Efficiency of organic carbon subduction constrained by the solubility of carbon in hydrous slab melt at graphite saturated conditions

R. DASGUPTA[1] AND M. S. DUNCAN[1,2]

[1]Dept. of Earth Science, Rice University, Houston, TX 77005 (Rajdeep.Dasgupta@rice.edu)

[2]Geophysical Laboratory, Carnegie Institution of Washington, Washington, DC 20015 (mduncan@carnegiescience.edu)

The cycle of carbon between the Earth's interior and the ocean-atmosphere system is a critical process in planetary differentiation, redox evolution of the planet, and planetary habitability. The balance of a planet scale carbon cycle, i.e., the net flux of carbon between the Earth's interior and exterior relies heavily on the fate of carbon during subduction. While the fate of carbonates during subduction has been constrained in numerous studies, little is known how organic carbon is quantitatively transferred from the Earth's surface to the interior. Here, we conducted high pressure-temperature experiments to determine the carbon carrying capacity of slab derived, rhyolitic melts under graphite-saturated conditions to constrain the subduction efficiency of organic carbon, the remnants of life, through time.

Experiments were performed at 1.5-3.0 GPa and 1100-1400 °C on a model hydrous rhyolitic melt in graphite capsules. Experimental glasses were measured for carbon and water by FTIR and SIMS and for major elements by EPMA. Based on our experimental data, we developed a thermodynamic model of CO_2 dissolution in slab melts, with which we quantify the extent of organic carbon mobility as a function of slab parameters (pressure, temperature, and oxygen fugacity) during subduction.

Our data and model suggest that the subduction of graphitized organic carbon, and the formation of graphite/diamond by the reduction of carbonates at depth, remained efficient even in ancient, hotter subduction zones – conditions at which subduction of oxidized carbon likely remained limited. We suggest that the lack of remobilization in subduction zones and deep sequestration of organic (reduced) carbon in the mantle likely facilitated the rise and maintenance of higher atmospheric oxygen in the Paleoproterozoic and is causally linked to the Great Oxidation Event. Efficient subduction of reduced carbon also explains the presence of ancient mantle diamonds with light carbon isotope signatures, and could have suppressed the oxidation or even caused reduction of the mantle until subduction of oxidized species started to dominate.