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Quantifying bioturbation and soil thickening over the late Quaternary

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We present geochemistry and biochemistry data to explore how bioturbation has operated in a residual sandstone-derived soil that thickened during the Holocene following aeolian deflation during the Last Glacial Maximum. Our site is located on a plateau cut into Triassic sandstones in humid Blue Mountains, SE Australia, where precipitation is ~1100 mm/a, and the mean annual maximum and minimum temperatures are 17ºC and 5ºC, respectively.

Vegetation cover increase occurred ~13 ka, based on nearby palaeodune activity and pollen data from other highland sites. Our interpretation of terrestrial cosmogenic radionuclides (TCN) data suggests that ~30 cm of soil thickening has taken place since 13 ka, which includes 16 cm of bedrock lowering.

Biofabrics preserve a short-term picture of biotically-displaced soil. In general, bioturbation decreases exponentially with increasing soil depth. The upper 21 cm of the profile is ~95% bioturbated; the middle 13 cm is 13 – 32% bioturbated; and the lowest 52 cm is 1 – 6% bioturbated. Tree roots penetrate weakness in the sandstone below this depth.

Fallout radionuclides (7Be, 210Pb, and 137Cs) in the profile also suggest that vertical mixing in the upper 20 – 40 cm occurs over short—decadal—timescales.

Optically stimulated luminescene (OSL) data records the time that quartz grains were last at the surface, and are used here to demonstrate vertical mixing of the profile over tens of thousands of years. OSL data indicates that some soil grains at all burial depths were once at the surface, consistent with modern process observations.

Carbon and nitrogen isotopic values (delta 13C and delta 15N) of soil organic matter support the existence of soil organic matter turnover in the upper 30 cm of the soil column when regressed with log(SOC) and log(TN). Our carbon isotope data defy typical trends below ~30 cm for residual, undisturbed soils. We suggest this may reflect the absence of bioturbation during the LGM when the climate was cold and dry, and soil was deflated. Since ~13 ka, we believe the vegetation cover increased and bioturbation became affective, resulting in mixing of organic and mineral material, and concurrent soil thickening.