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Carbon capture in man made strata

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Man made strata have enormous potential to capture carbon, through the precipitation in situ of calcium carbonate (calcite). In investigations of 'made ground' in the UK, we have shown that precipitation of calcite takes place to depths of 1 m or more, removing the equivalent of 85 T CO_2 per hectare annually [1]. Carbon isotope data show that the carbon was derived from photosynthesis, in sites where there is vegetation. In other circumstances, at high pH (<11) chemical reaction between infiltrating water and soil materials leads to carbonate formation, and in these ^{14}C dating confirms modern carbon.

Our model for the carbonation of man made strata involves a combination of biology and mineralogy. Growth of plants acts as a carbon pump; photosynthetically-derived carbon enters the soil via the root system, where it decays through microbially-mediated processes to re-form CO_2. A proportion of this is partitioned into the soil solution where it forms bicarbonate and carbonate, according to pH, that on combining with dissolved calcium can precipitate to form calcite. The key to this carbon-stabilisation process is the availability of Ca, which can be derived from natural calcium silicates [2] but also in man made ground artificial materials including Portland cement and metallurgical slags [1].

Application of the process of carbon capture in man made strata provides multiple functions [3]. In addition to fixing atmospheric CO_2 (analogous to the use of reed beds to clean contaminated waters), microbially-induced carbonate precipitation is a known technique for ground improvement that also increases soil strength [4]. But in addition to possible geotechnical improvements, there may be negative consequences such as reduced permeability (and that can lead to lack of drainage). Created with the consent of the public, man made strata need to provide a range of ecosystem services, including desired flora and fauna. Equally, the development of man made strata needs to be carried out within a framework of sustainability, so that the non-financial cost of their creation does not exceed the value of the services that they offer.

Critically, the creation of man-made strata with a carbon capture function offers opportunities for safer waste management and novel mined products. For example carbon from organic sources thermally stabilised as biochar could be included to add carbon, enhance soil fertility and immobilise pollutants where present. Ca-rich residues from industry could acquire a new function; the process recarbonates slags and cement products, recovering CO_2 emitted by calcining during manufacture and closing the carbon loop in a life-cycle analysis. Natural Ca silicate rocks, especially those currently without a

market, could also be incorporated to increase net carbon capture benefits. Design of just 12000 ha (120 km^2) of land of this type could remove 1 million T CO_2 annually.

References:

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