Synthetic Mineral-Organo Associations in Soil: Vulnerability of Mineral Associated Carbon to Microbial Decomposition with Depth

Rachel C. Porras, Peter S. Nico, Caitlin Hicks Pries, and Margaret Torn
Lawrence Berkeley National Laboratory, Berkeley, CA, 94720, USA

Rachel C Porras, Lawrence Berkeley National Laboratory, Berkeley, CA, United States

Globally, soils, including deeper subsoils (>30 cm), represent an important reservoir of soil organic carbon (SOC) that can potentially be of great importance to the carbon cycle. However, the bioavailability of this SOC and, in particular mineral-associated SOC, to microbial decomposer communities and its potential to amplify the effects of climate change is highly uncertain. To gain insight into the bio-accessibility of mineral-associated organic C, we conducted a series of incubations using soils collected from three depths (0-10, 50-60, and 80-90 cm) under coniferous forest. The soils are moderately acidic (~pH 6.5) sandy, mixed, mesic Ultic Haploxeralfs.

To understand how mechanisms controlling SOC bio-accessibility differ with depth and with the properties of mineral-organo associations (MOAs), we synthesized two common soil minerals, goethite and ferrihydrite. ^{13}C labeled MOAs were prepared by reacting the synthetic Fe oxides with 9.9 atom % ^{13}C labeled glucose for 12h in the dark. Synthetic MOA's were initially created at 100% of maximum sorption capacity and gently washed to remove non-absorbed and weakly held interstitial material. Post washing, goethite MOAs retained 52% of added glucose while ferrihydrite MOAs retained 77%. The synthetic MOAs were added to aliquots of soil collected from each of the three depths. The soils containing the ^{13}C labeled mineral-organo associations were incubated at 20°C.

Respired $^{13}CO_2$ was measured and used to estimate the amount of microbially decomposed mineral associated ^{13}C-glucose. After 72 hours, 92% ± 3%, 36% ± 3%, and 26% ± 3% of ^{13}C labeled glucose added directly to soils in our controls was decomposed for 10-20cm, 50-60cm, and 80-90cm, depth increments respectively, indicating generally high availability of the fresh glucose. In contrast, less than 0.2% of mineral associated ^{13}C-glucose was decomposed for either of the synthetic MOAs confirming that association with reactive mineral surfaces does dramatically retard microbial decomposition of otherwise readily biodegradable organic substrates in soils. Calculated $^{13}CO_2$ flux rates were similar for synthetic goethite- and ferrihydrite-organo complexes and also showed a decrease with depth. Interestingly, a 'disturbance control,' in which glucose free ferrihydite was added to the soils, resulted in an apparent slight decrease in baseline respiration. This effect decreased with depth, and if confirmed could indicate a potential impact on carbon availability of unsatisfied mineral surface area at depth.

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