

Manganese oxides: A ‘mineral pump’ mechanism for transforming organic carbon?

KAREN JOHNSON¹, CAROLINE PEACOCK²,
GRAHAM PURVIS³, ELISA LOPEZ-CAPEL³, NEIL GRAY³,
TOM WAGNER³, CHRISTIAN MÄRZ³, CHRIS GREENWELL¹
AND FRED WORRALL¹

¹University of Durham, UK, karen.johnson@dur.ac.uk

²University of Leeds, UK, ³Newcastle University, UK

Minerals are known to stabilise organic carbon in sediments but how they do it is far from understood. We present a mechanistic understanding of stabilisation of organic carbon by manganese oxides using experimental data from the largely controlled system of a clean water treatment works (WTW). Mn oxide coatings in a WTW filter bed trap dissolved organic carbon (DOC) as the coating builds up in layers around clean sand grains at 3%w/wC. We identify two main Mn-OC fractions, one of which is thermally refractory (0.03%w/wC is released at temperatures above 550°C) and the other thermally labile (2.7%w/wC is released at temperatures below 550°C).

We hypothesise that the stability of the Mn-OC is due to carboxylate groups within the OC binding to the Mn oxide surface coupled with the physical entrapment of the OC within the Mn oxide mineral. We also identify a significant difference in the nature of the bonding environment between surface bound Mn-OC and bulk Mn-OC, which leads us to speculate that polymerisation reactions may be occurring at depth within the mineral. Further research is needed to understand the reactivity and fate of the stabilised carbon during reductive dissolution of Mn oxides. Since Mn oxides are effectively recycled between solid and soluble Mn forms at oxic/anoxic boundaries, we speculate that a ‘mineral pump’ mechanism may be responsible for cycling many Gt of carbon each year in both terrestrial and marine environments, which may have significant implications for the global carbon cycle.