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Calcite vein U-Pb and Sr isotope constraints on the age and duration of seafloor alteration

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The uppermost part of the ocean crust can be strongly carbonated with carbonate minerals amounting to 0.1-0.2 wt % CO2 in modern crust, up to ~3 wt % CO2 in Jurassic age crust from ODP site 801 and up to 5 wt% CO2 in Cretaceous age crust from DSDP site 417/418. These data suggest carbonation of ocean crust either continues over very protracted periods of time or has operated at different rates through Earth's history. Investigating the timing of carbonation is critical to assess the long-term CO2 cycle, the chemistry of seawater and the duration of seafloor alteration that impacts the geochemical cycles of other fluid mobile elements in subduction zones.

We selected 25 vein samples from ODP site 801 and 29 vein samples from DSDP sites 417/418. The U content of the veins is highly variable ranging from <10 ppb up to > 10 ppm. Seafloor carbonates with more than ~300 ppb U yield reliable dates, whereas veins with less than 100 ppb U yield imprecise ages or no age data. The majority of veins from site 801 yield U-Pb ages that indicate formation during a ~30 Myr period between 192 +/- 6 Ma and ~162 Ma. The oldest age indicates the Pacific's oldest ocean crust is 25 Ma older than previously recognised. The cumulative age distribution of these samples indicates the seafloor concentration of ~3 wt % CO2 can be explained by a carbonation rate similar to today's maximum (Kendrick et al., 2022). In contrast, only about half the samples selected from sites 417/418 yielded U-Pb ages, with a large number of samples dominated by common Pb. Most veins have U-Pb or Sr isotope stratigraphic ages within 30 Myr of crustal accretion, requiring a carbonation rate significantly higher than observed today. Overall, the data from both sites indicate most carbonation occurs with 30 Myr of accretion. However, a few veins from both sites formed ~60 Myr after accretion. Collectively, the data suggest the elevated CO2 content found in Cretaceous-age ocean crust is a product of both its age and higher carbonation rate in the geologic past.