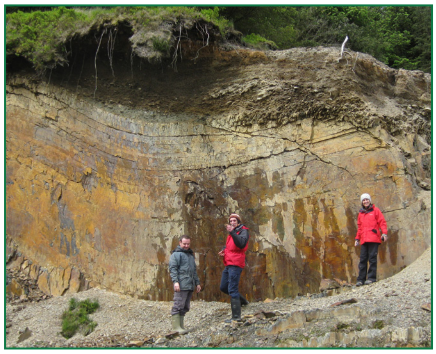
Salts of the earth



It takes 500 years to build up one inch of soil, according to the US Department of Agriculture. Yet we are losing this critical natural resource between 100 and 1000 times faster, through desertification, erosion, urban development and pollution.

Understanding the weathering processes which both form and erode soil is a central focus for the WUN Critical Zone & Soils Science Consortium. The huge difference in time frame between soil formation and loss is mirrored in the way different disciplines approach the issue, according to Sue Brantley, Professor of Geosciences at Penn State University (PSU), one of the Consortium's leading players.

"Each discipline involved in the Consortium frames their work by different timescales," said Professor Brantley. "Geologists might think in terms of rock formed over tens of thousands of years, but for hydrologists it might be the seconds it takes for water to follow a particular course. It's only by bringing together these different approaches that we'll find solutions to the huge challenges faced by the Critical Zone."

The Critical Zone is the thin outer layer of the Earth which sustains life, from the vegetation canopy to the soil and groundwater – or 'tree top to bedrock' as it is sometimes known. Soil is a key element of the critical zone, yet little is understood about how it forms.

"We know quite a lot about soil erosion," said Steve Banwart, Professor of Environmental Engineering Science at the University of Sheffield. "But we need to better understand soil formation if we want to find ways to manage or accelerate the process and even reverse some of the loss by reclaiming barren or contaminated land or improving agricultural productivity."

Central to soil productivity is carbon which is present both as living soil organisms and as decaying plant material. As the planet warms, soil is increasingly drying out, losing its carbon to the atmosphere as CO_2. As soil carbon provides the glue to help maintain soil structure, without it, soil lacks cohesion between mineral grains and is even more susceptible to erosion.

The natural assumption is that the carbon in soil is created by dead plant matter being decomposed by microorganisms. But the University of Sheffield team has found that up to 30 percent of the carbon fixed by photosynthesis passes to the soil while plants are alive, thanks to a type of fungi called myrcorrhiza which grows round plant and tree roots.

"Over eighty percent of plant types in the world live in a symbiotic relationship with mycorrhiza," said Dr. Jonathan Leake who leads the biology work. "The fungi provide plants with mineral nutrients which they extract from the soil by active processes fuelled by the plants providing them with a substantial sugar supply from recent photosynthesis. The sugar-for-nutrient exchange is not only a critical component of soil formation through the breaking down of minerals, but has a huge impact on plant growth and development."

The Mycorrhiza grow threads or 'hyphae' which snake through the soil – up to 100 km in just one kilo of soil. When the hypae find lumps of rock with high concentrations of useful minerals, they proliferate and break down the rock to pass the nutrients back to the plant.

Researchers led by Prof Banwart and Dr Leake have been able to demonstrate this in the lab, using soil profiles up to several feet deep. This is a large collaborative project led by the University of Sheffield with scientists at the Universities of Leeds and Bristol. Through the WUN network, the experiment is able to make the move from lab into the field, initially in the Critical Zone observatory managed by Professor Brantley at PSU.

The observatory is one of six across the US funded through the National Science Foundation with plans underway for a further four in Europe.

International collaboration between observatories enables useful comparison of sites which are similar geologically but have different climates. Research into soil formation on shale bedrock by WUN researchers from Sheffield, Bristol and PSU is comparing findings at the Plynlimon research site in Wales with the PSU observatory, as the bedrock of both sites – although thousands of miles apart – has a similar geological origin.

Soil is one focus of the observatories, but with clean drinking water an ever more precious resource as the world's population increases, where water goes and what happens to it on its journey is also a key – and interrelated – area of research.

The Penn State observatory is positioned on a small watershed. Sensors on the trees are providing data on how much water these pull up from the soil. Bore holes into the bedrock are showing geologists how water has changed the chemistry of the rock, over what time period and under what rate of flow.

"We need to understand how long it takes water to rid itself of toxins through reactions with rock, to ensure that we can find ways to keep drinking water clean in the future," explained Professor Brantley. "And this brings us back to the soil because it's in the soil and rock that we read the water's history."

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