Removal of carbon dioxide from the atmosphere using alkaline mineral materials: the hidden potential of existing industries

RENFORTH, P.[1]

[1]Research Centre for Carbon Solutions, School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS (correspondance: P.Renforth@hw.ac.uk)

In addition to extensive reduction in greenhouse gas emissions we may also need to remove billions of tonnes of CO_2 per year from the atmosphere to avoid dangerous climate change[1]. The most credible approach to delivering this greenhouse gas removal appears to be the deployment of a portfolio of options (e.g., soil carbon management, biomass energy carbon capture and storage, direct air capture, enhanced weathering), that would otherwise be insufficient in isolation.

Alkaline materials are produced in numerous industries (cement, by-product slag from steel manufacturing, and red mud from aluminium production). These materials readily react with CO_2 to form carbonate minerals, representing stable long-term storage [2]. However, the potential of these materials to prevent climate change has been considered relatively minor because i) they are produced from emission intensive processes, ii) their carbonation potential can typically displace only a small proportion of these emissions, iii) fully exploiting the theoretical potential of current annual production may result in, at best, a total removal of <1 $GtCO_2$ per year [2].

Here we present new modelling results which suggests that with increases in future material demand to meet a growing and developing global population, the carbon dioxide sequestration potential of alkaline materials may be several $GtCO_2$ per year by 2100. If this potential is exploited in addition to extensive emissions mitigation (e.g., through energy efficiency improvements, low carbon power, or carbon capture and storage) it may be possible to create industries that are carbon negative.

Mechanisms to exploit this atmospheric carbon sequestration potential could include enhanced weathering, heap scale leaching and carbonation, controlled reactor weathering, or carbonation at elevated CO_2 partial pressures. Initial technoeconomic assessments suggest costs that may be favourable compared to other CO_2 removal options.

[1] IPCC (2018). SR: Global warming of 1.5°C.
[2] Renforth et al., 2011 Environ. Sci. Technol. 45