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Mantle carbon concentration: Still essential, still unresolved. New constraints and considerations

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Establishing the carbon content of the BSE is fundamental to understanding accretion and differentiation, as well as to the long-term operation of deep Earth volatile cycles. Despite intensive study, significant discrepancies remain in BSE C estimates. An influential estimate based on ratios to other volatiles (N, Ar, He) in basalts and volcanic gases inferred mantle C equal to 765±300 ppmw (Marty, 2012), whereas a survey of CO_2/Ba ratios of putatively undegassed basalts (Hirschmann, 2018) arrived at a value that is a factor of 7 lower, 110±40 ppmw. Recently, Marty (2020) derived a revised estimate of 337-479 ppmw based on C/N ratios of continental gases and basalts. New available data from basalts, based on CO_2/Ba or $CO_2/^3$He ratios reinforce the earlier low CO_2/Ba-based estimate. Though they also indicate that some mantle domains have more diverse CO_2/Ba, these appear to be from sources that do not represent a volumetrically significant portion of the mantle.

High estimates of mantle C imply superchondritic BSE C/N (160-220) and C/S (1.5-2) that seemingly could only be produced by extraction of high S cores, presumably on precursor planetesimals, and require large differences in exosphere/convecting mantle CO_2/Ba and CO_2/Nb ratios (CO_2/Ba: 40±14 vs. 310-440; CO_2/Nb: 1620±730 vs. 2400-3600), which cannot be reconciled with observed exosphere Ba and Nb unless >80% of volcanogenic C returns to the convecting mantle by subduction. The new C estimate from C/N diminishes the previous discrepancy with the CO_2/Ba-derived values by a factor of 2, suggesting that different approaches may eventually converge. One possible explanation for the remaining discrepancy is that mantle N may be overestimated, resulting in higher BSE C from C/N ratios. A second interpretation, that low mantle C based on basalt CO_2/Ba is underestimated owing to undetected degassing, cannot account for the similarity of CO_2 fluxes at ridges and Hawaii based on CO_2/Ba to those derived from $CO_2/^3$He and from O isotopes. Inferred high mantle C does not imply a deep volatile-rich portion of the mantle that is untapped by oceanic volcanism – as the C/N ratio evidence comes from sources geochemically similar to common oceanic basalts.