Clay Minerals as the Key to the Sequestration of Carbon in Soils

Jock Churchman

Adjunct Senior Lecturer at the University of Adelaide (School of Agriculture, Food and Wine) and Adjunct Professor at the University of South Australia (Future Industries Institute).

Climate change concerns us all. Emissions of carbon dioxide CO_2 account for most of it.

The idea that carbon C from excess atmospheric carbon dioxide could be stored for a long time in soils (“sequestered”) has often been proposed as one possible solution.

But there has been a lively debate within the soil science community as to whether sequestering C in soils really works to provide so-called “negative emissions”. Do soils act like trees for this purpose?

Soils are mineral-organic complexes. Minerals derive from rocks that are broken down by living and also dead and decaying organisms and rainfall.

Figure 1 shows that that C-containing organic matter and fine (“clay”) minerals can be bound together closely in undisturbed soils.

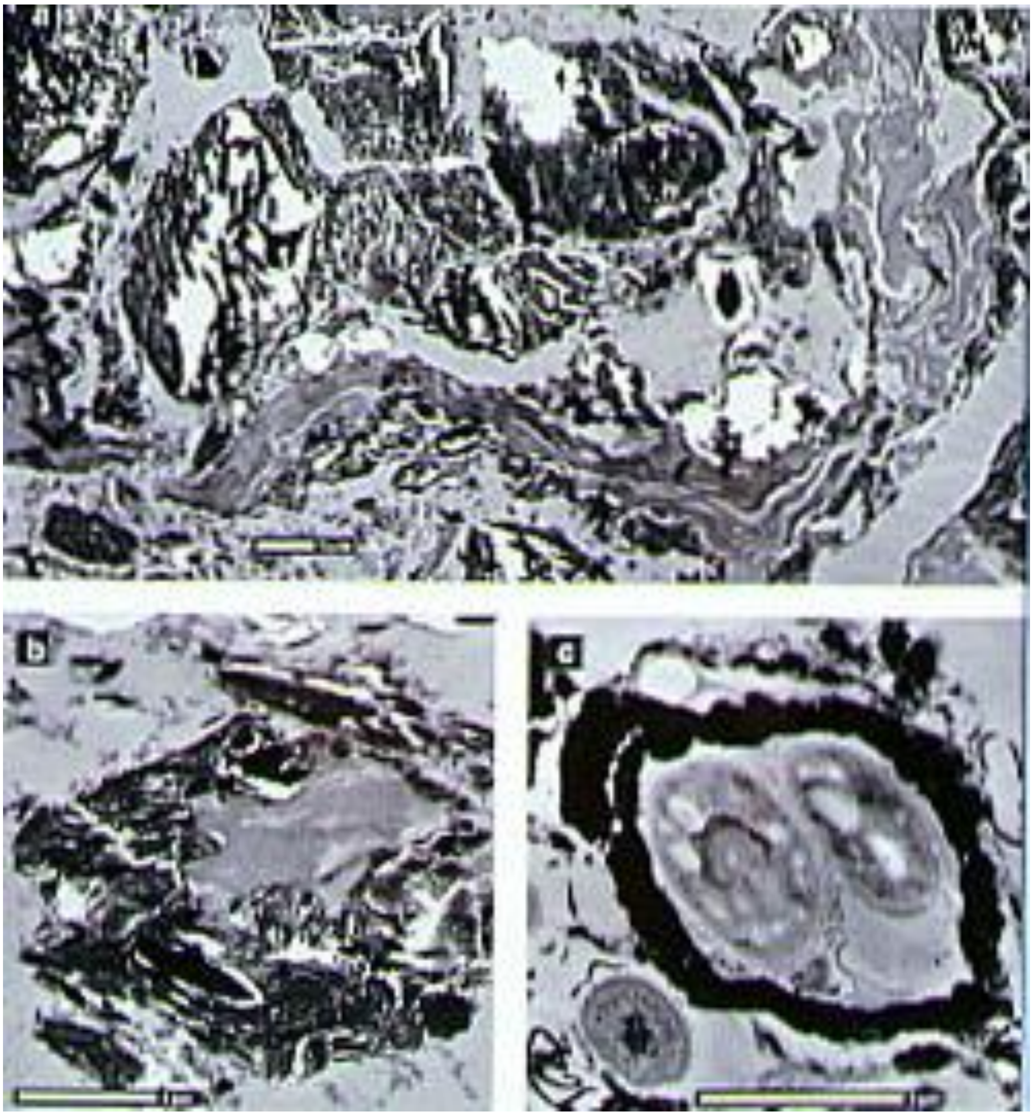

Figure 1. a. Clay minerals and oxides (dark) coat plant cells (light), including roots & quartz (broken shards). When they coat organic matter completely, they produce: b, c. micro-aggregates. (Transmission electron micrographs of ultrathin sections of uncultivated soil; scale = 1 micrometre)
Photo credit: Ralph Foster

But the stock of carbon in soils has diminished quite drastically over the years because of agriculture. The dream behind sequestration is that carbon lost from soil could be returned by appropriate management practices.

Our experiments in the field and the laboratory tested whether organic C could be put back into soils and whether it may be held there over a long period of time.

In sand-over-clay hydrophobic soils in southern Australia, clay is moved from deep within soil profiles into sandy topsoils to increase plant growth (sequence in poster photo). Eight years under grass after clay additions to topsoil led to concomitant increases in organic carbon, apparent from development of organic-rich areas containing plant roots (poster photo, right). Although statistically significant (~2 Mg CO_2-eq. ha^{-1}), these increases are miniscule relative to annual global emissions of CO_2 from fossil fuels.

In laboratory experiments, C (as dissolved organic matter) was adsorbed by clays to different extents, depending on their particular clay mineral composition.

More than 30% of the carbon adsorbed was immediately released in water from all soils.

Addition of clays enables more retention of C. CO_2 is largely added to soils through the growth and decomposition of plants. We also know that soils have a limited capacity for organic C, so soils have a finite capacity to sequester C. A better prospect for removal of C from the atmosphere, although only short-term, is through enhancing plant growth.

Soils are not a proven long-term receptacle for greenhouse gases to act as a means of substantially limiting climate change as we run out of time to prevent disastrous – and permanent - climate change.

The answers lie in the soil when it comes to (eventually) solving global hunger, but they lie elsewhere when it comes to (urgently) solving climate change.

Indeed, there is a risk that promoting the potential of carbon sequestration in soils could cause further inaction on climate change.

Poster photo credit: Glen Bailey

Paper reference: Churchman, G.J., Singh, M., Schapel, A. Sarkar, B., and Bolan, N. 2020. Clay minerals as the key to the sequestration of carbon in soils. Clays and Clay Minerals 68**,** 135–143.

Jock Churchman is Adjunct Senior Lecturer at the University of Adelaide and Adjunct Professor at the University of South Australia. A chemistry PhD from Otago University was followed by ceramic research (2y), post-doctoral fellowship at the University of Wisconsin-Madison (2y), and employment at the New Zealand Soil Bureau (16y), CSIRO (14y), the University of Adelaide (9y) and the University of South Australia (2y). He held fellowships at Reading University (1y) and the University of Western Australia (6mo). His research has included halloysite, clay mineral genesis, acid dissolution and organic complexes, clays and soil physical properties, and their environmental applications. He has published about 150 refereed journal articles and has co-authored or edited four books, including *Soil Clays* (2019) and *The Soil Underfoot* (2014).