Rhizogenic Weathering Impacts on Deep Soil Carbon

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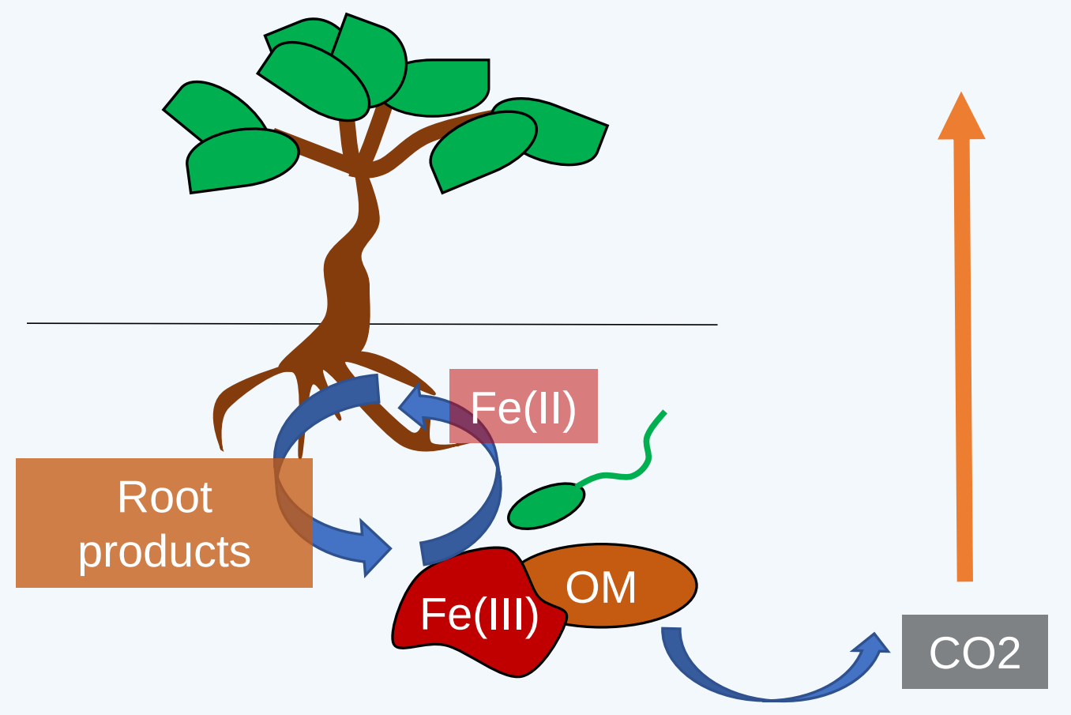
Introduction

Soils hold four times the amount of carbon (C) stored in the atmosphere[1]. About half of this is found deep within soils[2]. About 90% of this deep soil C is stabilized by mineral-organic associations[3] (MOAs). Plants are a major conduit of C from the atmosphere into the soil, releasing between 25-40% of the photosynthetically fixed C as rhizodeposits into the soil[4]. Root-driven weathering of primary minerals may form reactive secondary mineral phases. If soil C binds to these phases to form mineral-organic associations, it persists for centuries to millennia. However, rhizogenic weathering may also destabilize mineral-organic associations. It appears that root-derived C can increase C stocks in deep soils[5], and diminish C through disruption of mineral-organic associations[3]. Yet their relative impact on deep C pools is still unknown.[7]



Objective

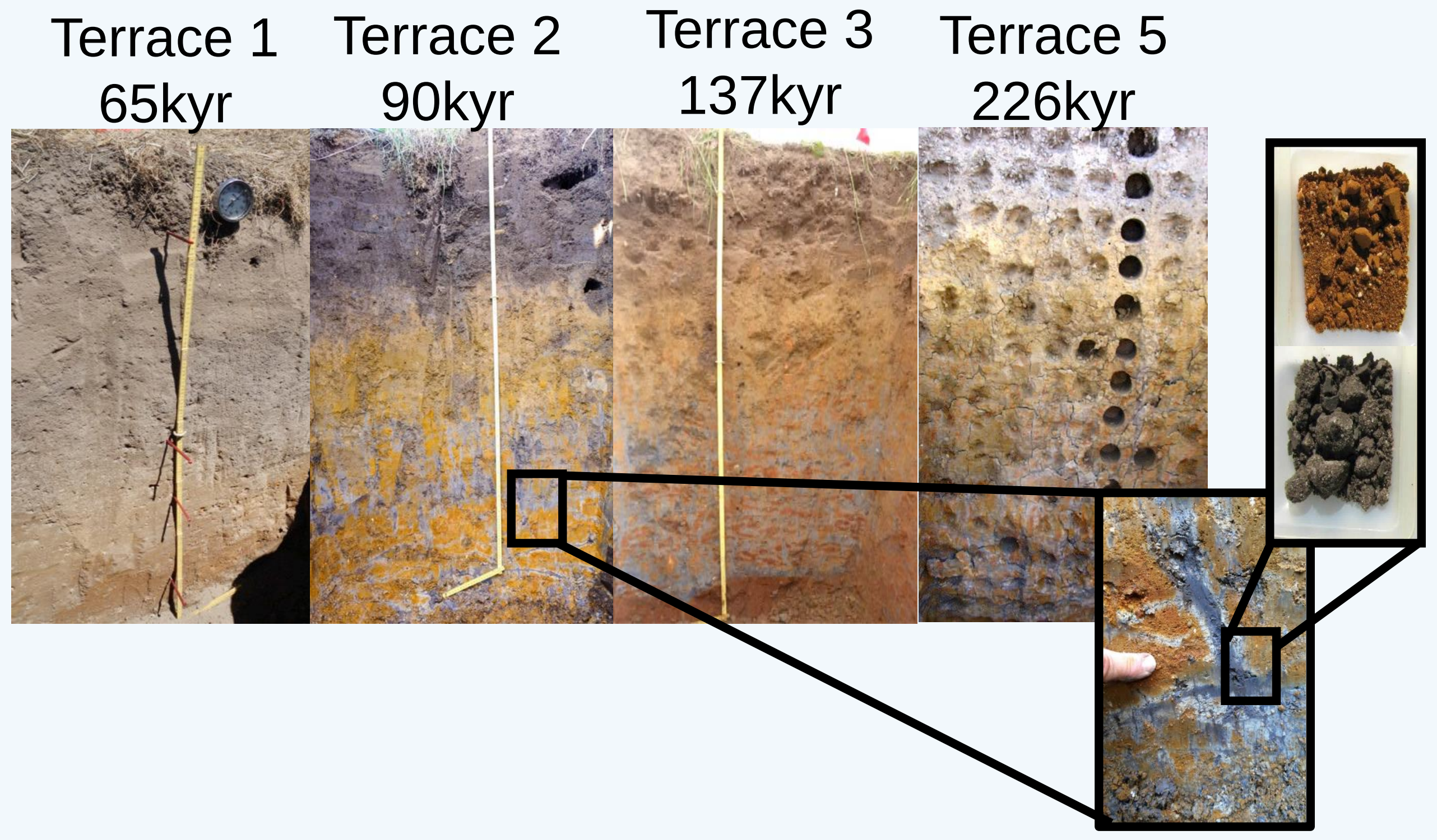
Examine root impacts on soil C residence time and chemistry, mineralogy and mineral-organic associations across the Santa Cruz Marine Terrace chronosequence (65ka-226ka).

Hypothesis

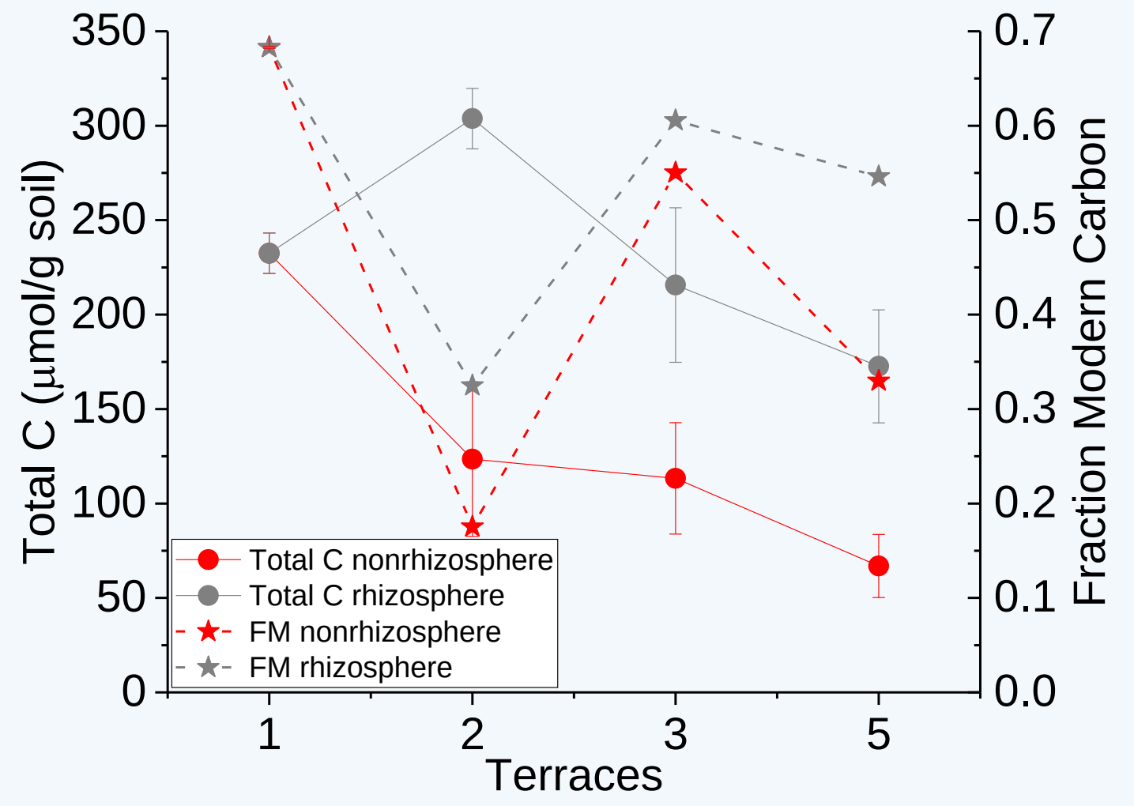
Root induced mineral weathering controls formation and disruption of mineral-organic associations, and therefore regulates carbon storage in deep soil.

Approach

We focused on the **Santa Cruz Marine Terrace Chronosequence,** with grey and red splits from **root zones** (rhizosphere & non-rhizosphere respectively)

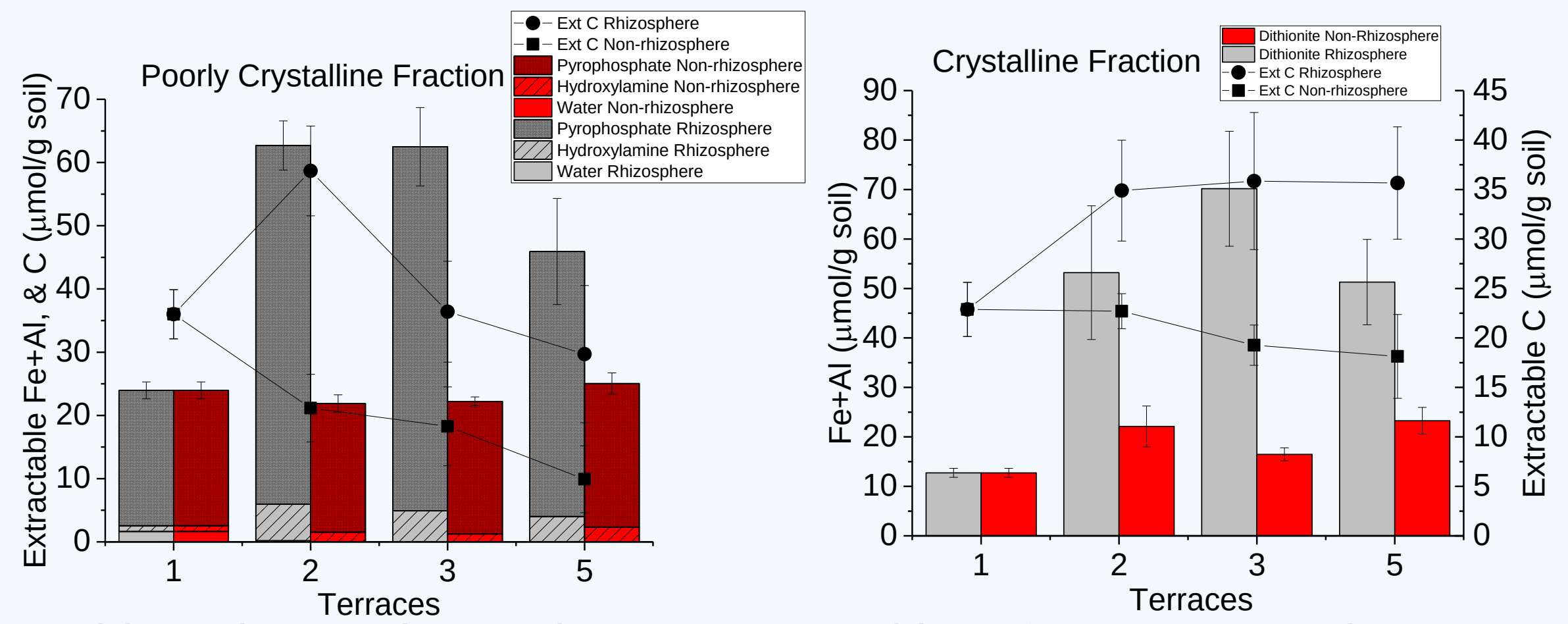


Carbon Quantity and Age



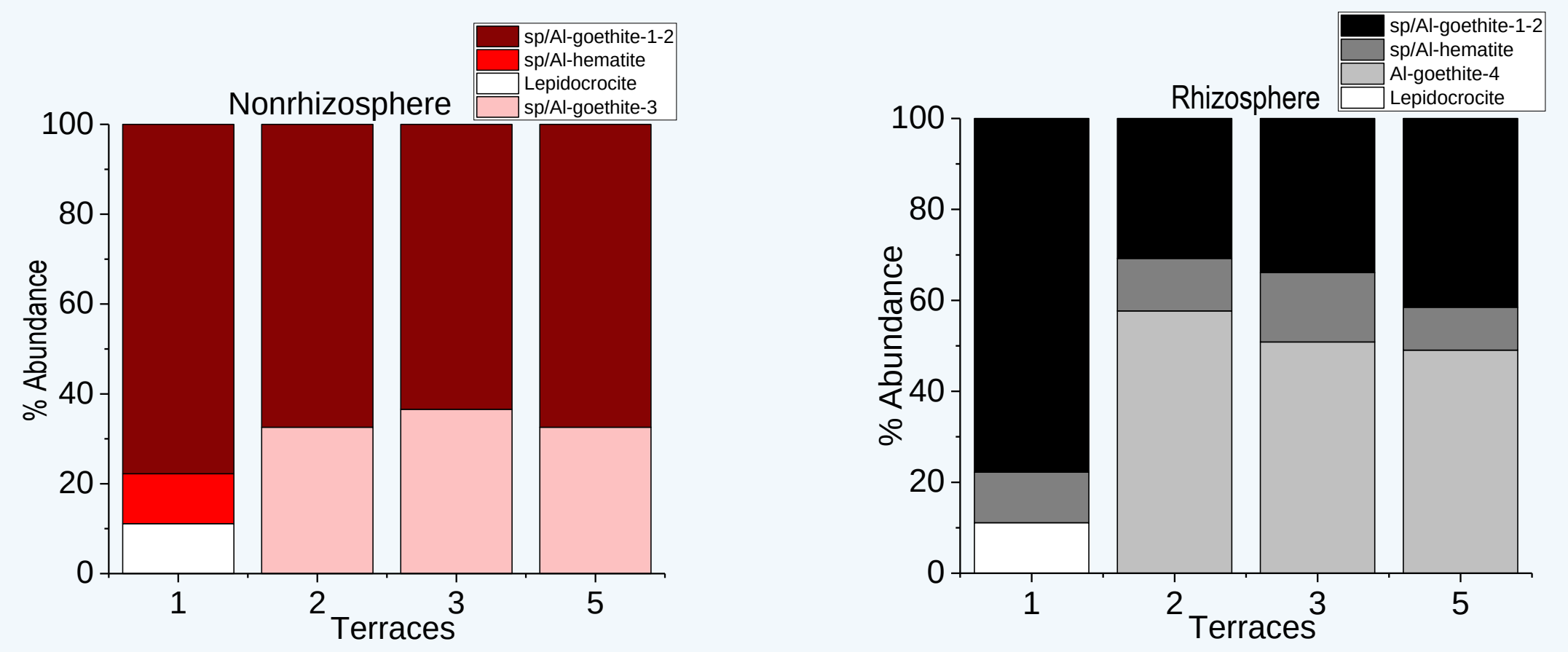
- Initial rhizogenic weathering (terrace 2) increases total soil carbon. Total C in non-rhizosphere soil steadily declines.
- C accumulation along with initial rhizosphere weathering coincides with substantially greater residence times.(lower FM values).

Sequential Extractions



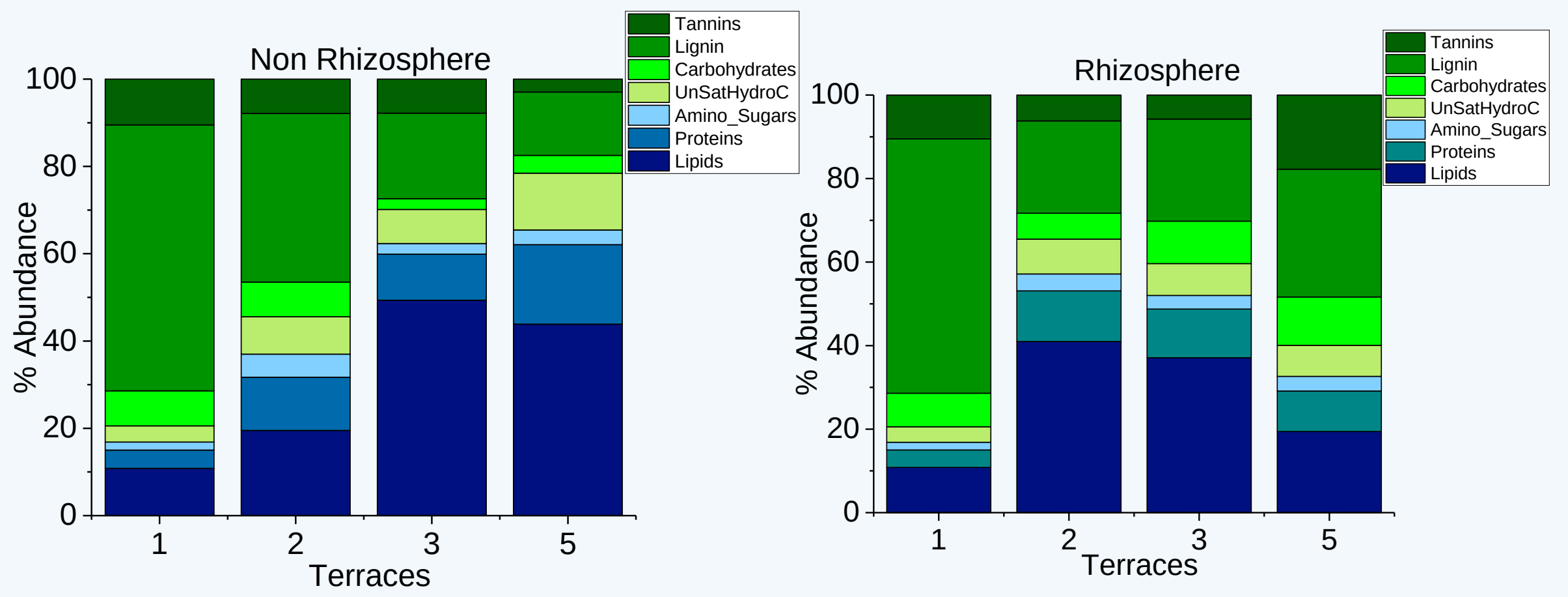
- Rhizosphere soil contains larger quantities of poorly crystalline Fe & Al phases.
- Initial rhizogenic weathering (terrace 2) sharply increases abundance of poorly-crystalline phases, as well as the amount of C associated with it, which then both continue to decline.
- More crystalline phases, and the amount of C associated with them, increases steadily in the non-rhizosphere soils.

Mössbauer



- Both rhizosphere and non-rhizosphere are dominated by Fe in nanogoethite and in clays (data not shown).
- With the onset of weathering in terrace 2, a dominant, more disordered nanogoethite phase - likely substituted with Al & C - is created (type 4), but decreases in abundance as weathering progresses.

High-resolution Mass Spectrometry

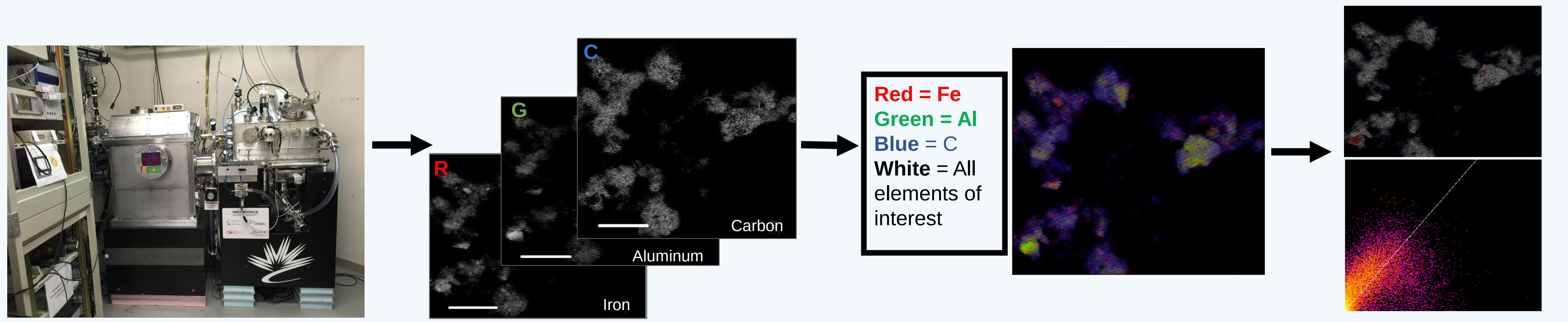


- Microbially-derived compounds (blue) increase gradually in the non-rhizosphere.
- The contribution of microbially-derived compounds shows a sharp increase in the rhizosphere, followed by a steady decline.

Conclusions

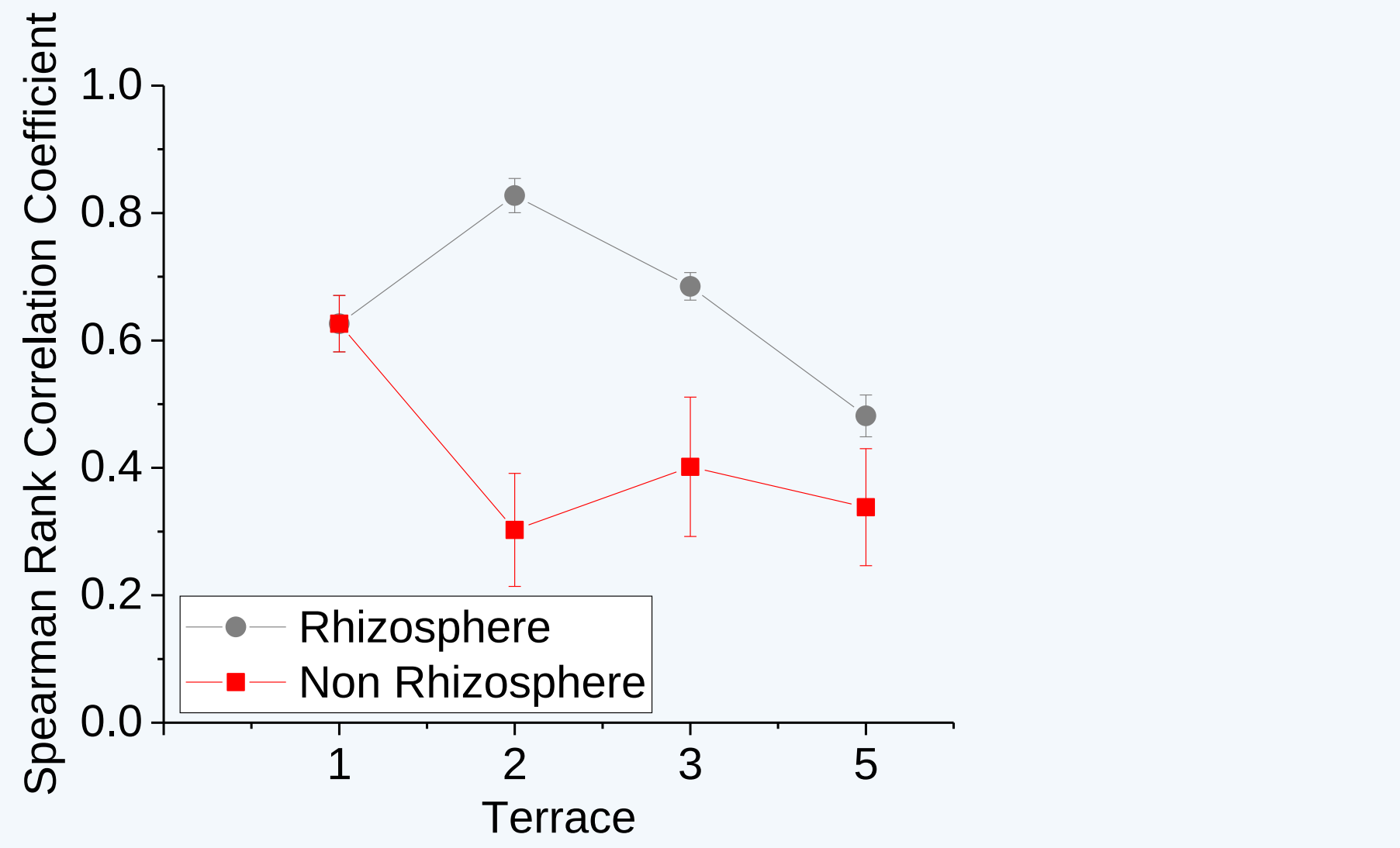
- Rhizosphere and non-rhizosphere soils show distinct weathering patterns with regards to the formation and transformation of mineral-organic associations.
- Initial rhizogenic weathering creates strong associations between microbially-derived C and poorly crystalline Fe (and Al) phases. At later stages, rhizogenic weathering transforms poorly crystalline into less reactive, more crystalline phases that retain lower amounts of C.
- Because this pattern was not observed in non-rhizosphere soils, we postulate that root activity is the main driver behind the frequently observed increase in C accumulation in the presence of poorly crystalline minerals during initial soil weathering[8,9].
- Our results suggest that root activity is a largely overlooked factor in the formation and disruption of mineral-organic associations in soils.

Analysis of Fe-C Associations Using Spectromicroscopy



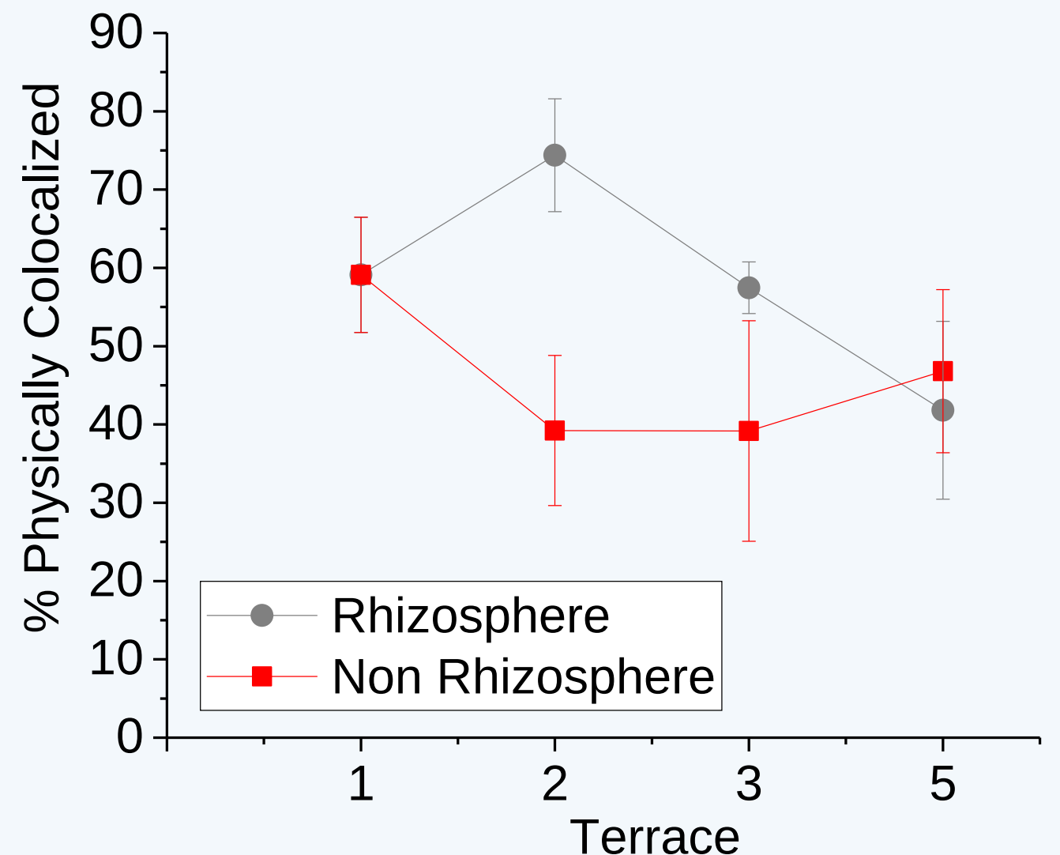
Fe-C Map & Correlation Diagram

Spatial Correlation Between C and Fe



- Initial rhizogenic weathering (terrace 2) increases the spatial correlation between C and Fe.
- Thereafter, the correlation becomes weaker (terraces 3-5).
- In the non-rhizosphere, the spatial correlation gradually becomes weaker.

Colocalization of C and Fe



- The fraction of C and Fe associated with each other increases initially (terrace 2), and decreases sharply thereafter.
- In the non-rhizosphere soil, the percent of C associated with Fe remains somewhat constant.

Acknowledgements

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