Agriculture's impact on the Si cycle by accelerated biomineralisation

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Biogenic silica plays a major role in the global cycling of silicon [e.g. 1] and in processes such as mineral weathering, soil acidification, and regulation of atmospheric CO_2. Phytoliths form by silicon biomineralisation within plants (especially grasses) and constitute a major pool of biogenic silica. Biogenic silica production rates reported for natural vegetation communities have a mean of ~70 $kgSiO_2ha^{-1}yr^{-1}$ [e.g. 2, 3, 4], but vary widely from only 2 $kgSiO_2ha^{-1}yr^{-1}$ to up to 1, 380 $kgSiO_2ha^{-1}yr^{-1}$ for a tropical bamboo forest [5]. This data indicate a global silica phytolith production rate of ~1 billion tons of SiO_2yr^{-1} prior to agricultural development.

However, many agricultural crops and pastures are based on silica-accumulating grass species that produce silica phytoliths far in excess of that produced by most natural vegetation communities. For example, silica phytolith production rates in grass crops such as rice, wheat, sugar cane and bamboo are usually an order of magnitude greater than those observed for most natural vegetation communities [6, 7, 8] and can be over 3, 000 kg per ha^{-1} yr^{-1} [8].

Accelerated silicon biomineralisation consequent of agriculture not only results from higher silicon uptake within such crops but also by the increased biomass produced by agricultural practices such as fertilisation and irrigation.

Further factors that impact the global silicon cycle from this process include: 1) the large area being cultivated annually with high silica phytolith producing crops and pastures (e.g. ~0.7 billion ha under cereal crops alone), and 2) the slow turnover rates of silica phytoliths (e.g. >300 yrs under tropical rainforests [4] and grasslands [3]).

The results presented here show that agriculture, by greatly accelerating the production of biogenic silica from the cultivation of high silica phytolith producing plants, has considerably impacted the silicon cycle with implications for other silicon-associated geochemical processes. Such implications are explored in this paper.

[1] Derry *et al.* 2005. *Nature*, **433**, 728–731. [2] Cornelis *et al.* 2010. *Biogeochem.* ***97**, 231–45.*[3] Blecker *et al.* 2006. *Global Biogeochem. Cyc.* **20**, 3023. [4] Alexandre et al, 1997. *Geochim. Cosmochim. Acta,* **61**, 677–82. [5] Meunier et al, 1999. Geology, **27**, 835–87. [6] Parr *et al.* 2009. *Sugar Tech* **11**, 17–21. [7] Parr & Sullivan (In press) *Plant & Soil.* [8] Parr *et al.* 2010. *Global Change Biol.* **16**, 2661–7.

2575 Ma age of Nuvvuagittuq metamorphic garnet

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The recent discovery of pre-3.75 Ga metasedimentary rocks in the Nuvvuagittuq supracrustal belt (NSB) of northern Quebec, Canada, provides a new suite of rocks to further our understanding of Eoarchean Earth process. The NSB includes a CaO-poor (cummingtonite) amphibole, plagioclase, biotite, quartz and garnet-bearing mafic schist. The exact age and history of this rock is being debated: associated zircon ages give a minimum age of 3.77 Ga [1], and a $^{146}Sm/^{142}Nd$ isochron suggests that the NSB includes components as old as ca. 4.28 Ga [2].

Garnet Sm-Nd geochronology is a valuable tool to elucidate the tectonic and metamorphic histories of mafic rocks; recent improvements in sample preparation have improved both the accuary and precision with which we are able to date the growth of garnet [3]. Although garnet dating in the cummingtonite amphibolite rocks will not resolve the age debate, it will tell us when the most recent garnet-forming metamorphic event occured at which time Nd isotopes were last mobilzed and exchanged among metamorphic phases.

After crushing and hand picking a visually clean garnet separate we performed partial dissolutions to remove micro-inclusions. Using a three step sequence of acids: concentrated HF, concentrated $HClO_4$, and 7N HNO_3, acid-cleansed garnets showed high $^{147}Sm/^{144}Nd$ ratios (~6.0) indicating that low Sm/Nd micro-inclusions were eliminated. However, replicate preparations produced significant scatter in the isochron towards older apparent ages indicative of contamination from an older inherited high Sm/Nd inclusion phase (likely zircon). Adding a fourth aqua regia step to the partial dissolution sequence cleansed the garnet of these contaminants yielding slightly higher $^{147}Sm/^{144}Nd$ (~6.1) and a robust three point garnet-matrix isochron age of 2574.70 ± 0.72 Ma (MSWD=0.77). This new age represents the youngest age associated with the NSB and implies the terrane underwent a final greenschist-amphibolite grade heating event after the final ca. 2.7 Ga crustal growth episode documented by metamorphic overgrowths on zircons [4].

[1] Cates & Mojzsis (2007) *EPSL* **255** 9–21. [2] O'Neil *et al.* (2008) *Science* **321**, 1828–1831. [3] Pollington & Baxter (2011) *Chemical Geology* **281**, 270–282. [4] Cates & Mojzsis (2009) *Chemical Geology* **261**, 98–113.