LC3M Progress in 2017-18

iSEE researchers, partnered with the Leverhulme Centre for Climate Change (LC3M) at the University of Sheffield in the UK, have been exploring the potential of enhanced weathering in agricultural soils since 2016. The natural weathering of silicate rocks, which absorbs atmospheric carbon dioxide (CO_2) and traps it in the ocean as bicarbonate, can be enhanced by grinding the material to increase surface area. The ground rock (basalt) is applied to agricultural soils at the University of Illinois Energy Farm, where temperature, moisture, and plant/microbe interactions combine to release silica, phosphate, and cations that buffer soil pH and have the potential to improve crop production while bicarbonate reactions remove CO_2 from the atmosphere.

The 2017 research season commenced with the first field-scale application of basalt to the Illinois Energy Farm plots. About 198 metric tons of crushed rock sourced from Pennsylvania were applied to and tilled into maize fields equipped for measuring soil respiration and nitrous oxide (N_2O) production, for collecting soil water, and collecting eddy covariance data. Soil collected throughout the season was analyzed for acidity, carbon content, and nitrogen content, while peak season and end-of-season tissue sampling provided biomass and nutrient content in the crop. Tile drains beneath the 3.8-hectare fields at the Energy Farm measured flow rates and sampled water flowing through the vadose zone for laboratory analysis of major cations and strontium isotopes, which help calculate the rate of basalt weathering in the soil. More than 10 million liters of drainage water passed through the sampling system in 2016-17.

In the first year of field-scale research, the emission of N_2O, a greenhouse gas produced by soil microbes, was reduced in basalt-treated maize plots compared to controls, as had been previously observed in the 2016 pilot study. As N_2O represents a loss of nitrogen that would

fertilize crops, reduced N_2O emissions are a potential benefit to both atmosphere and agriculture. Soil pH increased more rapidly in basalt-treated maize plots after application than in controls in 2017, and pH remained higher in basalt-treated plots at the end of the growing season. Initial measurements for 2018 indicate that the trend is continuing in the second year of basalt treatment. N_2O and yield data are being used to develop DayCent models for the effects of long-term basalt application on greenhouse gas balances and agricultural productivity. These models are informed by years of data from the Energy Farm, and can be adjusted for other regions by changing soil properties, climate conditions, and crop characteristics.

The second annual basalt treatment was applied to the maize plots in Fall 2017, and the first application was made to the perennial Miscanthus plots in Spring 2018. Applications will occur for five growing season in each crop. Tile drain water and soil sampling occurred in both crops over the winter and spring months, and the 2018 field season commenced in late April 2018.

The Illinois team consists of Plant Biology Professor Evan H. DeLucia, Plant Biology and Crop Sciences Associate Professor Carl Bernacchi, iSEE Postdoctoral Research Associate Ilsa Kantola, Department of Plant Biology Technician Michael Masters, and two field technicians, Haley Ware, an undergraduate student in Natural Resources and Environmental Sciences, and Konrad Taube, a 2015 U of I graduate in Molecular and Cellular Biology. Collaborators at the University of Sheffield and the University of Southampton, and James Cook University in Queensland, Australia, are applying basalt to greenhouse experiments, sugar cane, and oil palm to measure rates of weathering and the effects of basalt application in tropical and subtropical agriculture.

Team members made two presentations in 2017:

- "Geoengineering through Agriculture: A Path to Reducing Atmospheric Carbon Dioxide." DeLucia at the Plant Biology Colloquium, University of Illinois, June 2017.
- "Enhanced Weathering in the American Midwest: Plot to Field Scale." Kantola at the 1st Annual Meeting, Leverhulme Centre for Climate Change Mitigation, University of Sheffield, September 2017.

DeLucia, Kantola and others also published a paper in 2017:

- "Farming with Crops and Rocks to Address Global Climate, Food and Soil Security," with Leverhulme Director David Beerling and others, published in *Nature Plants* in February 2018.