SOC stabilization mechanisms and temperature sensitivity in old terrace soils

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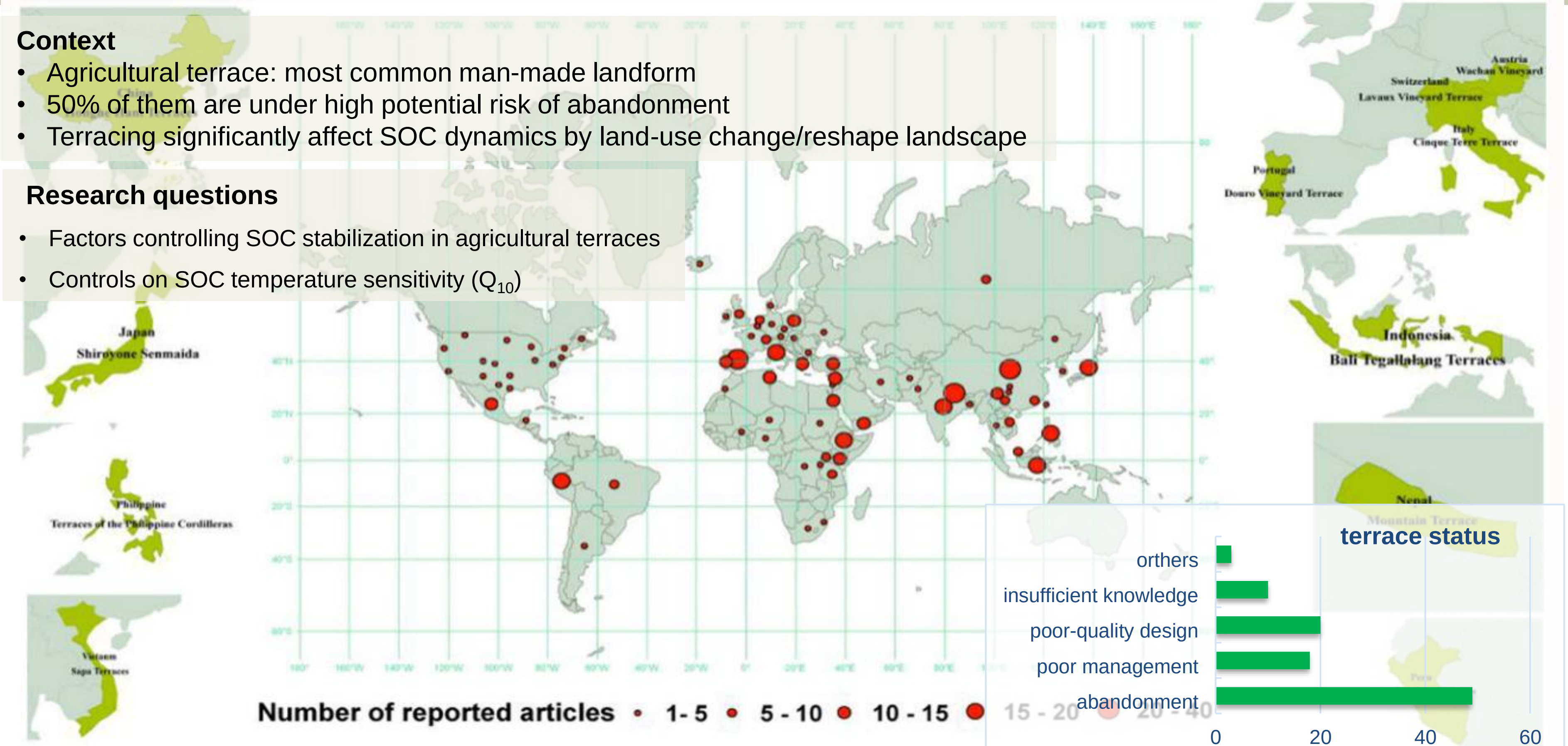
Context and research questions

Context

- Agricultural terrace: most common man-made landform
- 50% of them are under high potential risk of abandonment
- Terracing significantly affect SOC dynamics by land-use change/reshape landscape

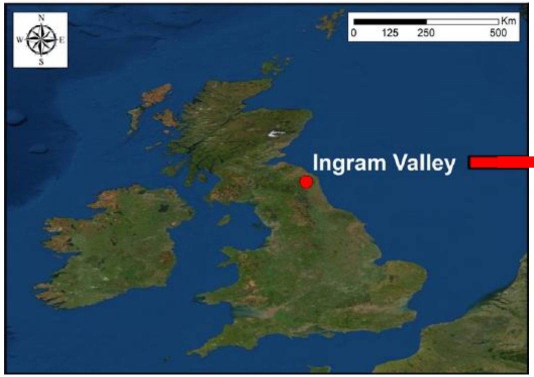
Research questions

- Factors controlling SOC stabilization in agricultural terraces
- Controls on SOC temperature sensitivity (Q_{10})

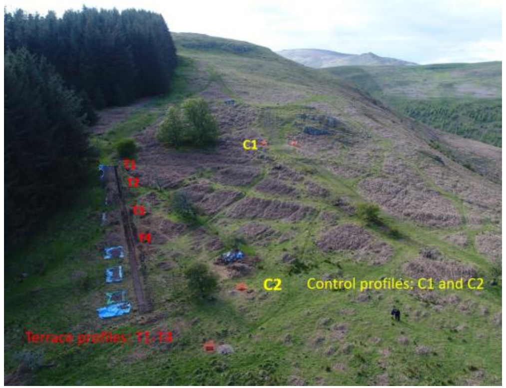


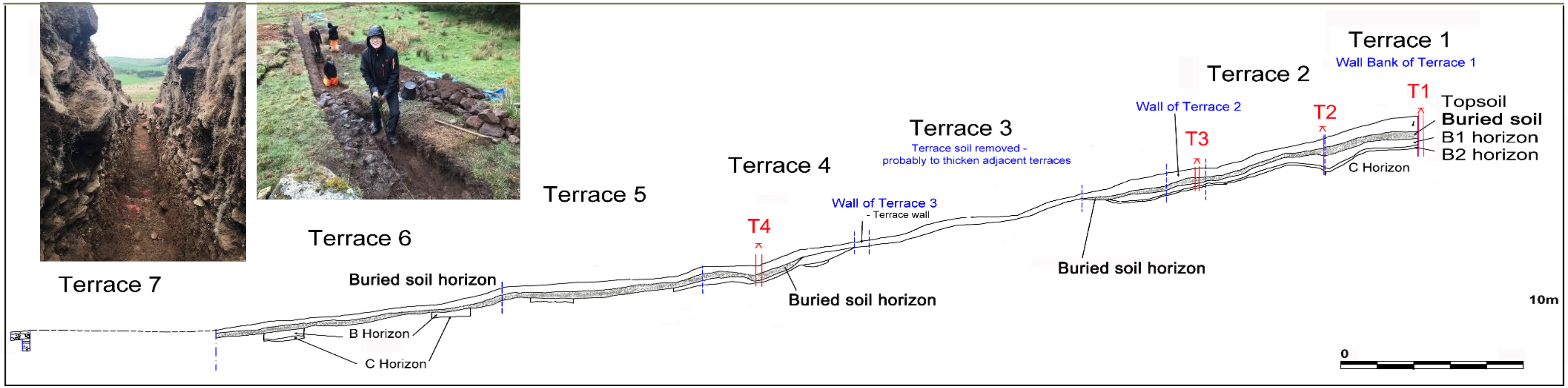
Wei et al., 2016 ESR

Studying area



- Northumberland National Park, UK
- multi-period archaeological landscapes
- Early Bronze Age c. 1800–1500 BC
- Maritime temperate climate





Lab analysis

SOC fractionation

BULK SOIL (40g, 8 mm)

Particulate organic C >250 µm	Micro-aggregated C 53–250 µm	Silt & clay <53 µm
Unprotected C [POM]	Physically protected C [M]	Chemically protected C [S+C]

Stability: low → high

SOC respiration - soil incubation (8 weeks)

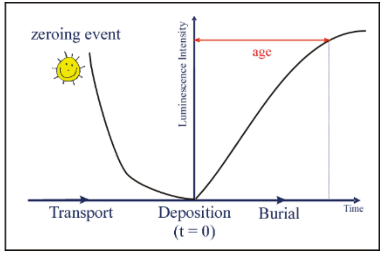
30 g 2 mm sieved bulk soil; 350 ml sealed jars; 20 ℃ and 30 ℃; soil respiration + SOC temperature sensitivity (Q_{10})

Elemental composition and pedogenic oxides

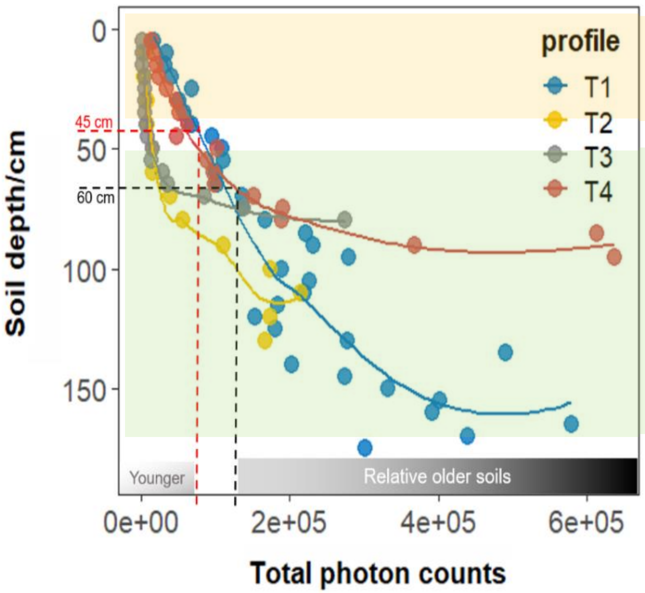
- ✓ Rubidium/Strontium (weathering indicator)
- ✓ Sequential pedogenic extractions (Fe, Al, Mn)

Soil burial age —— field pOSL

➢ Optically stimulated luminescence (OSL)



Results —— SOC respiration (SPR) and temperature sensitivity (Q_{10})



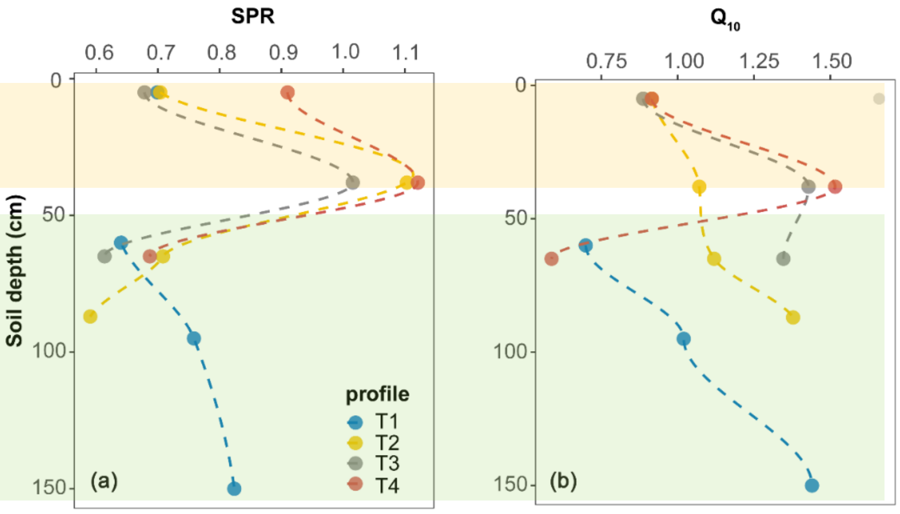


Fig. 1 Depth profile of (a) soil potential respiration rates (SPR) and (b) SOC tempe rature sensitivity (Q_{10}). Values are expressed as the ratio between the terrace and control profiles.

Overall, SOC from old soil layers have been protected, but they show higher sensitivity to warming

Results —— Stabilization mechanisms of terracing SOC

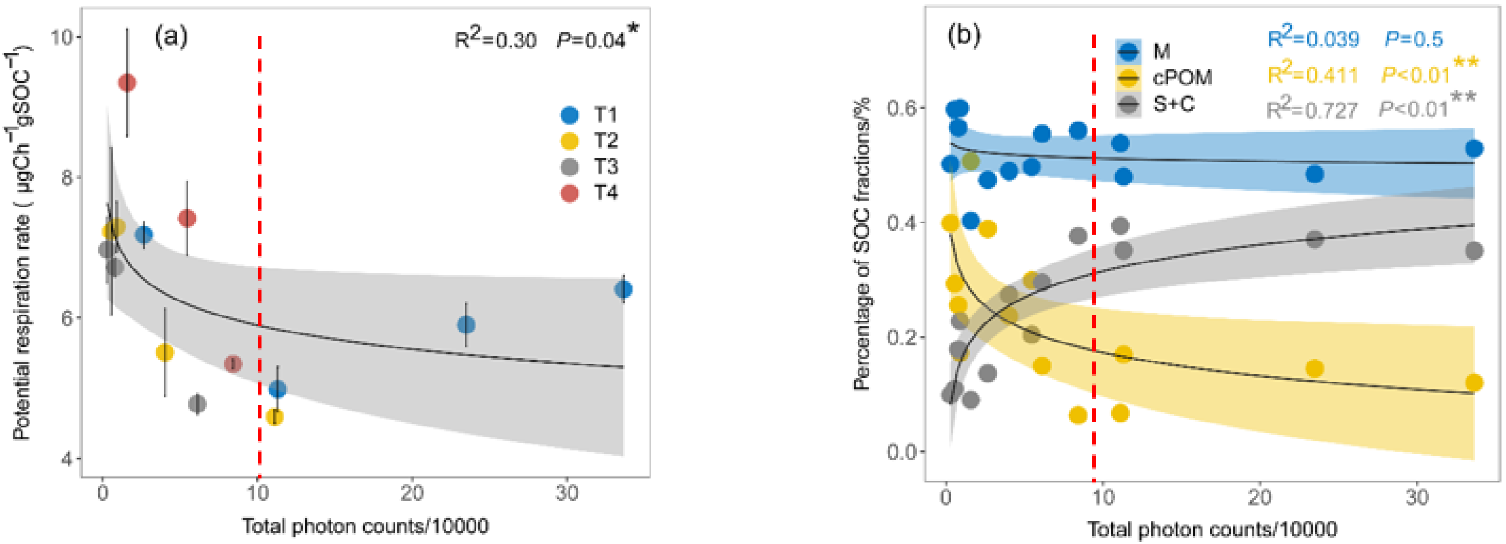


Fig. 2 Relation between terrace soil burial age (total photon counts) and, (a) soil potential respiration rates (SPR) and (b) SOC fractions as a percentage of total SOC (%). Formula: y=log(x).

- older soil horizons (buried layers) tended to have a lower SPR
- The shift to more processed recalcitrant SOC (S+C fracction) with terrace age contributes to SOC stability in terraced soils (Fig. 2b)

Results —— controls on SOC temperature sensitivity

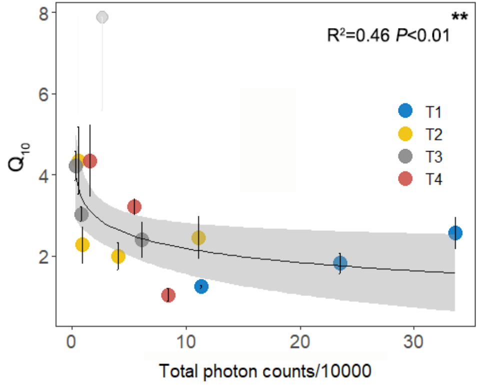


Fig. 3 Relationship between SOC temperature sensitivity to decomposition (Q10) and relative terrace soil burial age (total photo counts).

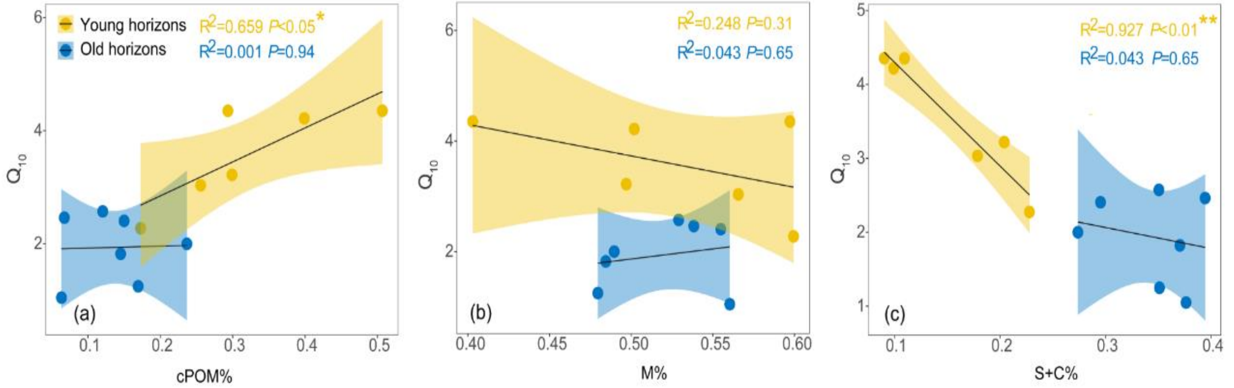


Fig.4 Relationship between SOC temperature sensitivity (Q10) and (a) unprotected SOC (cPOM%), (b) physical protected SOC (M%) and (c) mineral protected SOC (S+C%) for relative younger and older terrace soil horizons, respectively. *= P<0.05; **P<0.01.

Table 1 Correlation between SOC fractions and pedogenic oxides

	Al_p	Fe_p	Mn_p	Al_o	Fe_o	Mn_o	Al_d	Fe_d	Mn_d
Young soil layers									
cPOM						-0.81			-0.76
m									
s+c	0.78	-0.88		0.89	0.88	0.83	0.84		0.88
Old soil layers									
cPOM									
m									
s+c									

Young soil horizons

SOC mineral protection attenuate the SOC intrinsic temperature sensitivity by reducing the availability of SOC substrate to decomposers

Old horizons?

Results —— controls on SOC temperature sensitivity

Table 2 Relationship between SOC temperature sensitivity (Q_{10}) and C:N ratios of bulk soil and SOC fractions.

	Bulk soil	cPOM	M	S+C
Q_{10}	**0.60***	0.03	**0.61***	**0.62***

* P<0.05. N=13.

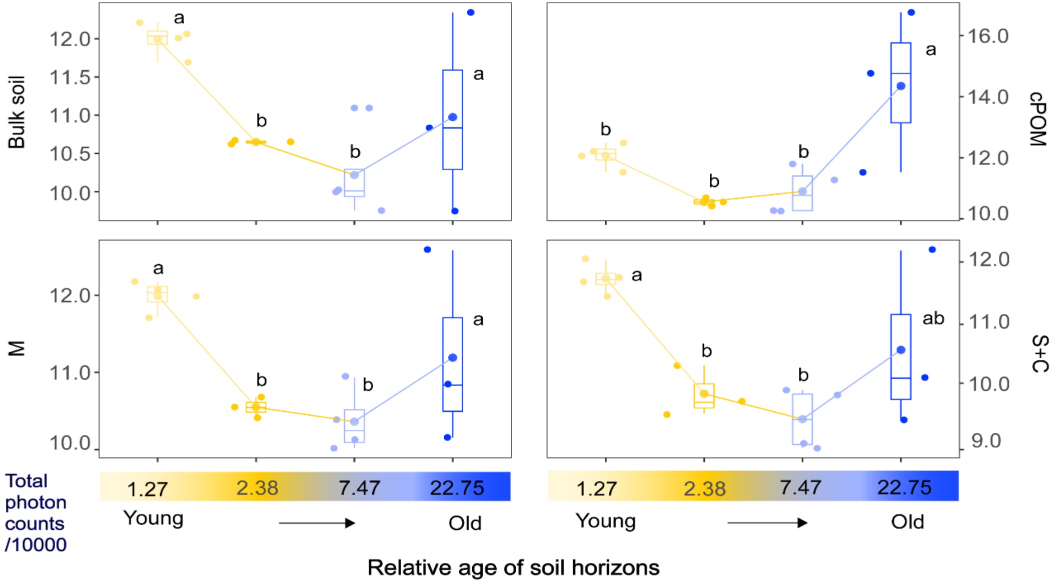


Fig. 5 C:N ratios for bulk soil and SOC fractions along with the gradient of terrace soil burial age (total photon counts). Significant differences in C:N ratios between soil age gradient are indicated by different lowercase letters (P<0.05).

Old horizons

Higher C:N ratio (lower quality) of SOC lead to a higher temperature sensitivity of SOC stored in buried horizons

Conclusions

- Soil burial due to terracing provides a C stabilization mechanism.
- With increasing burial age, the SOC pool composition shifts from particulate OC to mineral protected OC pool.
- Both soil C:N ratio (C quality) and SOC mineral protection regulate Q_{10}
- The dominant mechanism controlling this temperature sensitivity depends on the burial age

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