionation during calcite formation

Content

The $\delta^{13}C$ from CO_2 ($\delta^{13}CO_2$) in ice cores covering the last 150 kyr contains, besides other variabilities, a 0.4permil trend between the Penultimate and the Last Glacial Maximum (PGM and LGM) and a wide and deep minimum around 60 kyr BP, both of which are still not understood. Here we use BICYCLE-SE, a model of the global carbon cycle, and new compilations of marine $\delta^{13}C$ data for a revised interpretation this $\delta^{13}CO_2$ time series. We find that in addition to rather well known variability in ocean circulation, and the marine and the terrestrial biology, solid Earth processes are potentially necessary to explain the reconstructed $\delta^{13}C$ data. In detail, variability in the $\delta^{13}C$ signature of volcanic CO_2 outgassing, or of $\delta^{13}C$ of weathered carbonate rock could explain at least the long-term trend in $\delta^{13}CO_2$ between PGM and LGM, while for an explanation of the minimum around 60 kyr BP the necessary assumptions on $\delta^{13}C$ signatures are outside of ranges supported by data. A 400-kyr variability in marine $\delta^{13}C$, potentially related to weathering, has been identified for various epoch of the Cenozoic. We will identify how such a 400-kyr variability in weathering can help in the interpretation of the $\delta^{13}C$. Our simulation results cleary show, that the global mean surface ocean $\delta^{13}C$ contains most of the dynamics already found in atmospheric $\delta^{13}CO_2$. This finding is supported by a data/model comparison of marine $\delta^{13}C$. Especially, when comparing a non-polar global $\delta^{13}C$ stack from planktonic foraminifera (here restricted to data based on the species *G. ruber*) with simulation results the importance the so-called carbonate ion effect (the isotopic fractionation during calcite formation within *G. ruber* as function of surface ocean CO_3^{2-}-concentration) for an understanding of the ^{13}C cycle becomes apparent.

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