The fate of carbon during oceanic crust alteration through time

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Although it is largely accepted that volatiles are incorporated into the oceanic crust during alteration by seawater and hydrothermal fluids, the flux of C involved in this transfer remains poorly known. We conducted a study of C concentration and isotopic composition in 170 My old altered basalts (Hole ODP 801C, western Pacific oceanic crust). They were selected to constrain the variability of C uptake with oceanic crust aging by comparison with young 15 My old altered basalts (Hole 1256D). Hole 801C basalts show total C content between 0.3 to 2 wt% CO_2 and are enriched in C relative to the fresh basalts and the young basalts from Hole 1256D. In the upper part of the oceanic crust (depth < 300 m below basement), C is incorporated mainly as carbonates (~1 wt% CO_2). These carbonates are precipitated from seawater dissolved inorganic C. Below 300 m depth in the basaltic basement, the carbonate C content decreases drastically down to an average value of 0.06 wt% CO_2 while ~70% of the total C is then contained as reduced C (C-H-O and C compounds). This C does not show major variation with depth and is similar, both in terms of concentration (≈ 0.3 wt% CO_2) and isotope composition (≈ -21 ‰), to that in the young basalts of Hole 1256D. This suggests that it originates from the early history of oceanic crust, close to the ridge axis, and did not increase significantly with time. This reduced C was probably produced from abiotic reduction of magmatic CO_2 at relatively high temperatures (≥ 300-400°C), explaining why it was not incorporated anymore in the cold crust, away from ridge axis. Despite the sediment blanketing, which reduces the seawater accessibility to the oceanic crust, circulation of seawater was still active in the 170 My old oceanic crust as shown by the occurrence of young carbonates in the upper part, where the porosity remains high. Using these data and published C data on basaltic and serpentinized oceanic crusts, we have computed that most of the basaltic oceanic crust is dominated by C with $\delta^{13}C$ below -15 ‰ which does not fit with the C released in arc volcanism (mainly > -10 ‰) that is supposed to come from the devolatilization of subducted old oceanic crust. Only the upper part of the basaltic oceanic crusts and the sediments have C with $\delta^{13}C$ above -10 ‰.

[1] Shilobreeva et al., GCA, 75, 2237-2255