Carbon capture and storage and pollution from volcanic eruptions

(C.C. Patterson Award Lecture)

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The work presented here is a team contribution by the CarbFix group [1–4], the volcanic hazard groups at the University of Iceland and Copenhagen, and the Icelandic Met Office [5–10]. I am grateful for their contribution.

All the carbon in the atmosphere, living creatures, and dissolved in the oceans is derived from rocks and will eventually end up in rocks, the largest carbon reservoir on Earth. The carbon moves from one reservoir to another in the carbon cycle. Humans have accelerated this cycle by mining and burning fossil fuels, causing rising atmospheric CO_2 concentrations, global warming, rising sea levels, and ocean acidification. One option for mitigating high levels of atmospheric CO_2 is to capture CO_2 and safely store it in subsurface rocks for thousands of years or longer. The CarbFix group has shown that over 95% of CO_2 injected into reactive basaltic rocks is mineralised within two years of injection at 20-50°C. This method has now been scaled up to an industrial level, including capture of gas mixtures to cut capture cost, providing an economical and safe method for storing carbon for thousands of years.

Volcanic eruptions are sources of juvenile carbon for the atmosphere, living creatures, and the oceans. Furthermore, eruption plumes carry with them volcanic ash, volcanic gases, volatile metals, and nutrients. Some of these gases, metals and nutrients condense on the surface of the ash, forming, on average, a nanometre/s thin water-soluble salt coating on the ash as the plume rises and cools down to sub-zero temperatures. As soon as this volcanic ash is exposed to surface waters, the coating dissolves and can either poison or fertilize surface waters. Most often, pristine volcanic ash enhances the growth of biomass in the ocean, but on land it can have grave consequences for vegetation and life.

[1] Gislason & Oelkers (2014) *Science* **344,** 373–374. [2] Sigfusson et al. (2015) *IJGGC* **37**, 213–219. [3] Matter et al. (2016) *Science* **352**, 1312–1314. [4]Snæbjörnsdóttir et al. (2018) *GCA* **220**, 348-366. [5] Gislason et al. (2011) *PNAS* **108**, 7307–7312. [6] Olsson et al. (2013) *GCA* **123**, 134–149. [7] Jones et al. (2015) *JVGR* **291**, 112–124. [8] Gislason et al. (2015) *GPL* **1**, 84-93. [9] Galeczka et al. (2017) *JVGR* **347**, 371–396. [10] Stefansson et al. (2017) *JGR:A* **122**,1971–1982.