PhD Project Advertisement

Project title: Carbon sequestration in agricultural soils through silicate weathering
Project No: FBS2022-38-Kirk-cr

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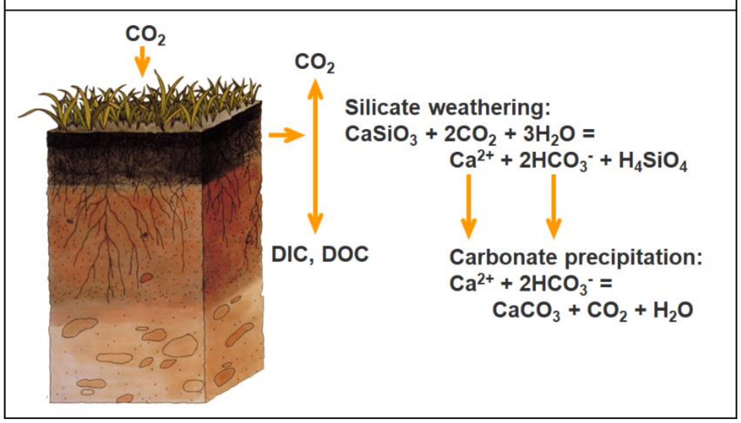
Project description:

One of the most promising 'geo-engineering' methods to mitigate climate change is to capture CO_2 from the air and react it with silicate rocks to form carbonate rocks, so permanently sequestering the CO_2. A Swiss-based company (Climeworks) is already offering to do this for $1,000 per tonne of CO_2 using a CO_2-capturing technology and pumping the CO_2 deep underground to react with basalt rocks. However this process is highly energy intensive, and the net CO_2 capture is correspondingly reduced. A less energy-intensive approach – which this project will test – is to exploit CO_2 capture by plants in photosynthesis and decomposition in soil on agricultural land, using finely-divided silicates applied on the soil to fix the CO_2 as environmentally-benign carbonates (Fig. 1). Soils are a good source of CO_2 for this because C fixed by plants and released in root and soil respiration results in the CO2 pressures in soil air being 10–1000 times that in the bulk atmosphere. There are many sources of suitable silicate rocks and calculations have been made of the circumstances required for the C capture gains to exceed the C costs of mining and transport to application sites.

Fig. 1 Enhanced silicate weathering & carbonate precipitation in soil



Most attention to date has been on large, regional-scale applications of silicates in warm and wet tropical areas considered to be weathering 'hot spots'. This project will consider the potential for this technology on arable and pasture land in the UK, and the extent to which it could contribute to reducing carbon emissions from UK farming to zero. Simple calculations indicate that, as a minimum, substitution of silicates for agricultural lime could offset a significant proportion of carbon emissions. Agricultural lime is typically incorporated to less than 20-cm depth. A much greater CO_2 offset could be achieved if the effects of the applied silicate reached subsoil and caused carbonate precipitation there. In principle this could be achieved by manipulating the chemistry of the surface soil and exploiting leaching processes. However, the necessary conditions for this to work are not well understood, and there are no reliable models with which to predict where such a technology would be successful, and how to develop routes to adoption by the agriculture sector.

This project will explore technologies for exploiting enhanced silicate weathering to sequester atmospheric CO_2, and the potential for such technologies to reduce net greenhouse gas emissions from UK farming. Specific objectives towards these ends:

1. To test the hypothesis that it is practicable to manipulate surface soil conditions to enhance dissolution of applied silicates and precipitate leached dissolution products as carbonate in the subsoil. This will be done in controlled-environment experiments with planted soils and alternative sources and forms of silicates.
2. To develop and test a predictive model of enhanced silicate weathering in soils, including the processes governing leaching and precipitation of carbonate in subsoils. The model will be tested against the results of the experiments under Objective 1.
3. To assess the extent to which this technology might affect the mineral nutrition and trace element composition of arable crops and pasture grasses.
4. To explore routes to adoption by manufacturers of agricultural products and farmers.

Training opportunities:

This is a great opportunity to work in a project at the cutting edge of food systems and environmental science and to learn cutting-edge techniques in soil chemistry, physics and biology, plant nutrition, and mathematical modelling. The student will join a group of over 50 PhD students in the Cranfield Environment and Agrifood Theme, including students from other UKRI-funded doctoral training centres. They will have access to a full range of associated training modules. They will also benefit from interactions with an industrial partner, including work placement.

Student profile:

This studentship is available only to individuals who are eligible for UK fees status. The project would be suitable for students with a BSc degree (minimum upper second class honours) in biology, chemistry, geology, environmental science or a closely related science.

Stipend (Salary):

FoodBioSystems DTP students receive an annual tax free stipend (salary) that is paid in instalments throughout the year. For 2022/23 this will be £17,668 and this will increase slightly each year at rate set by UKRI.

For up to date information on funding eligibility, studentship rates and part time registration, please visit the FoodBioSystems website.

Equality Diversity and Inclusion:

The FoodBioSystems DTP is committed to equality, diversity and inclusion (EDI), to building a doctoral researcher(DR) and staff body that reflects the diversity of society, and to encourage applications from under-represented and disadvantaged groups. Our actions to promote diversity and inclusion are detailed on the FoodBioSystems DTP website.

In accordance with UKRI guidelines, our studentships are offered on a part time basis in addition to full time registration. The minimum registration is 50% FT and the studentship end date will be extended to reflect the part-time registration.

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