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Soil carbon research from past, present and future using synchrotron-based techniques

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Building and protecting soil carbon is critical to agricultural productivity, soil health and climate change mitigation. This study aims to answer new questions of the molecular scale mechanisms at the organo-mineral interfaces for building soil carbon in the past: *Terra Preta Australis* (ancient indigenous dark earth, dated back to 1600 years BP); present: the longest, continuous biochar field experiment in the world, located at Wollongbar, New South Wales (building new carbon over 14 years); future: the Australian Soil Free Air CO₂ Enrichment (SoilFACE) field facility at Horsham, Victoria (mimicking elevated CO₂ conditions in the field over 8.5 years in the Southern Hemisphere). Based upon synchrotron-based *in situ* spectromicroscopy, we reveal the functional complexity and spatial resolution of soil organic carbon under contrasting management practices, cropping histories and soil types over millennium. It will provide critical information to advance knowledge of building soil carbon for productive, sustainable and resilient cropping systems.

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