Climatic and mineralogical controls on cycling rates of mineral-associated soil organic matter

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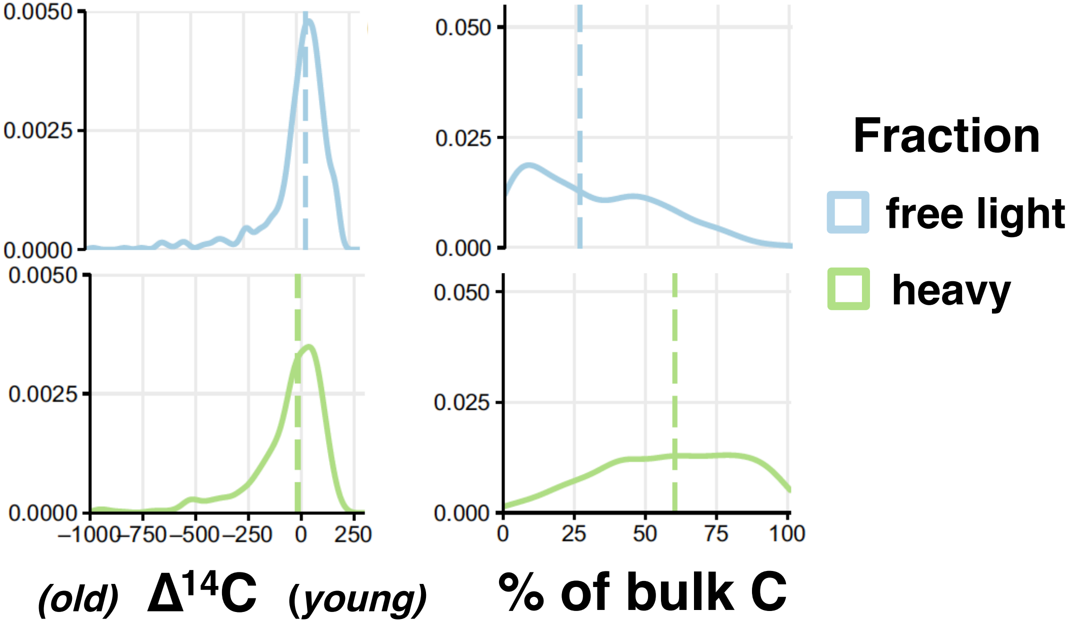
B32D: Soils in the Anthropocene

MOTIVATION

- **Majority of soil C is mineral-associated (“heavy”)**
- **Some mineral-associated C very old**
- **Yet globally, heavy fraction C is surprisingly young**



Global distribution of $\Delta^{14}C$ in fractions (<30cm) ***(right)***

(Heckman & Hicks-Pries et al. 2021)

MOTIVATION

- Majority of soil C is
  miner
  ("hea
- Heavy
  surpr

ction

ee light

eavy

Global dis
fractions

(Heckman &

What controls

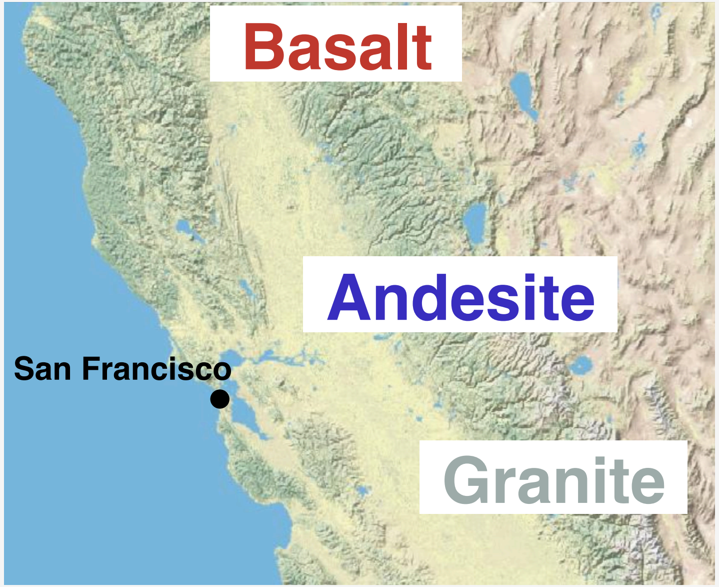
FAST (annual - decadal)

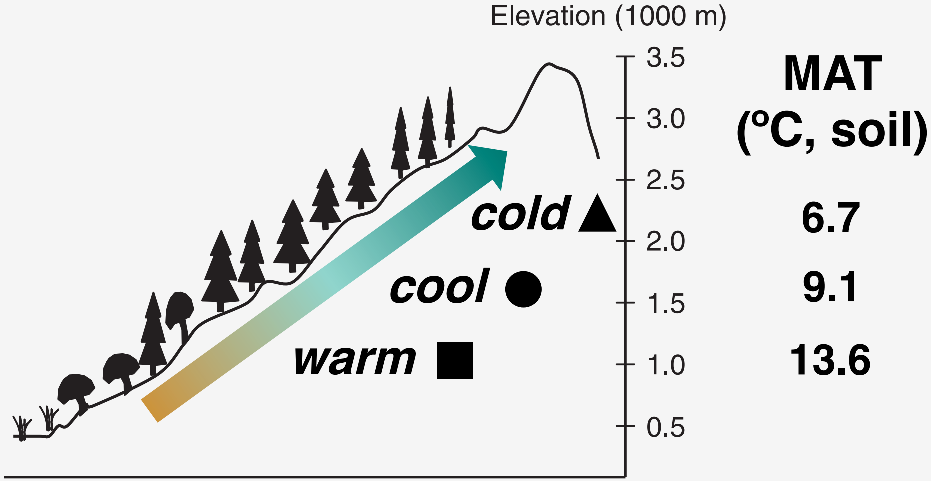
_vs._

SLOW (centennial – millennial)

mineral-associated C?

EXPERIMENTAL DESIGN


Basalt
Andesite
San Francisco
Granite

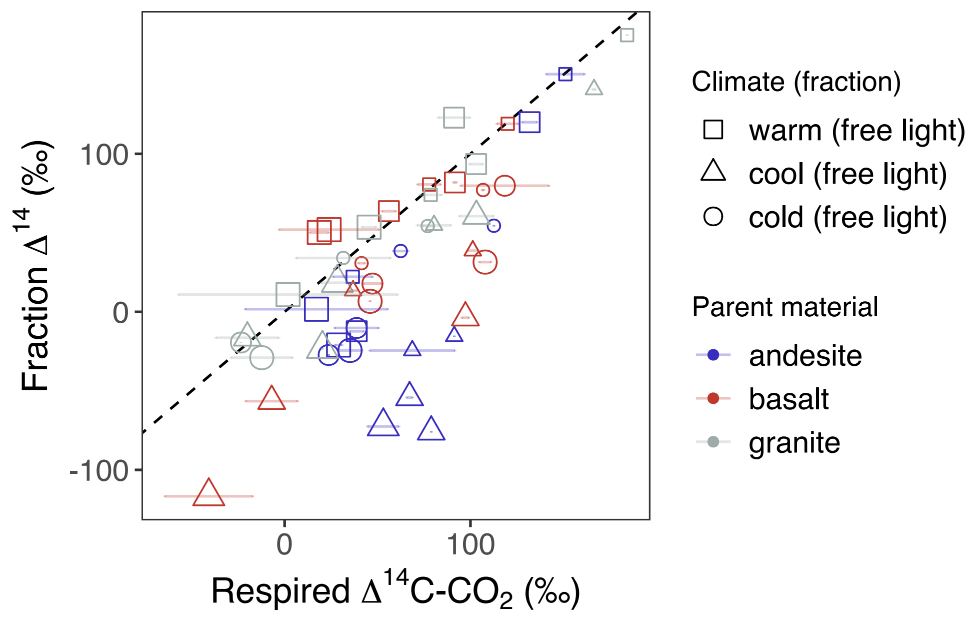

Elevation (1000 m)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
cold ▲
cool ●
warm ■
MAT
(°C, soil)
6.7
9.1
13.6

Sampled: 2001, 2009, 2019
Analyses: $\Delta^{14}C$, incubation, density & thermal fractionation

Results

FRACTION vs RESPIRED $\Delta^{14}C$

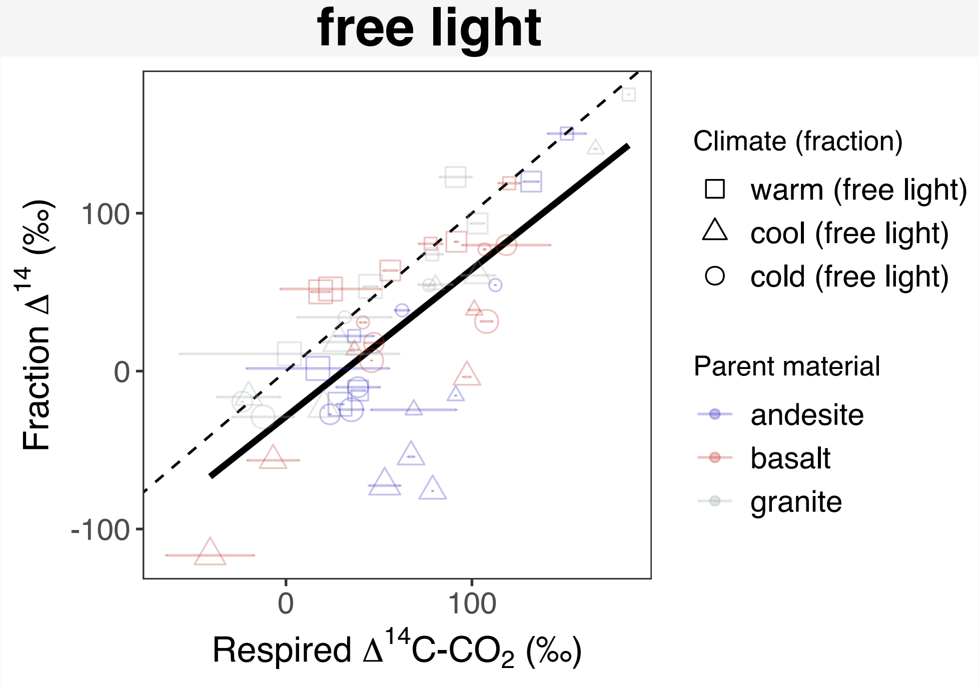
free light



2001 & 2019 data;

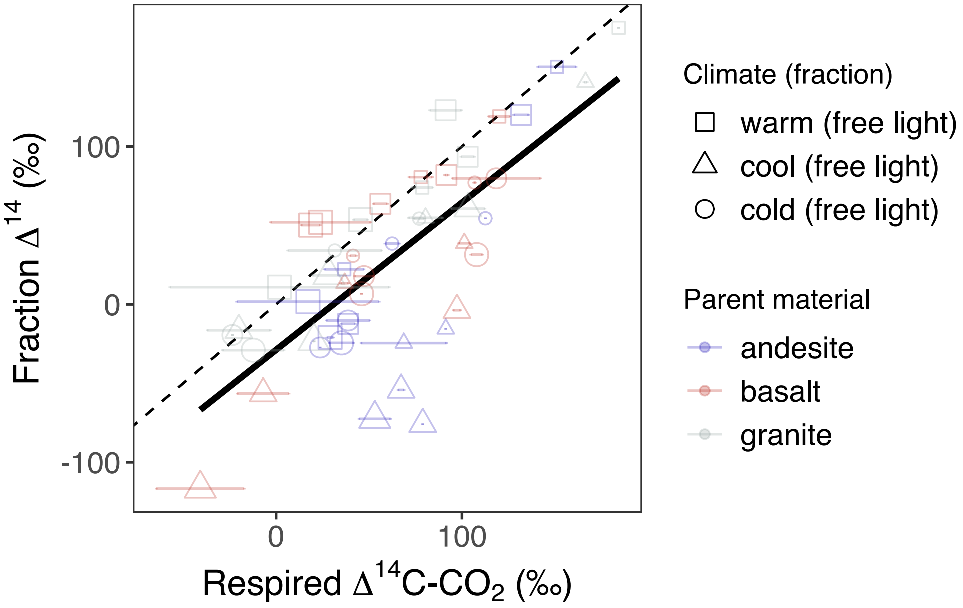
point size increases with depth

FRACTION vs RESPIRED Δ^{14}C

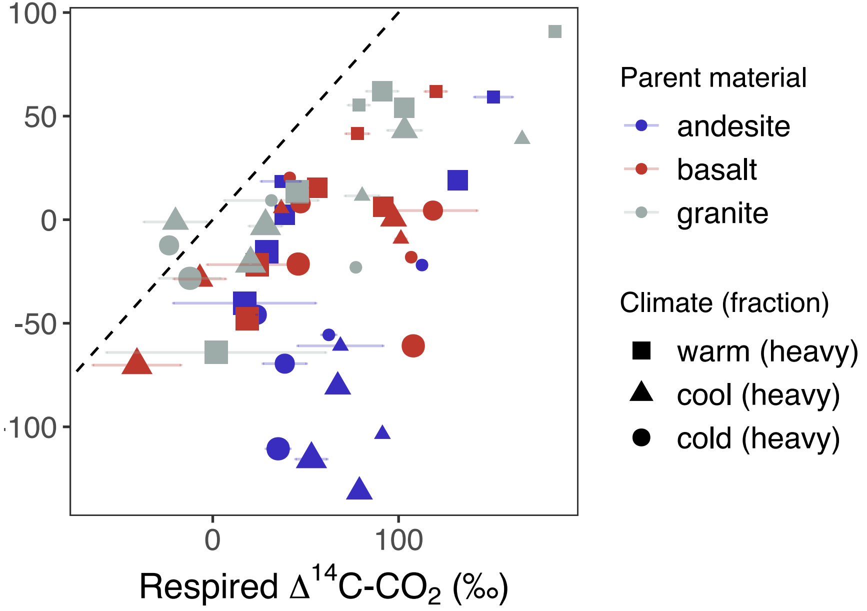


FRACTION vs RESPIRED $\Delta^{14}C$

free light

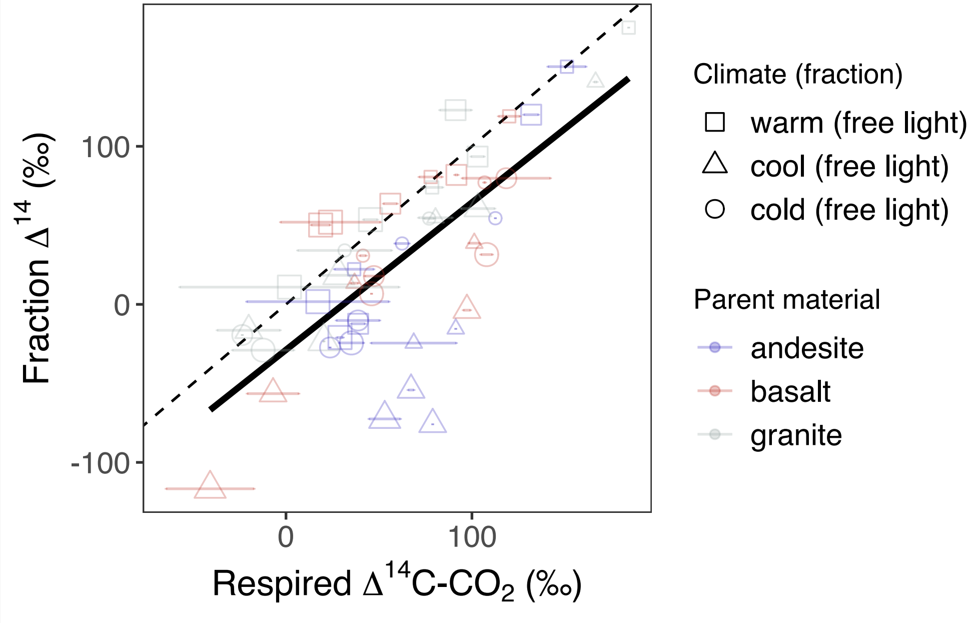


heavy

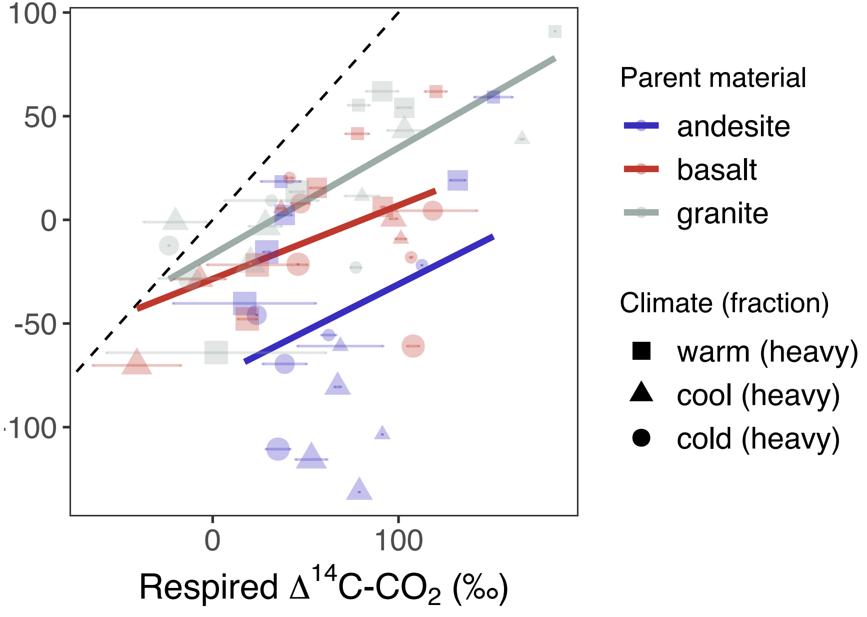


FRACTION vs RESPIRED Δ^{14}C

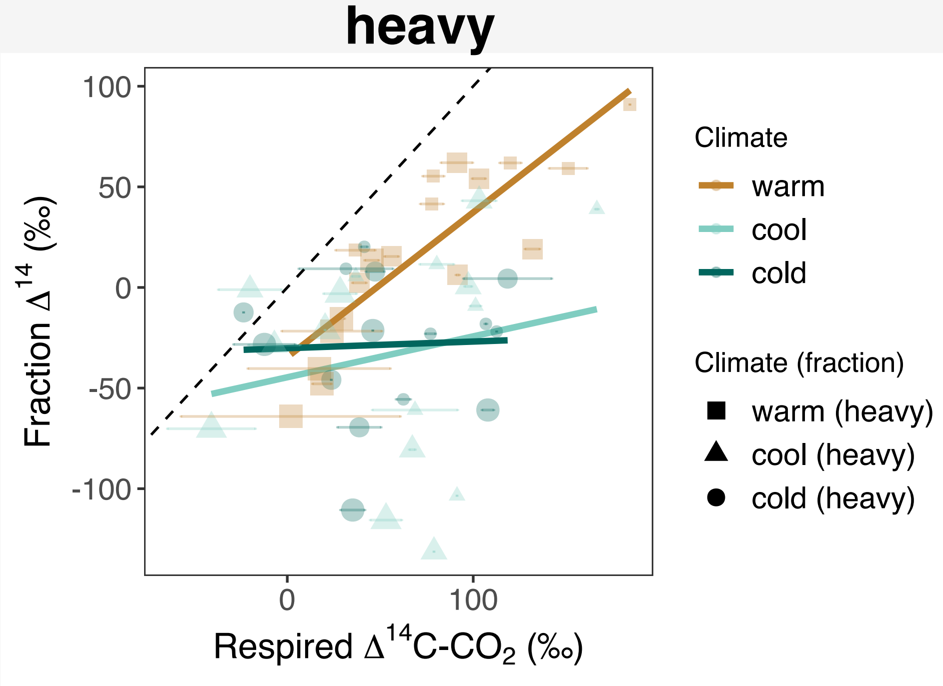
free light

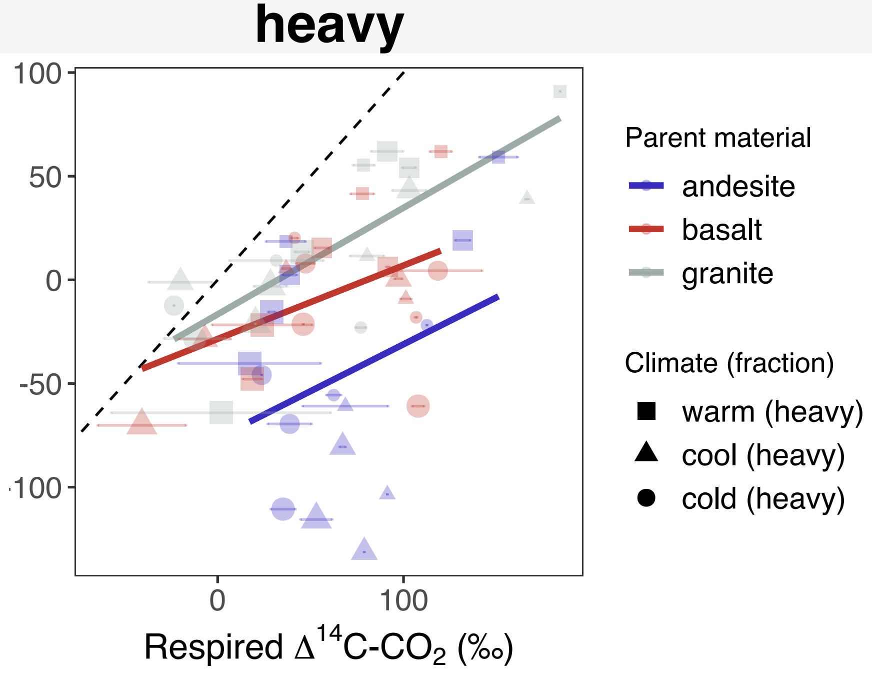


heavy

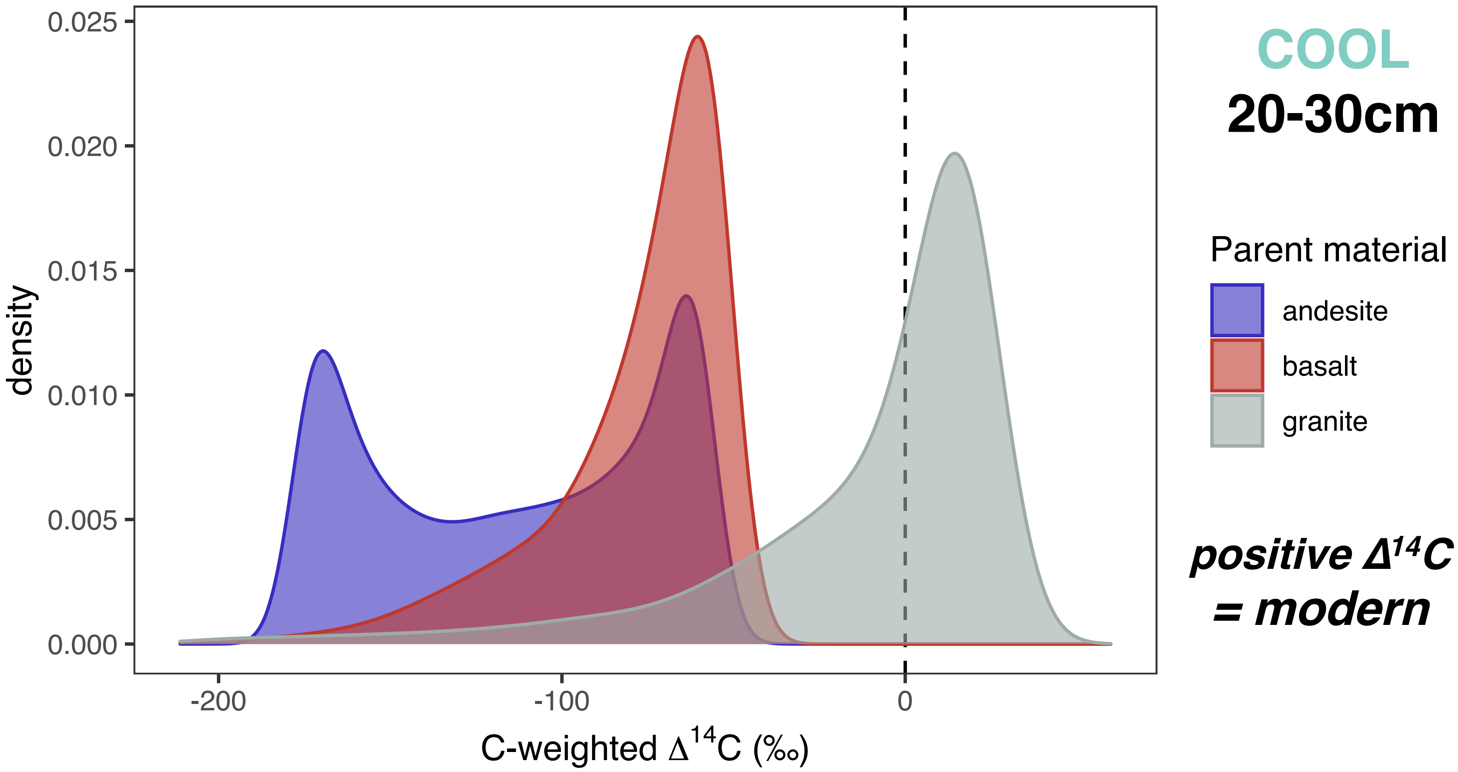


FRACTION vs RESPIRED Δ^{14}C


heavy


heavy

HEAVY FRC $\Delta^{14}C$ DISTRIBUTION

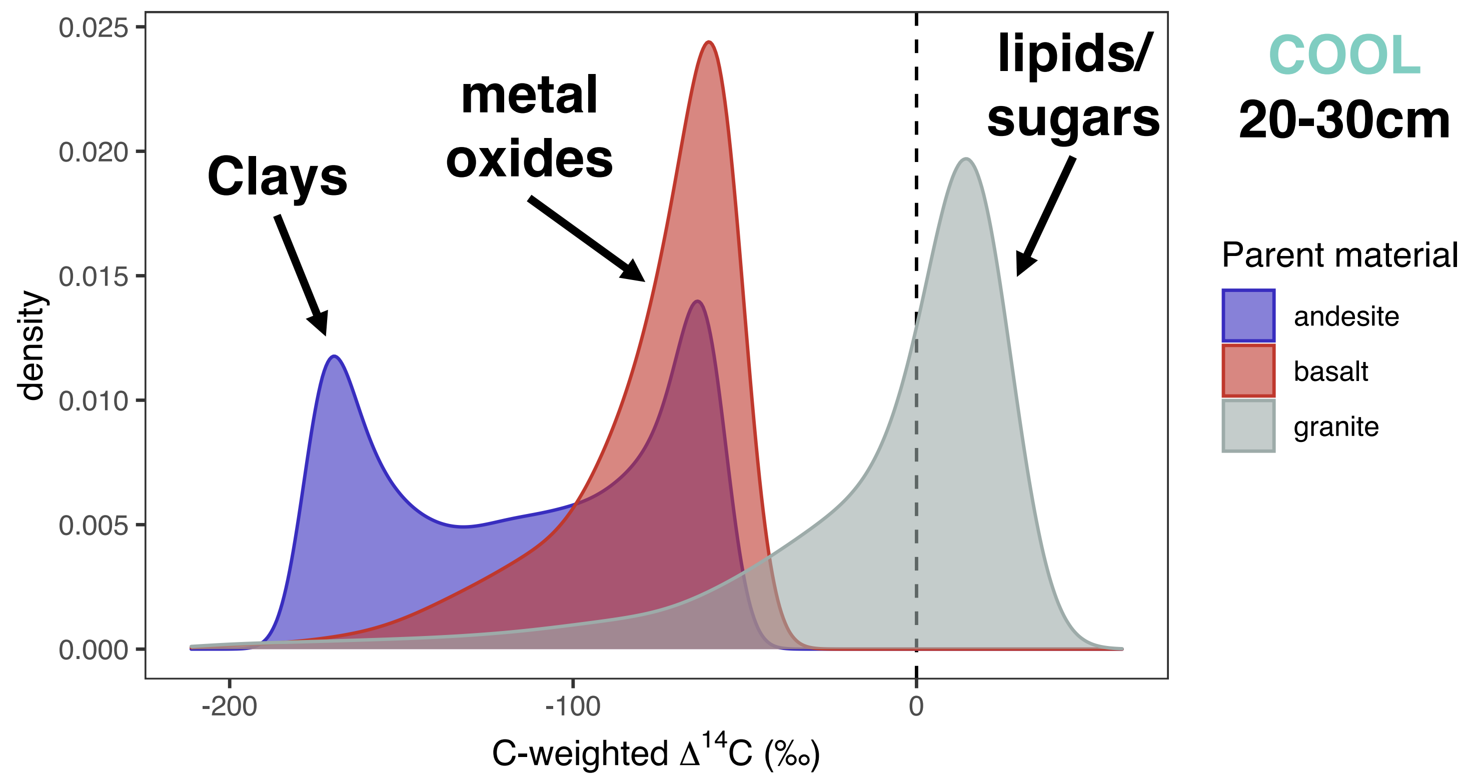


COOL

20-30cm

positive $\Delta^{14}C$ = modern

HEAVY FRC Δ^{14}C DISTRIBUTION



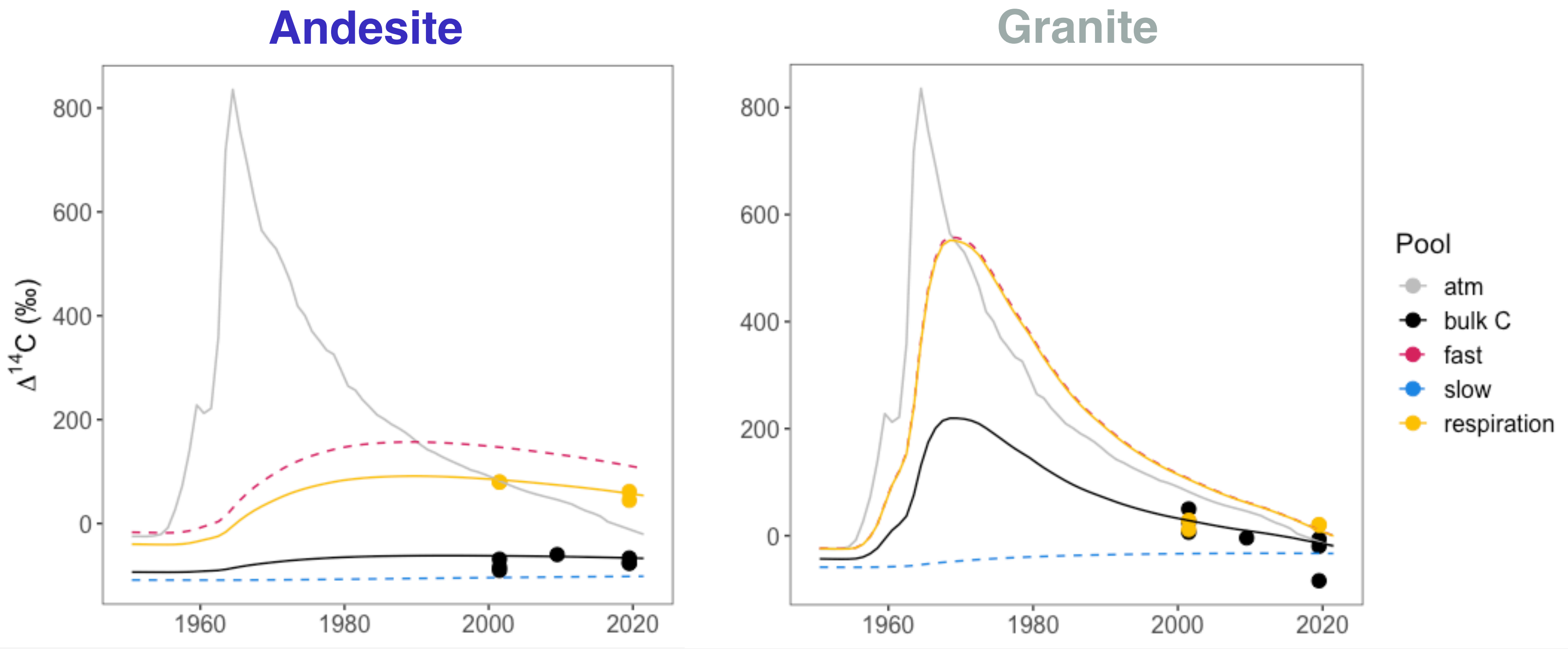
Clays

metal oxides

lipids/ sugars

COOL 20-30cm

NEXT STEP: TIMESERIES MODELS



2-pool example models

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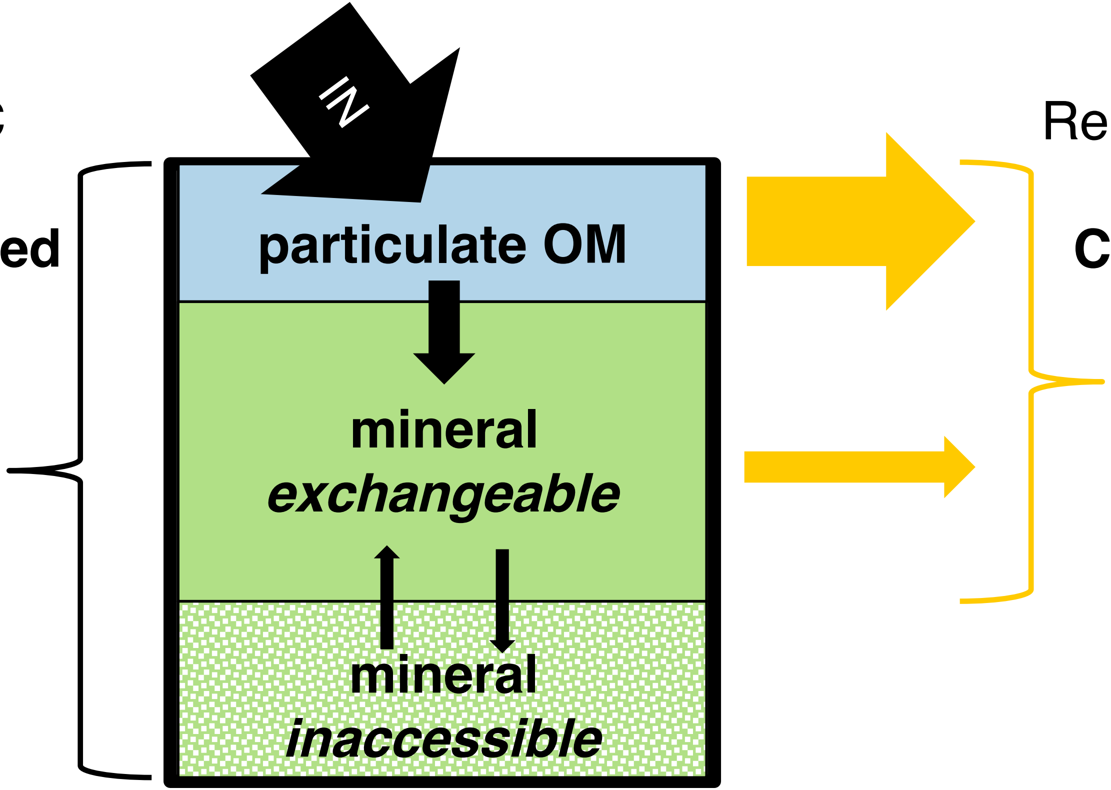
photo by S. von Fromm

SOIL C POOLS and RESPIRED C

Bulk soil $\Delta^{14}C$

=

C mass weighted



particulate OM

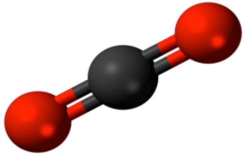
mineral
exchangeable

mineral
inaccessible

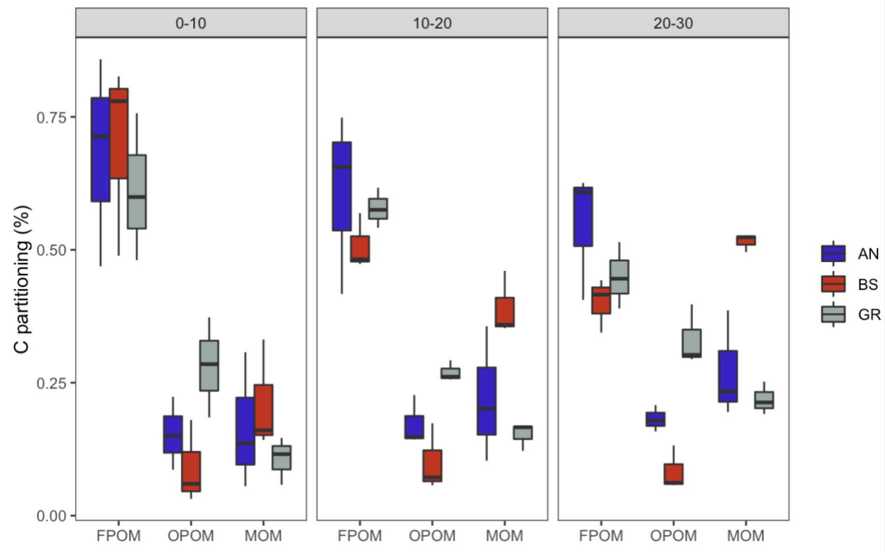
Respired $\Delta^{14}C\text{-}CO_2$

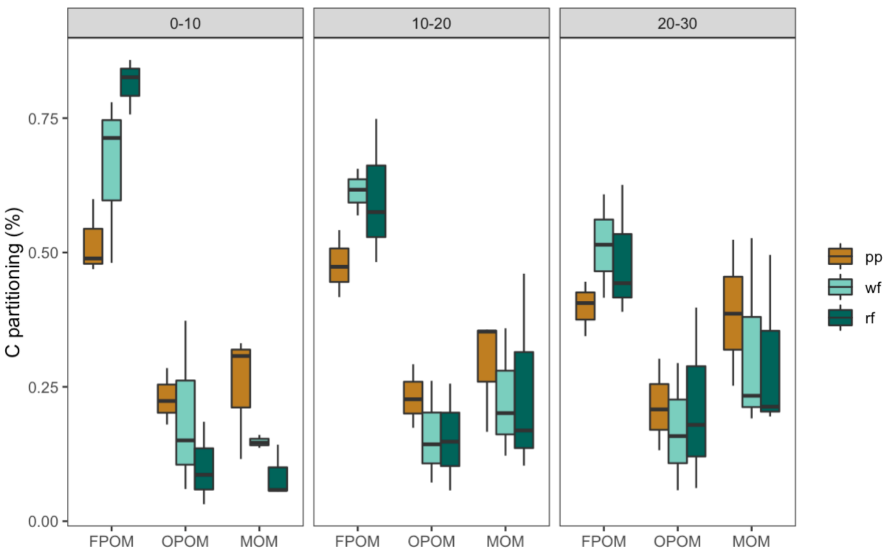
=

C flux weighted

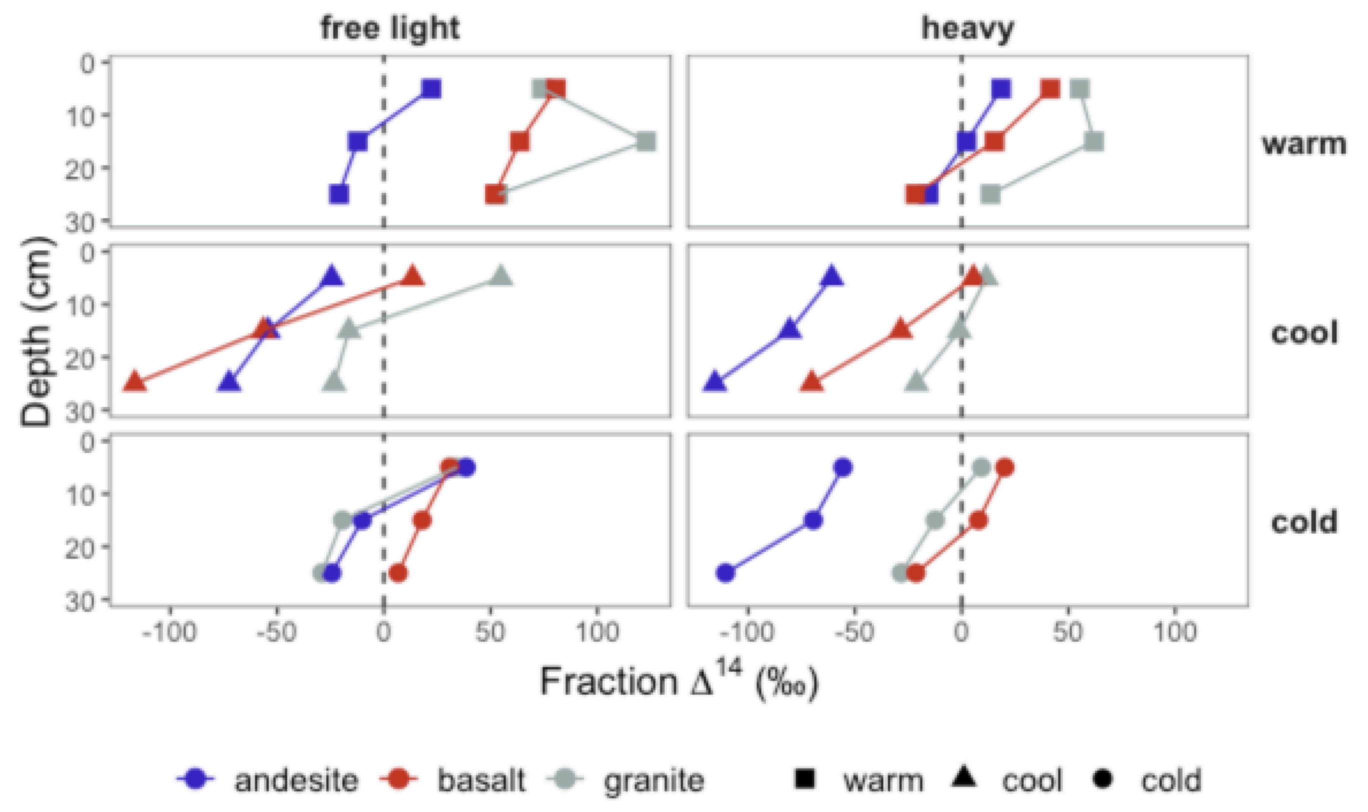


FRACTION C DISTRIBUTION





FRACTION Δ^{14}C DEPTH PROFILES



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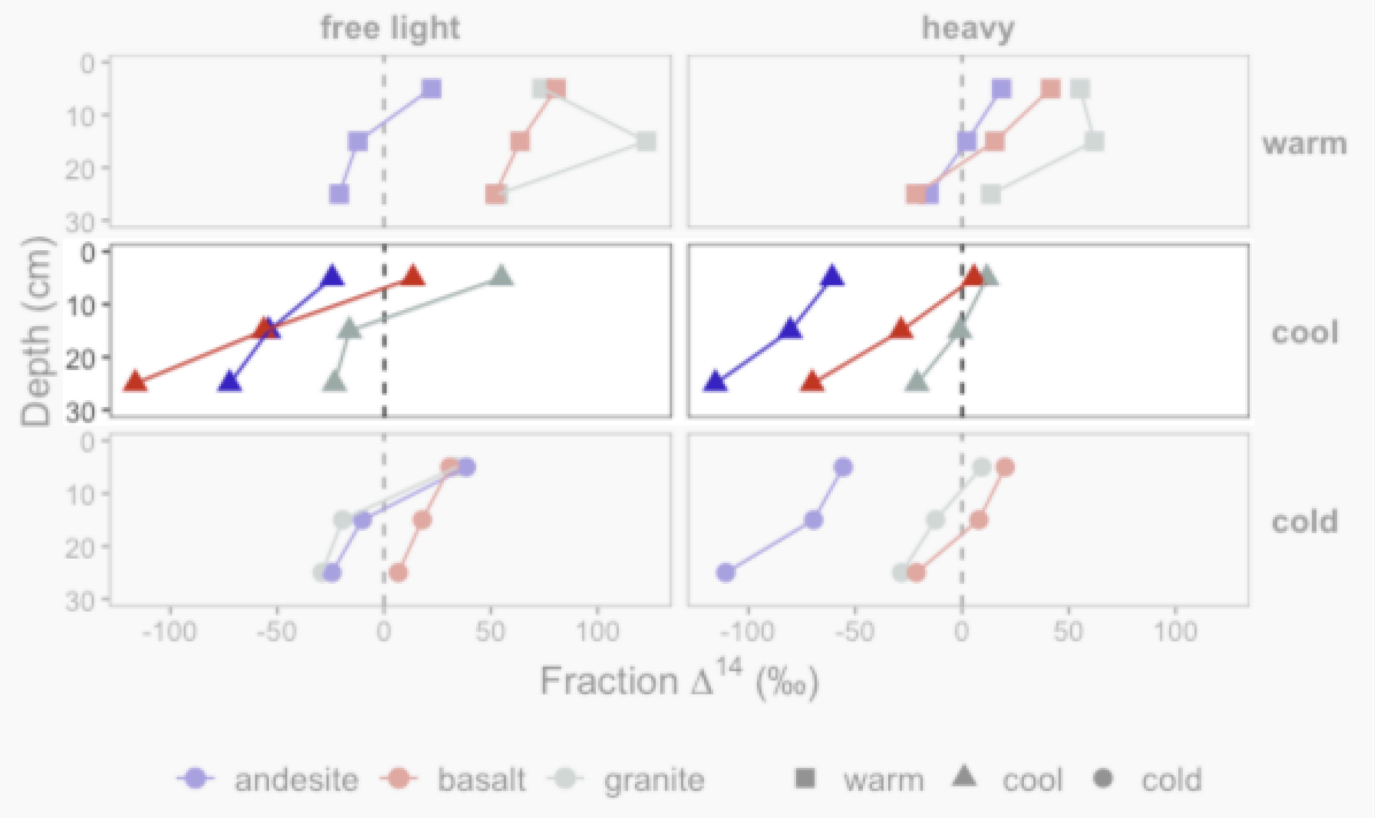

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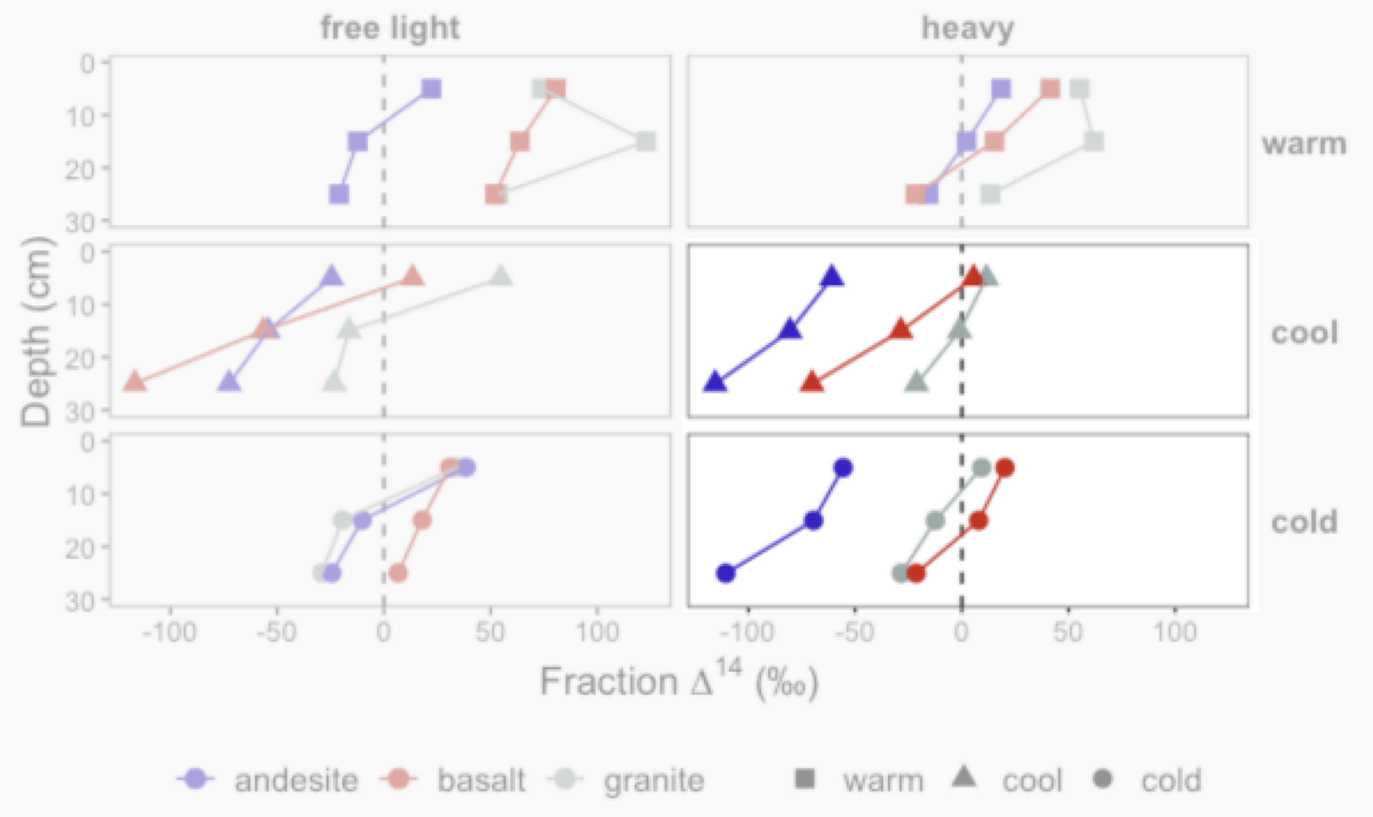
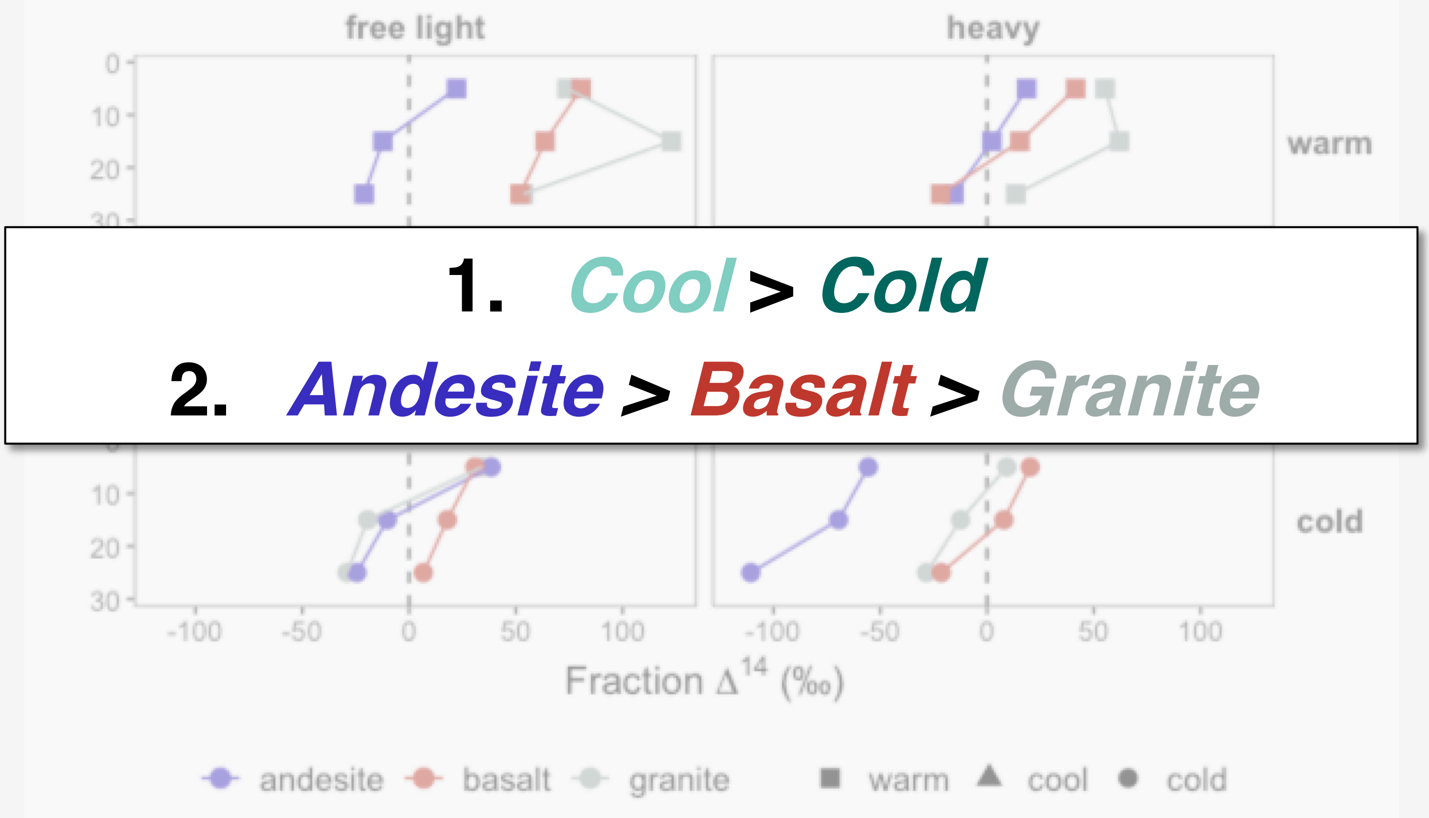


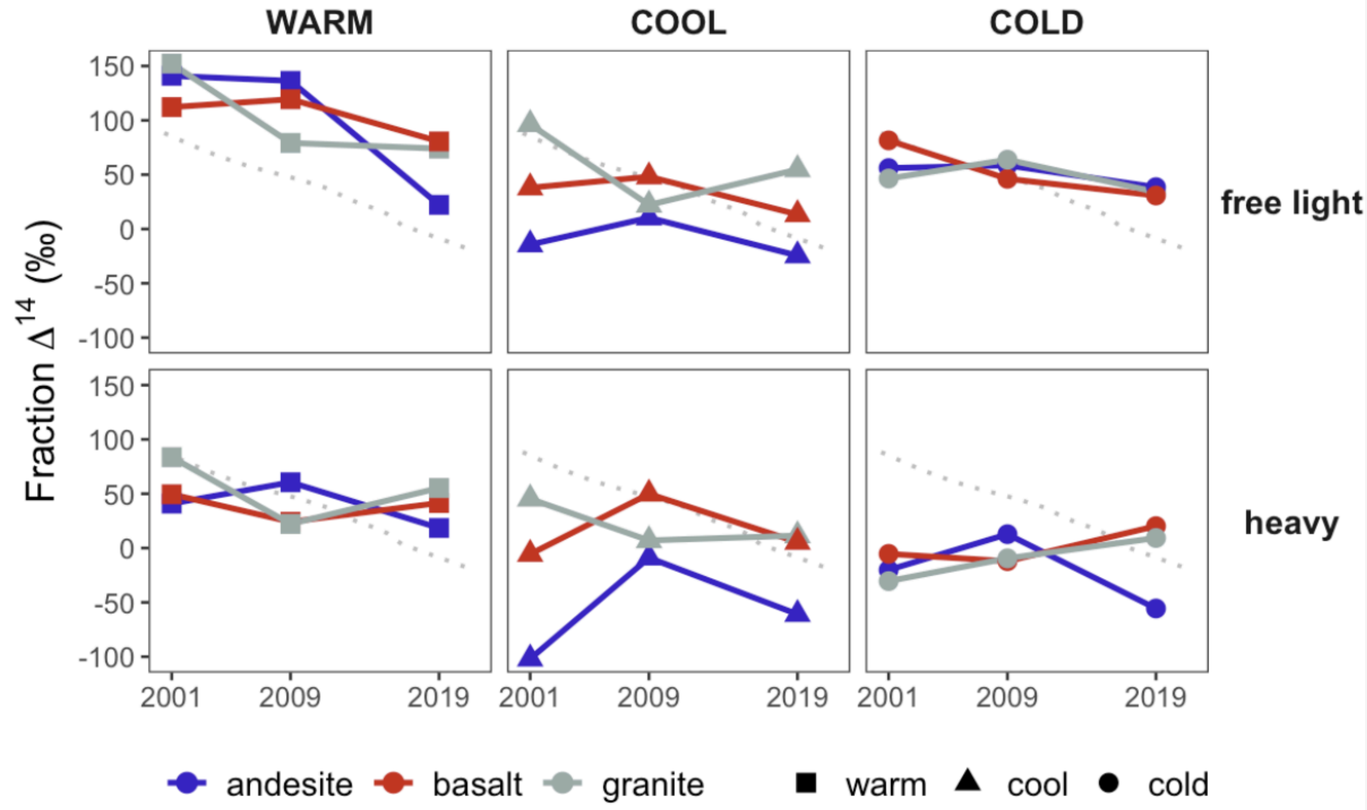
FRACTION Δ^{14}C DEPTH PROFILES



1. *Cool* > *Cold*
2. *Andesite* > *Basalt* > *Granite*

FRACTION $\Delta^{14}C$ TIME SERIES

negative $\Delta^{14}C$ = older

positive $\Delta^{14}C$ = younger