'Green' geosequestration: Secure carbon sequestration via plant silica biomineralisation

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Phytoliths form via biomineralization processes as microscopic grains of silica in plants, especially grasses. During plant growth a proportion of the organic carbon produced by plants is encapsulated by silica within the microscopic phytoliths. This phytolith occluded carbon (PhytOC) usually comprises much less than 1% of the dry weight of plants, and less than 10% of the total carbon pool in grassland topsoils (with ages of < 200 years). However, data from soil chronosequences shows that the high resistance of the PhytOC fraction (relative to the other soil carbon fractions) against decomposition processes results in PhytOC comprising ~70% of the total carbon pool in grassland topsoils that have been isolated for >3,000 years from fresh plant material addition by burial. Therefore, unlike most plant matter, which readily decomposes returning CO_2 to the atmosphere, the organic carbon occluded in phytoliths effectively sequestrates carbon in soils and sediments in a very secure manner. This 'green' geosequestration process (i.e. occlusion of carbon in phytoliths) is currently responsible for the secure sequestering within soil of ~300 million tonnes of CO_2 equivalent per year globally.

More over different plant types biomineralise silica and yield PhytOC at greatly different rates. Some major crops produce over 100 times more PhytOC than other major crop types. Furthermore, varieties within a single major crop type, such as sugar-cane and sorghum, have been found to produce widely differing quantities of PhytOC. This suggests that crop/cultivar choice decisions by farmers and foresters etc have a considerable impact on the amount of soil carbon sequestered and are a significant contributing factor affecting the global carbon cycle. It follows that the management of PhytOC in crops, pastures, forests etc has the potential to greatly enhance the current rates of secure terrestrial carbon sequestration.

Subducted noble gas and halogen preserved in wedge mantle peridotite from the Sanbagawa belt, SW Japan

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Water-rich fluids released from subducting slabs play an important role in arc volcanism. Indeed, subduction volcanism is thought to efficiently return volatiles contained in subducting material back to the Earth's surface. Less than 100% removal of the volatile component may result in volatile recycling into the deep mantle [1]. The volatile composition of subducting fluids is however, not well characterised. The Higashi-akaishi peridotite body in the Sanbagawa metamorphic belt, southwest Japan, is possibly a unique example of a km-scale sliver of a former mantle wedge exhumed from depths of at least 100 km. Serpentine dominated micro-inclusions in olivine grains in the peridotite are regarded as relics of former water-rich inclusions developed in the wedge mantle above a subducting slab. Thus, it is expected that these micro-inclusions should preserve characteristics of slab-derived fluids. Determination of their compositions could provide important geochemical constraints on subduction zone processes.

Noble gas and halogen determination of the micro-inclusions has been carried out using noble gas isotope analysis of both neutron-irradiated and unirradiated samples. The following isotopic characteristics have been determined: (1) $^3He/^4He$ ratios of 1.4-1.8 Ra represent a mixture of mantle and radiogenic He; (2) $^{40}Ar/^{36}Ar$ ratios up to 470 are close to the atmospheric ratio with a small contribution of mantle and/or radiogenic Ar; (3) Seawater-like noble gas elemental ratios enriched in heavy noble gases; and (4) halogen (Cl, Br, and I) composition is similar to marine pore fluids and brines. These characteristics imply that noble gases and halogens with compositions little different to marine pore fluids are injected into the mantle wedge just above the subducting slab.

The subducted halogen and noble gas elemental ratios are clearly distinct from those of arc volcanic gases. This implies that the Higashi-akaishi peridotite body has frozen in and preserved an inferred but previously unseen part of the volatile recycling process. Return of these volatiles to the atmosphere via arc volcanism requires the addition of a mantle component and fractionation during degassing. A small proportion preserved in the downgoing slab can explain the heavy noble gases observed in the convecting mantle.

Reference

[1] Holland G. and Ballentine C. J. (2006), Seawater subduction controls the heavy noble gas composition of the mantle, *Nature* **441,** 186-191.