Soils in archaeological structures of the southern Levant: archives of Holocene dust dynamics

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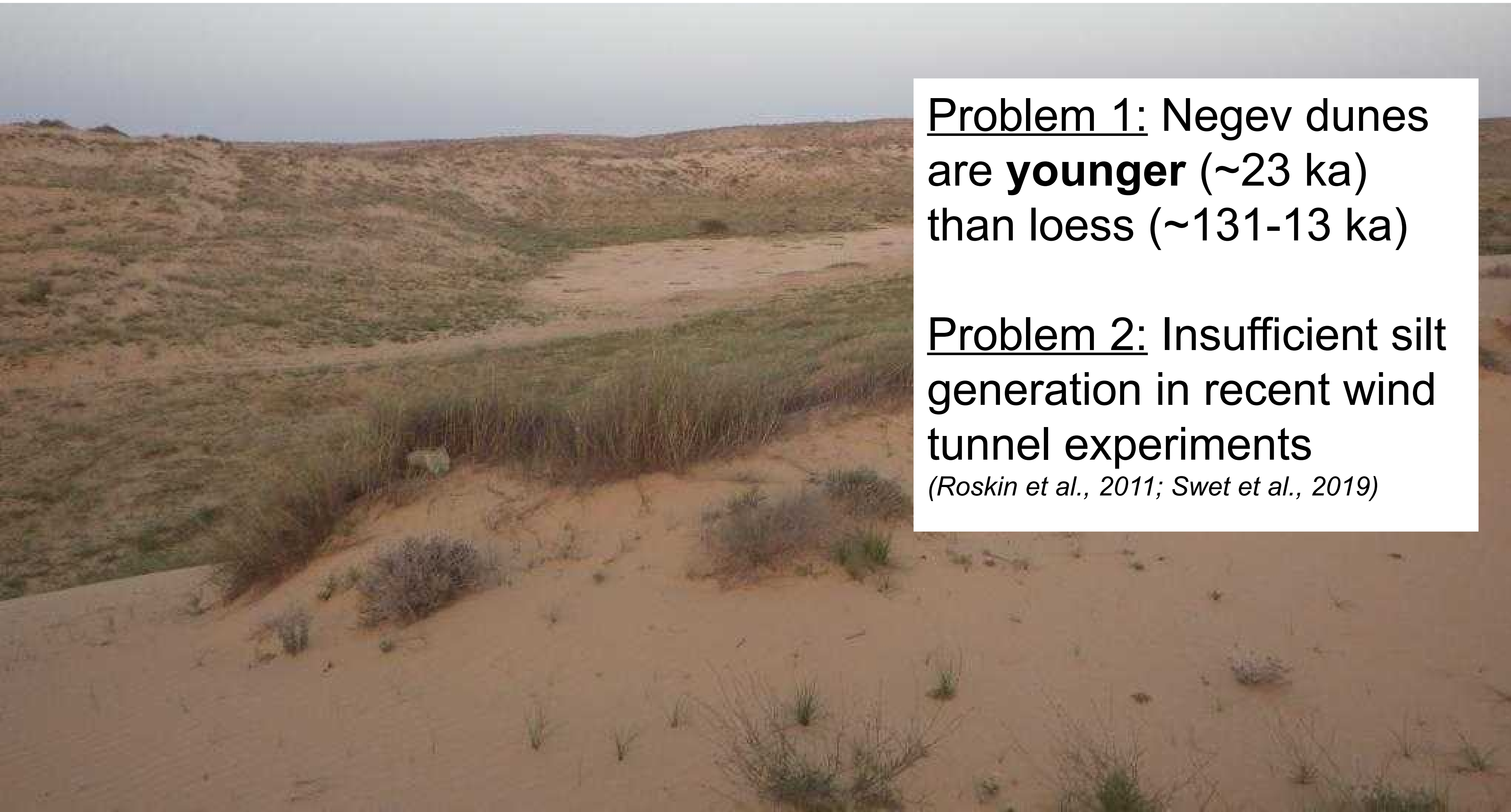
Loess in the Negev has been proposed to result from quartz abrasion in Negev-Sinai sand dunes – and Ergs in general as 'desert loess' sources.
(e.g. Crouvi et al., 2009, 2010)

Holocene loess seems **missing**: product of *dustier Pleistocene*, with *stronger winds* leading to abrasion of dune sands?



Problem 1: Negev dunes are **younger** (~23 ka) than loess (~131-13 ka)

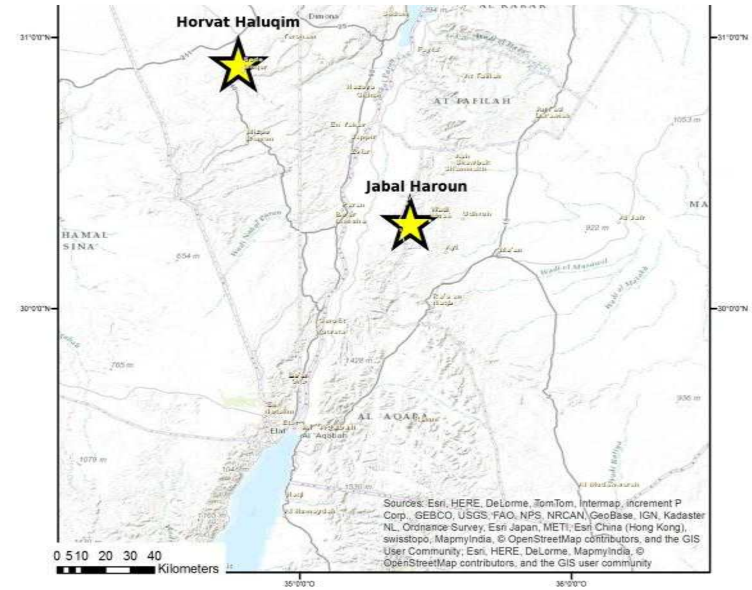
Problem 2: Insufficient silt generation in recent wind tunnel experiments
(Roskin et al., 2011; Swet et al., 2019)

<u>Basic premise of earlier studies</u>:

Settled dust = dust moving through the atmosphere

<u>Approach of earlier studies</u>: Identification of indicators of dust sources

Our approach: What about the sediments covering archaeological ruins?



Systematic comparison of sediments in arch. ruins in south Israel and Jordan

- (Partly) collapsed ruins are usually covered by debris
- The fine fraction likely includes ***aeolian dust***

→*Potential* ***Holocene loess*** *in the Levant (missing link between studies of Pleistocene and modern dust)*

Including sampling the occasional current dust storms

Systematic comparison

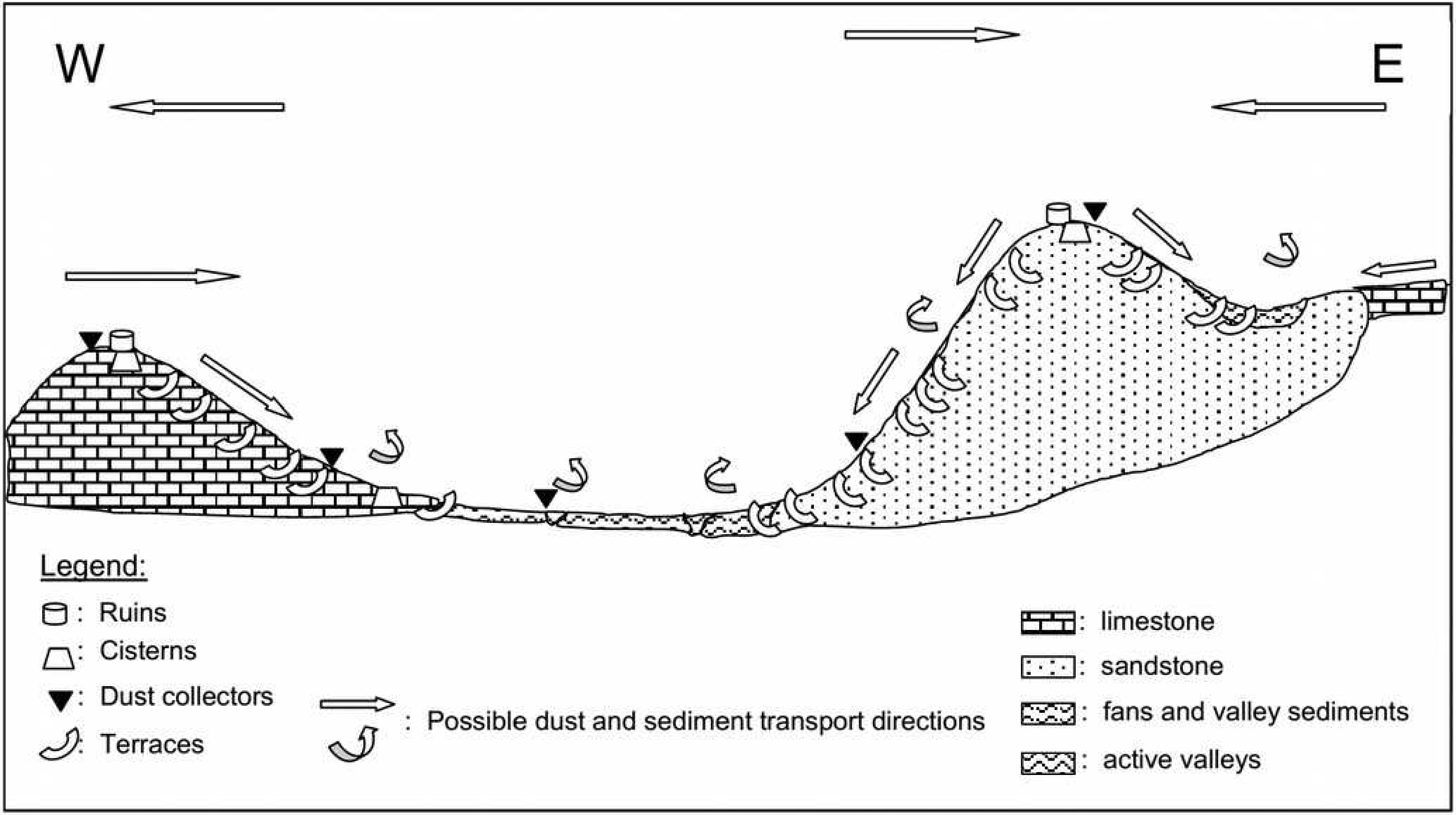
Hilltop ruins

Terraces

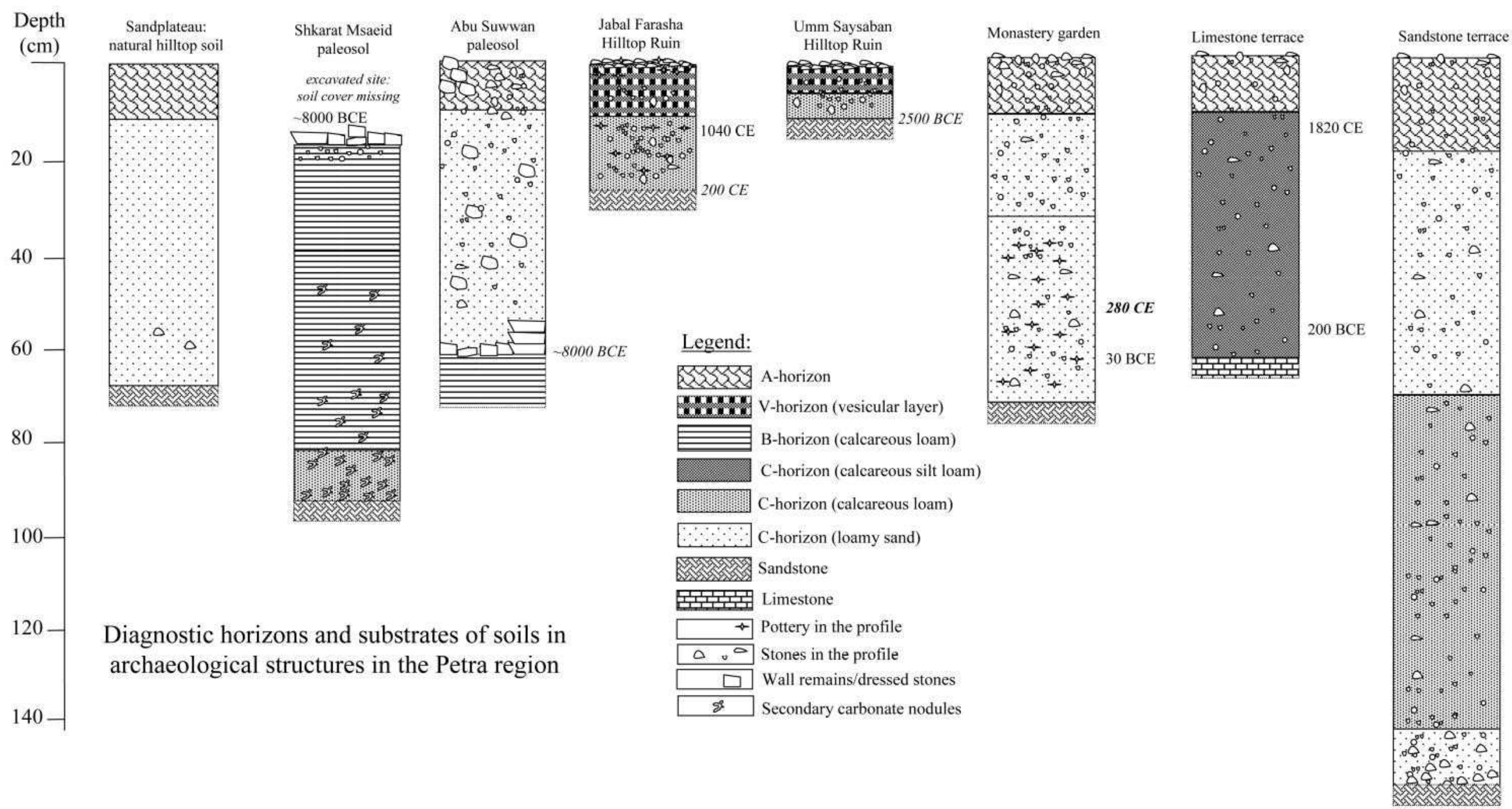
Closed cisterns

Open cisterns / reservoirs

Systematic comparison II: Relief position, source rock, regional setting



Comparison of sediments in various archaeo-logical structures in the Negev and Jordan



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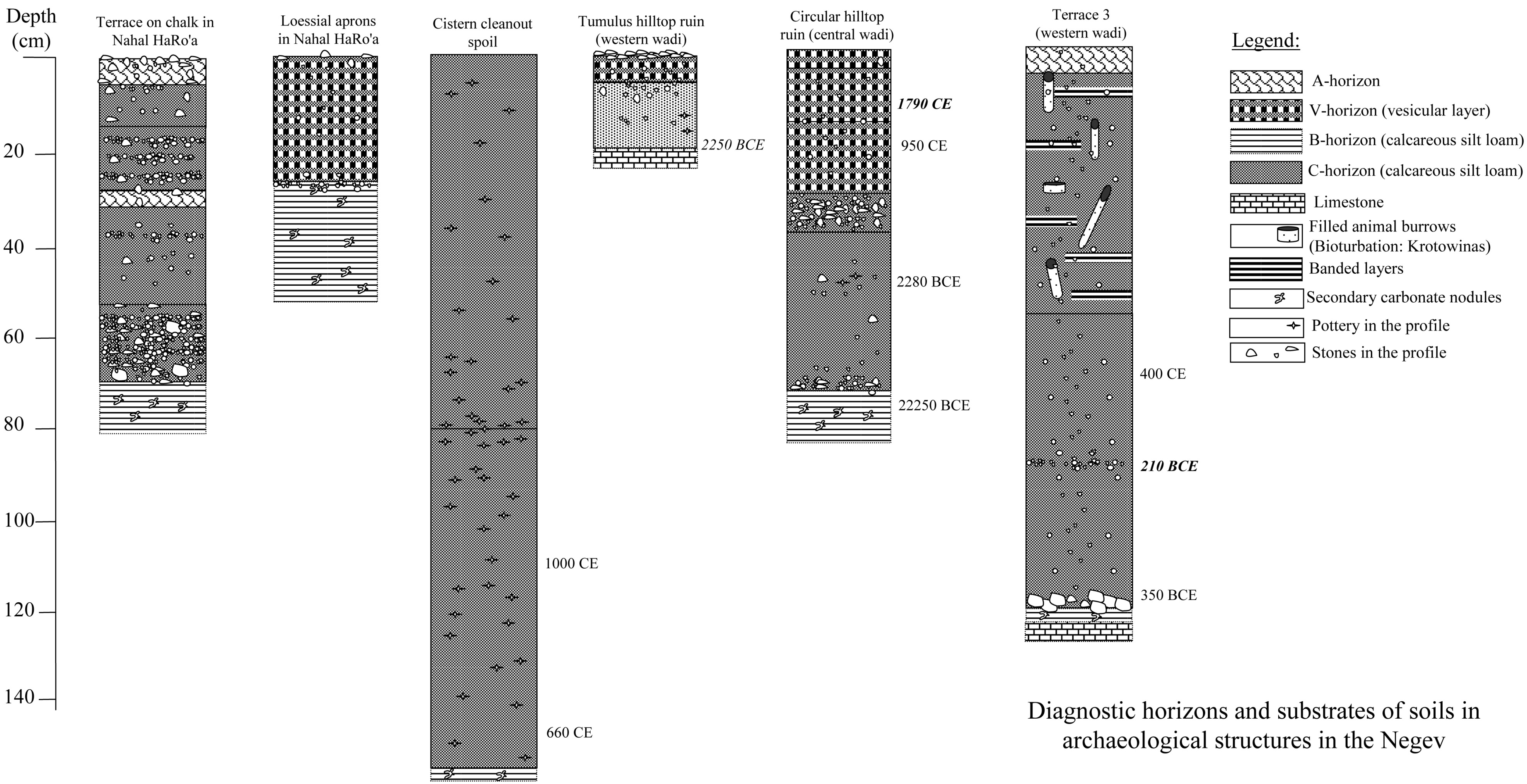

Diagnostic horizons and substrates of soils in archaeological structures in the Negev

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Results I

- Sediments in **all** archaeological structures are of **aeolian origin**!
- Often ongoing deposition; substrates similar to Pleistocene paleosols
- Can be **statistically modeled as characteristic sediment type** in both study areas (vs. natural soils, rocks, and current dust)

→ *grain size distribution including most particle size classes*

→ *high concentrations of various major and trace elements*

- Accretion rates **exceed** those of Negev Pleistocene hilltop loess!

Negev Pleistocene	Negev hilltop ruin	Current dust Negev
~85 g/m² a^{-1}	~150 g/m² a^{-1}	~150 g/m² a^{-1}
Petra isol. hilltop ruin	Petra ruin at cliff	Current dust Petra
~125 g/m² a^{-1}	~265 g/m² a^{-1}	~250 g/m² a^{-1}

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Suggests similar deposition processes!

Can be **statistically modeled as characteristic sediment type**

Negev Pleistocene

~85 g/m² a^{-1}

Negev hilltop ruin

~150 g/m² a^{-1}

Current dust Negev

~150 g/m² a^{-1}

Petra isol. hilltop ruin

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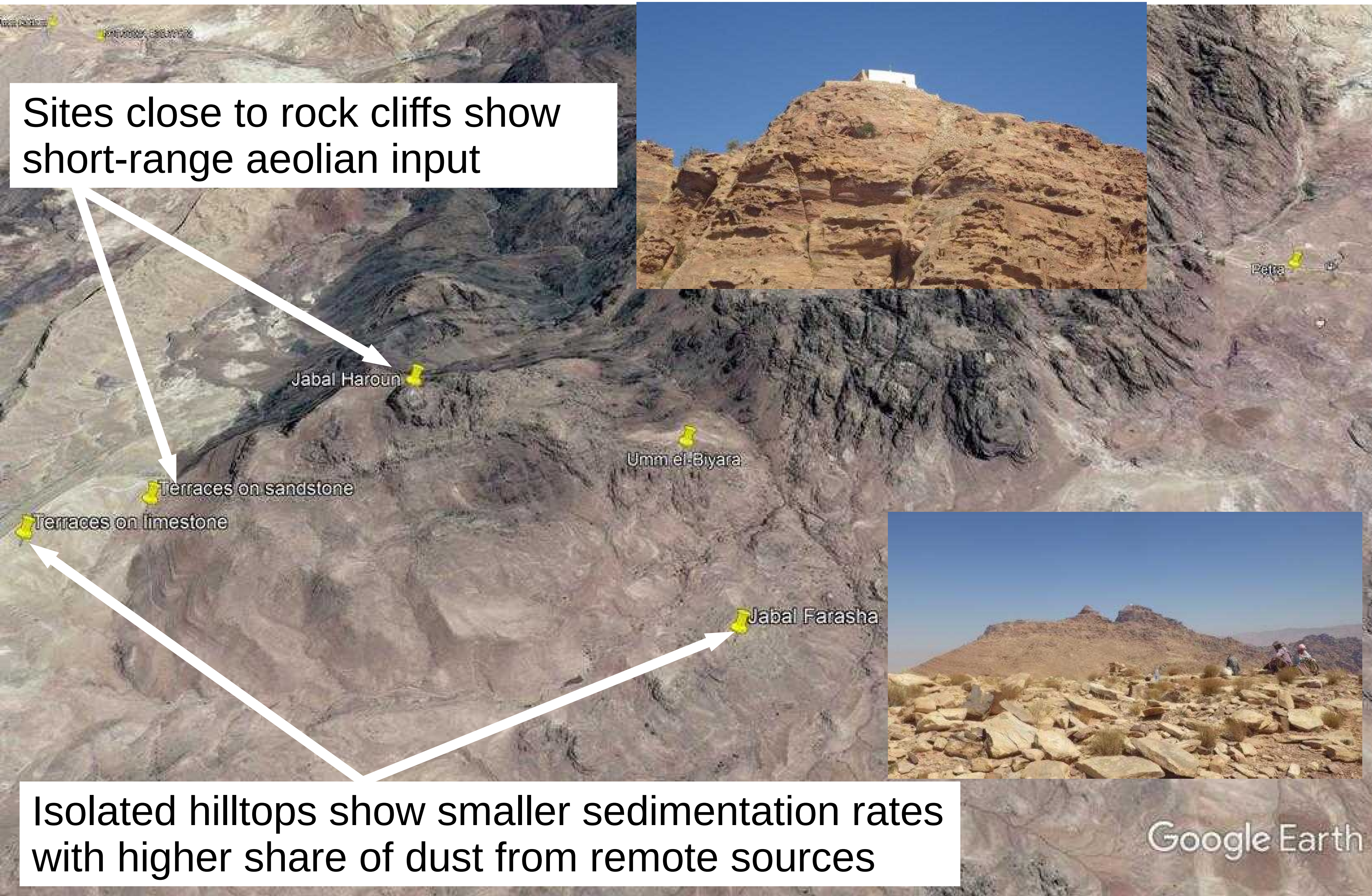
Current dust Petra

~250 g/m² a^{-1}

Suggests role of local sources!

Petra sites confirm role of local sources

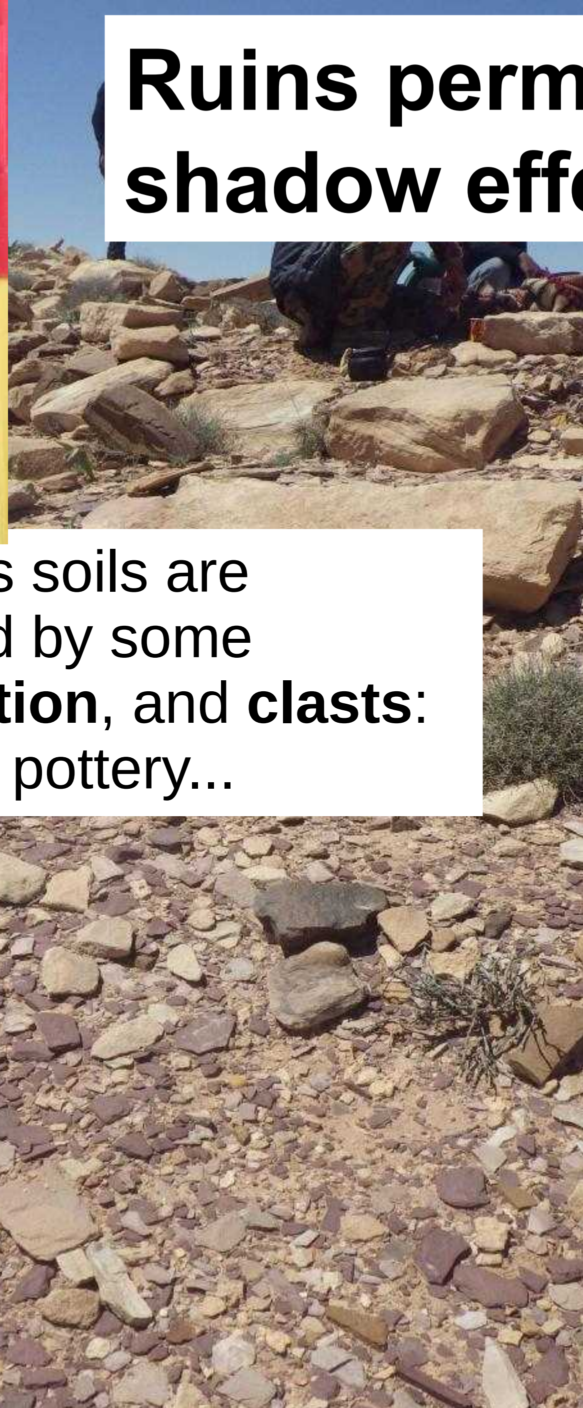
Sites close to rock cliffs show short-range aeolian input



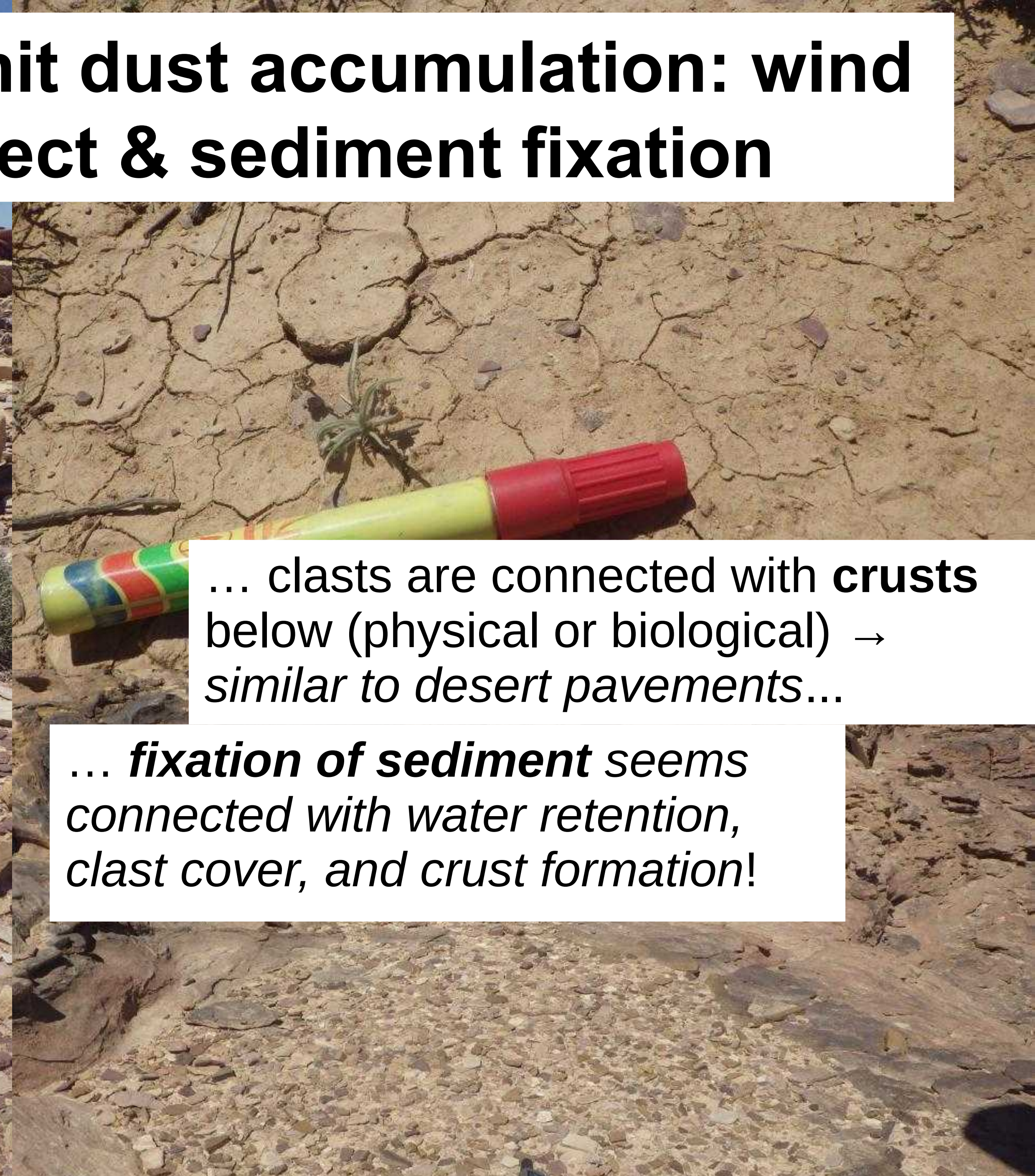
Isolated hilltops show smaller sedimentation rates with higher share of dust from remote sources

Ruins permit dust accumulation: wind shadow effect & sediment fixation

V-horizon (Turk et al., 2016)



All ruins soils are covered by some **vegetation**, and **clasts**: stones, pottery...



… clasts are connected with **crusts** below (physical or biological) → *similar to desert pavements*...

… ***fixation of sediment*** *seems connected with water retention, clast cover, and crust formation*!

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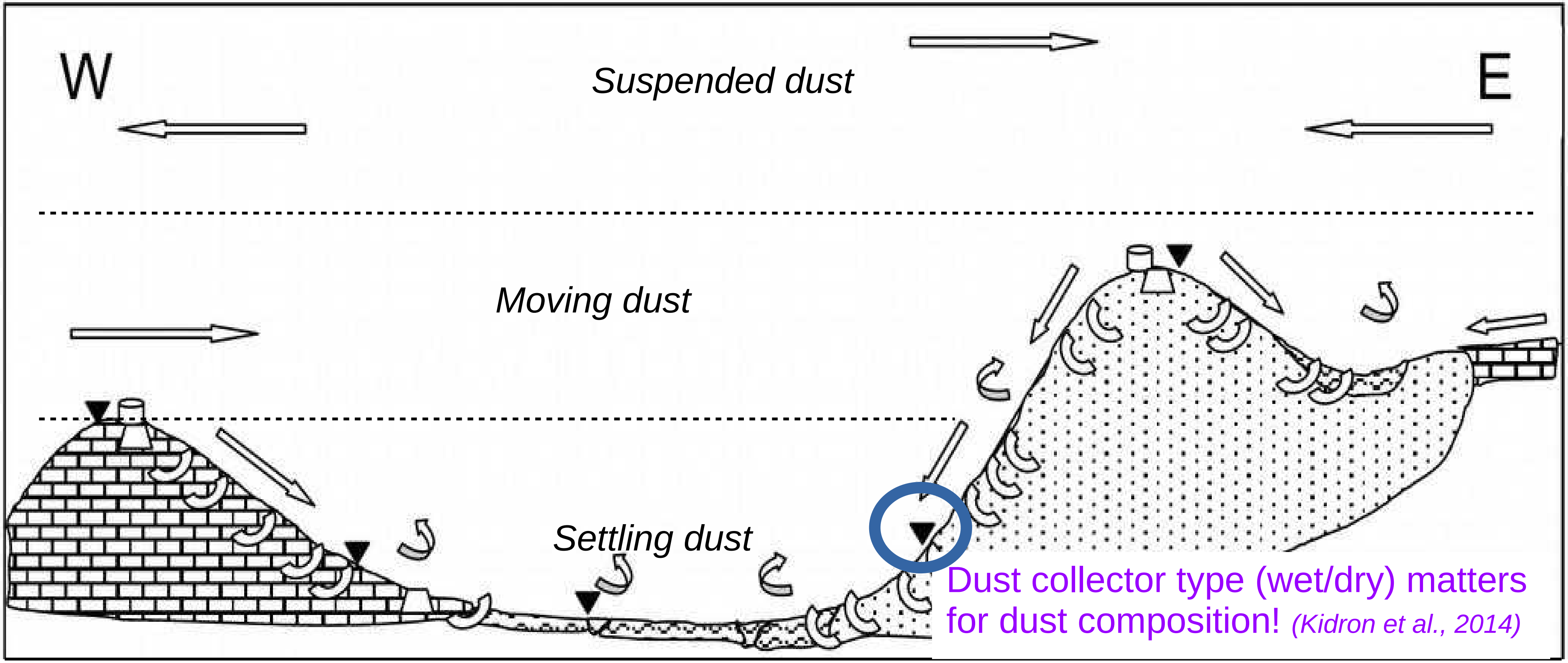
Results II

- Occurrence of 'Desert loess' so far approached as "source problem"
- Dust in drylands is however omnipresent: multiple sources and very effective dust-producing processes
  - fluvial comminution*
  - aeolian abrasion
  - insolation weathering
  - salt weathering
  - frost shattering
  - volcanism

*Experimentally determined as most effective short-time silt-producing process (Wright et al., 1998; Wright, 2007)

- The question of desert loess might in fact be a **"dust fixation problem"**! → material is not always immobilized

Settled dust ≠ dust moving through the atmosphere!



<u>Suspended dust</u>: always present, very homogeneous

<u>Moving dust</u>: local & regional sources mix, may *"harvest"* remote dust

<u>Settling dust</u>: variable storms, partial (or selective?) fixation

Singer A., Ganor E., Dultz S., and Fischer W. 2003. Dust deposition over the Dead Sea. Journal of Arid Environments 53(1): 41-59.
Singer A., Dultz S., and Argaman E. 2004. Properties of the non-soluble fractions of suspended dust over the Dead Sea. Atmospheric Environment 38(12): 1745-1753.

Implications and outlook

'Desert loess' profiles not only recorded atmospheric dust, but also (site-specific?) deposition processes

Should be kept in mind in interpretation, in particular when comparing different locations – earlier studies may need some revision

A better understanding of deposition processes is needed → comparison with current dust dynamics is key

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Thank you