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The link between subducted marine microalgae and volcanic arc emissions

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Ocean sediments consist mainly of calcium carbonate and organic matter (phytoplankton debris). Once subducted, some carbon is removed from the slab and returns to the atmosphere as CO_2 in arc magmas. Its isotopic signature is thought to reflect the bulk fraction of inorganic (carbonate) and organic (graphitic) carbon in the sedimentary source. Tumiati et al. (2022) challenged this assumption by experimentally investigating model sediments composed of ^{13}C-$CaCO_3$ + ^{12}C-graphite interacting with water at pressure, temperature and redox conditions of an average slab–mantle interface beneath arcs. We demonstrated that oxidation of graphite is the main process controlling the production of CO_2, while CO_2derived from carbonate decomposition/dissolution is negligible. The isotopic composition of CO_2 reflects therefore the CO_2/$CaCO_3$ rather than the bulk graphite/$CaCO_3$ (i.e., organic/inorganic carbon) fraction. Tumiati et al. (2022) also provided a mathematical model to predict the arc CO_2 isotopic signature on the basis of the fluid–rock ratios and of the redox state in force in its subarc source. In order to test the model in a carbonate + graphite system characterized by natural isotopic compositions, we replicated the experiments using dried cultured coccolithophores instead of marked compounds. Coccolithophores, which constitute the best part of open ocean sediments above calcite compensation depth, are able to provide at the same time calcium carbonate (coccoliths) and organic matter (cell material), which become aragonite and graphitic carbon, respectively, at the run conditions of 3 GPa and 700°C. We demonstrated that the model published by Tumiati et al. (2022) fits well the new experimental data, and it confirms to be valid to predict the isotopic composition of CO_2 emitted by arc volcanism even for low amount of graphite < 1 wt%, which is the assumed to be the average abundance in marine sediments.

Tumiati S., Recchia S., Remusat L., Tiraboschi C., Sverjensky D. A., Manning C. E., Vitale-Brovarone A., Boutier A., Spanu D., Poli S (2022). Subducted organic matter buffered by marine carbonate rules the carbon isotopic signature of arc emissions. Nature Communications, 13: 2909. DOI: 10.1038/s41467-022-30421-5.