

The terraces of Petra, Jordan: archives of a lost agricultural hinterland

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Petra's arid landscape seems barren at first look, but the trained eye can spot omnipresent terrace remains



Not so easily visible terrace remains

Easily visible terrace remains

Is this the agricultural hinterland once supplying Petra?

→ *multi-method project: biomarkers, pollen, phytoliths, soil studies*



Or was flood protection the main purpose?

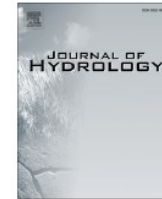
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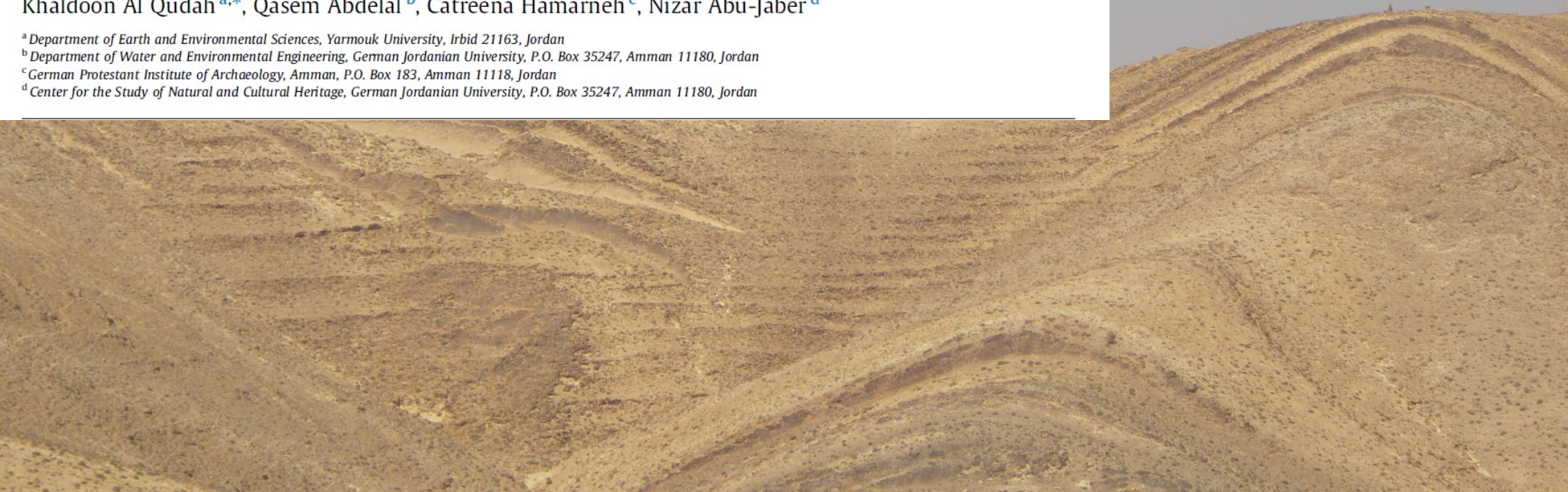
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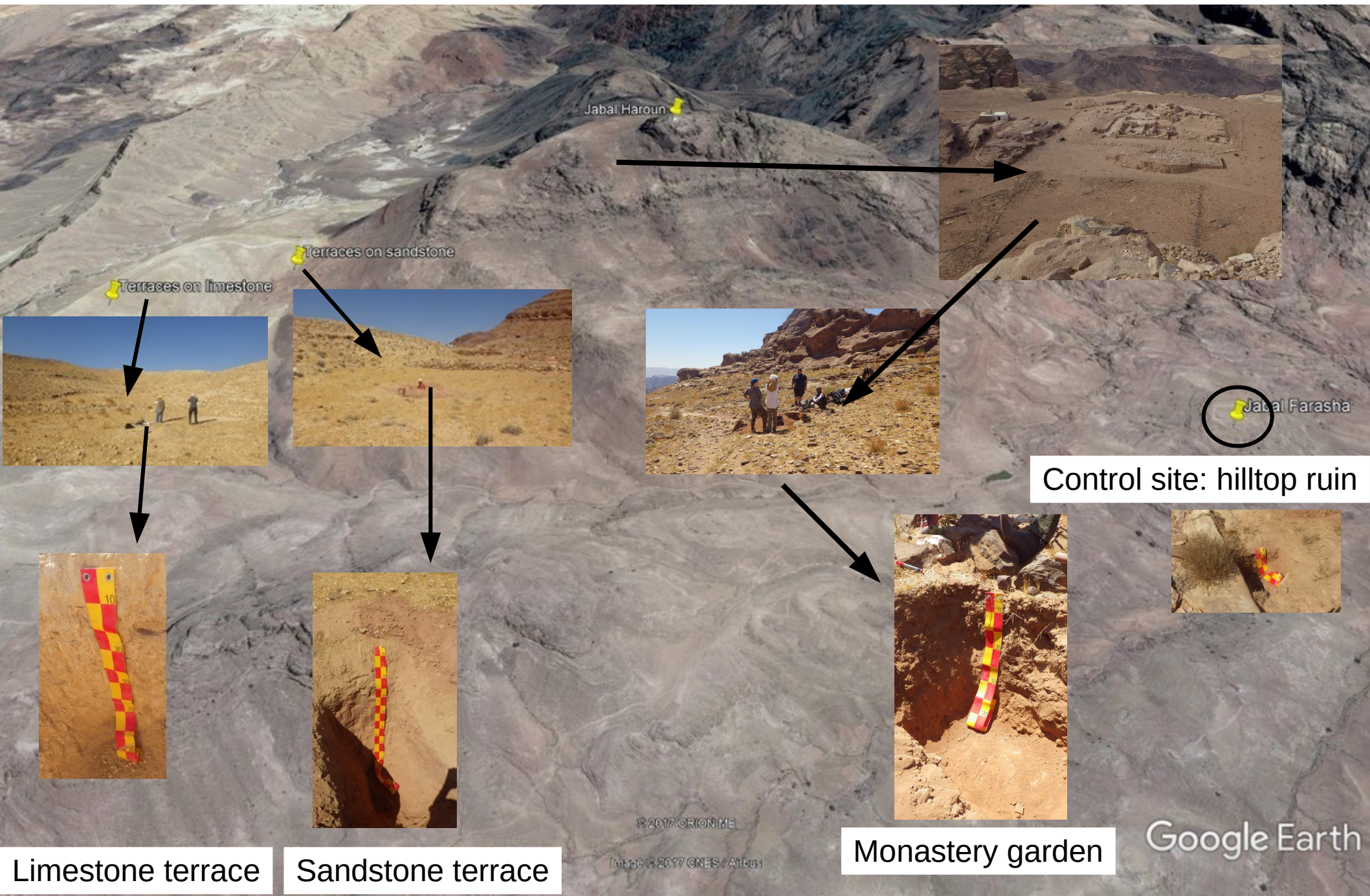
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Sampling sites near Petra



Limestone terrace

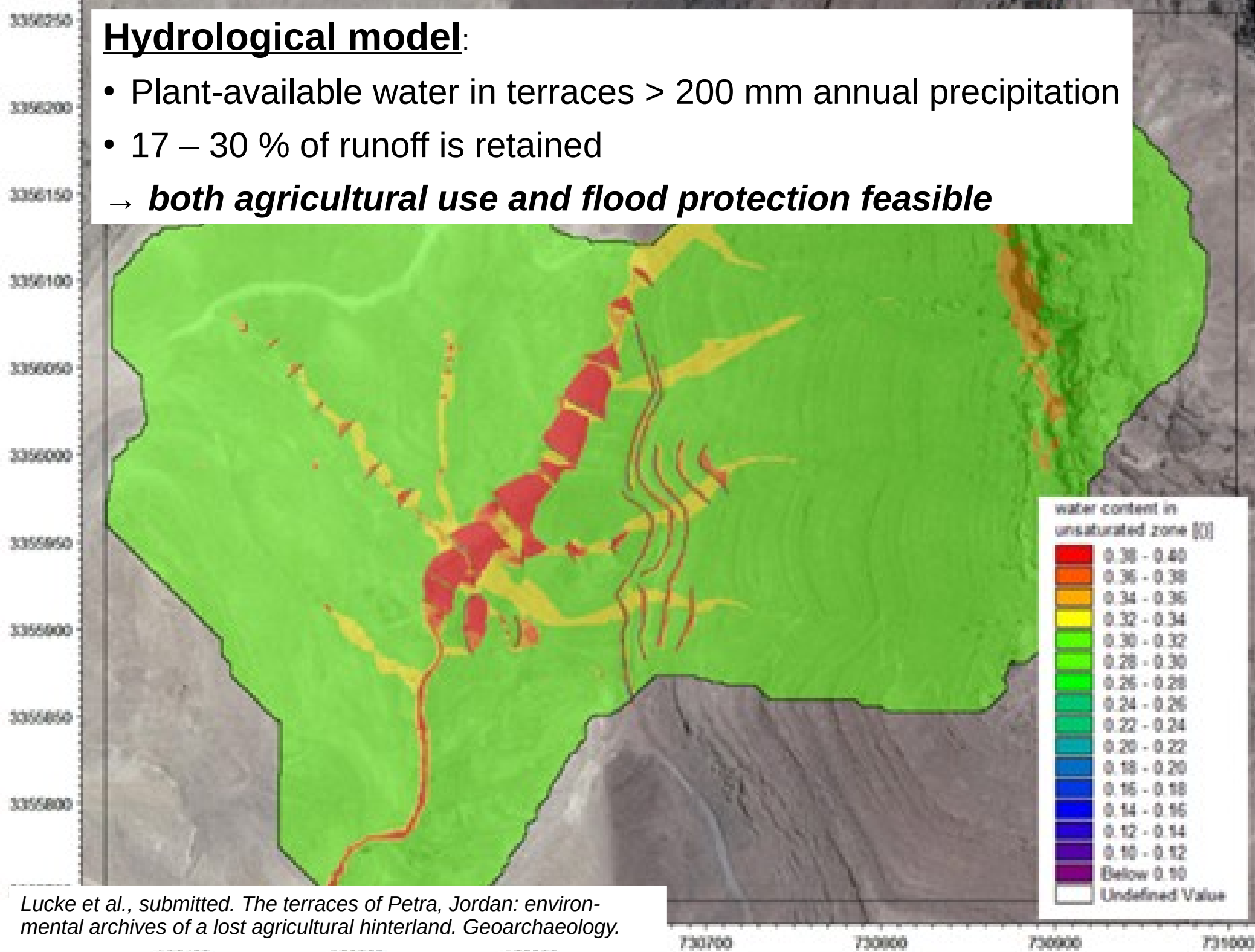
Sandstone terrace

Monastery garden

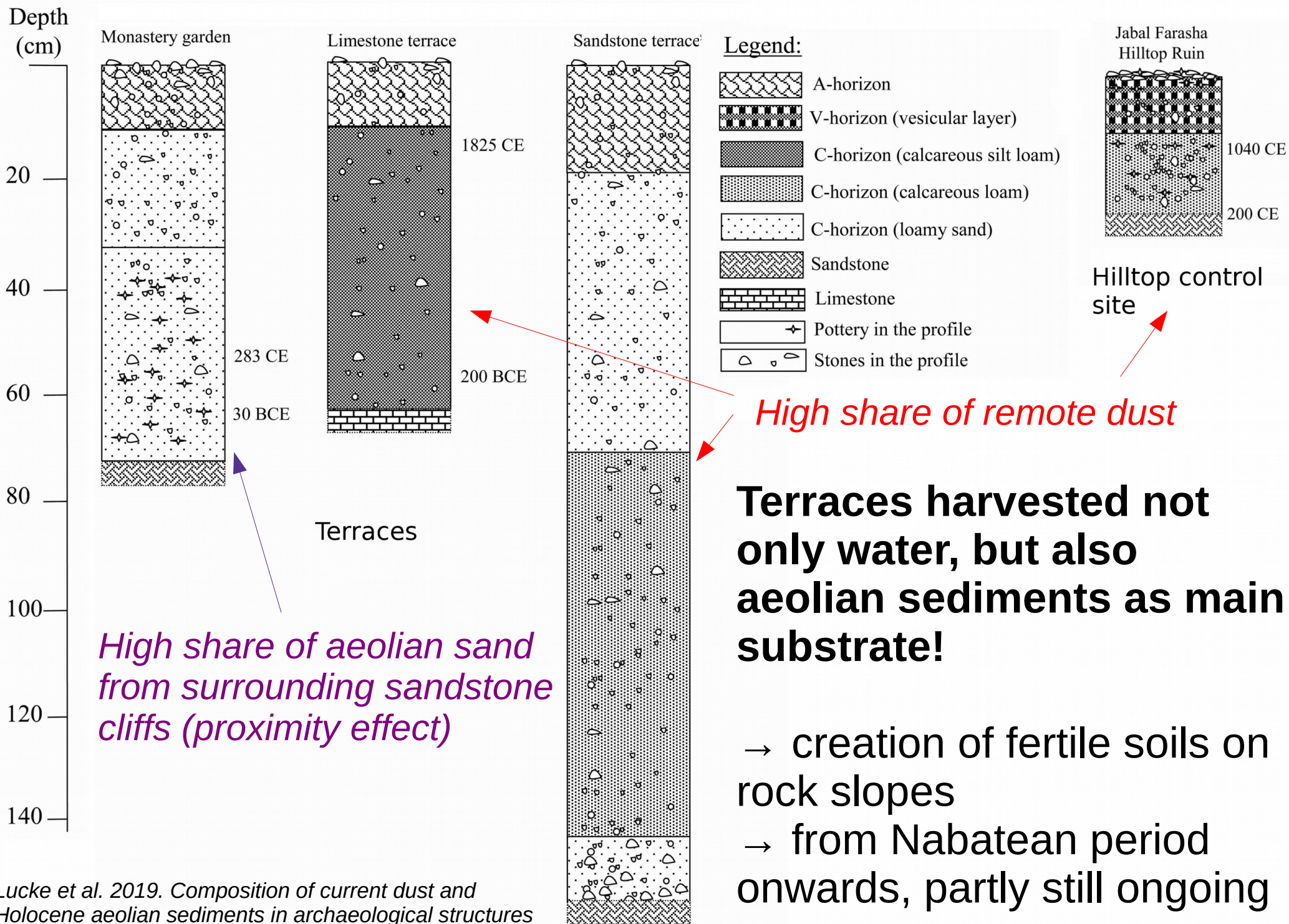
Control site: hilltop ruin

Hydrological model:

- Plant-available water in terraces > 200 mm annual precipitation
 - 17 – 30 % of runoff is retained
- ***both agricultural use and flood protection feasible***



Lucke et al., submitted. The terraces of Petra, Jordan: environmental archives of a lost agricultural hinterland. Geoarchaeology.



Lucke et al. 2019. Composition of current dust and Holocene aeolian sediments in archaeological structures of the southern Levant. MDPI atmosphere 10, 762.

Biomarkers provide clues on excrement remains (manuring & grazing)

Stanols ratio 1: marker of omnivore excrements (human or pig)

$$\frac{(5\beta\text{-cholestan-3}\beta\text{-ol} + 5\beta\text{-cholestan-3}\alpha\text{-ol})}{(5\alpha\text{-cholestan-3}\beta\text{-ol} + 5\beta\text{-cholestan-3}\beta\text{-ol} + 5\beta\text{-cholestan-3}\alpha\text{-ol})}$$

Stanols ratio 2: marker of herbivore excrements (grazing animals)

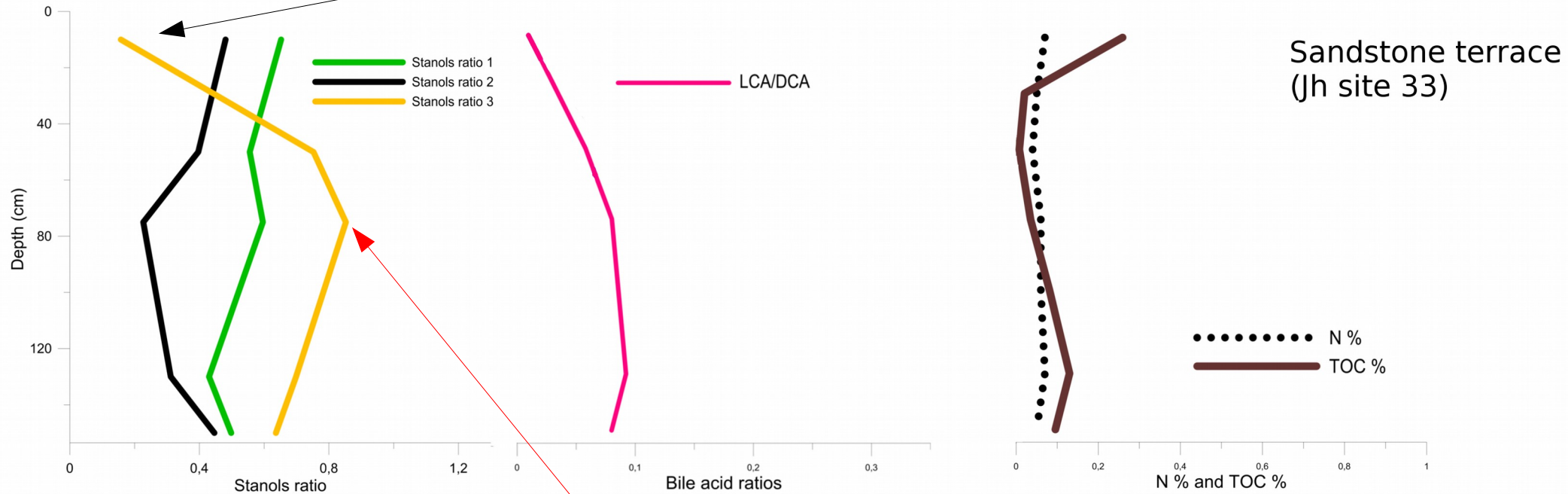
$$\frac{(5\beta\text{-stigmastan-3}\beta\text{-ol} + 5\beta\text{-stigmastan-3}\alpha\text{-ol})}{(5\alpha\text{-stigmastan-3}\beta\text{-ol} + 5\beta\text{-stigmastan-3}\beta\text{-ol} + 5\beta\text{-stigmastan-3}\alpha\text{-ol})}$$

Stanols ratio 3: ratio of omnivore vs. herbivore markers

$$\frac{(5\beta\text{-cholestan-3}\beta\text{-ol} + 5\beta\text{-cholestan-3}\alpha\text{-ol})}{(5\beta\text{-stigmastan-3}\beta\text{-ol} + 5\beta\text{-stigmastan-3}\alpha\text{-ol})}$$

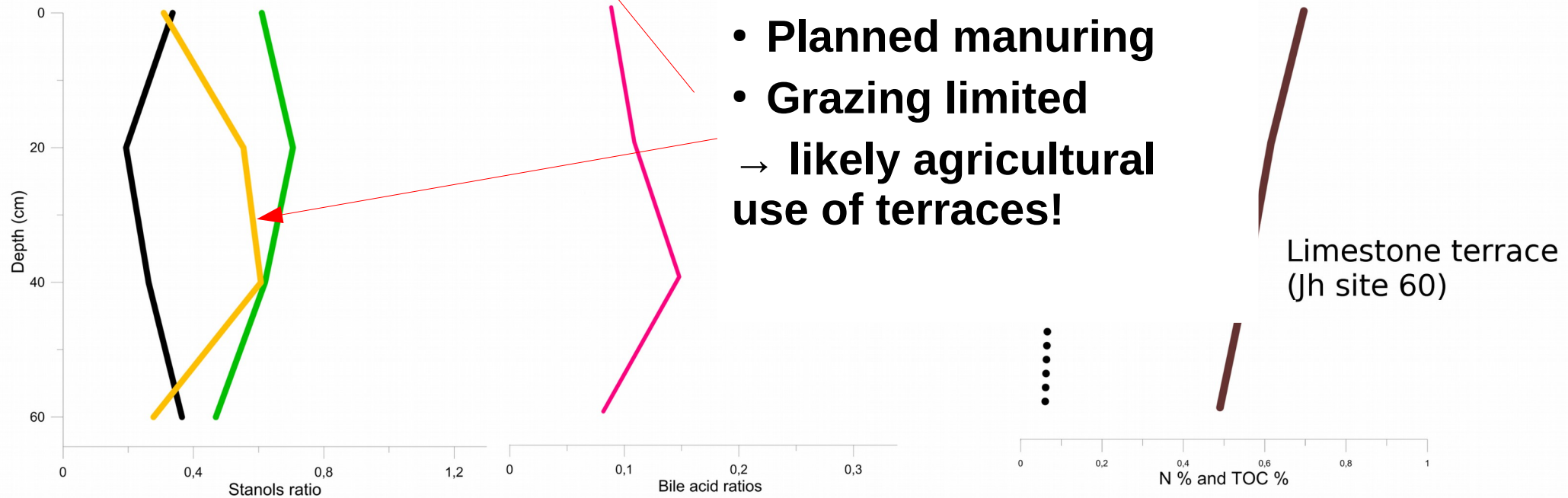
LCA/DCA: bile acid ratio marking human, bird, and donkey excrements

Grazing dominates recent use



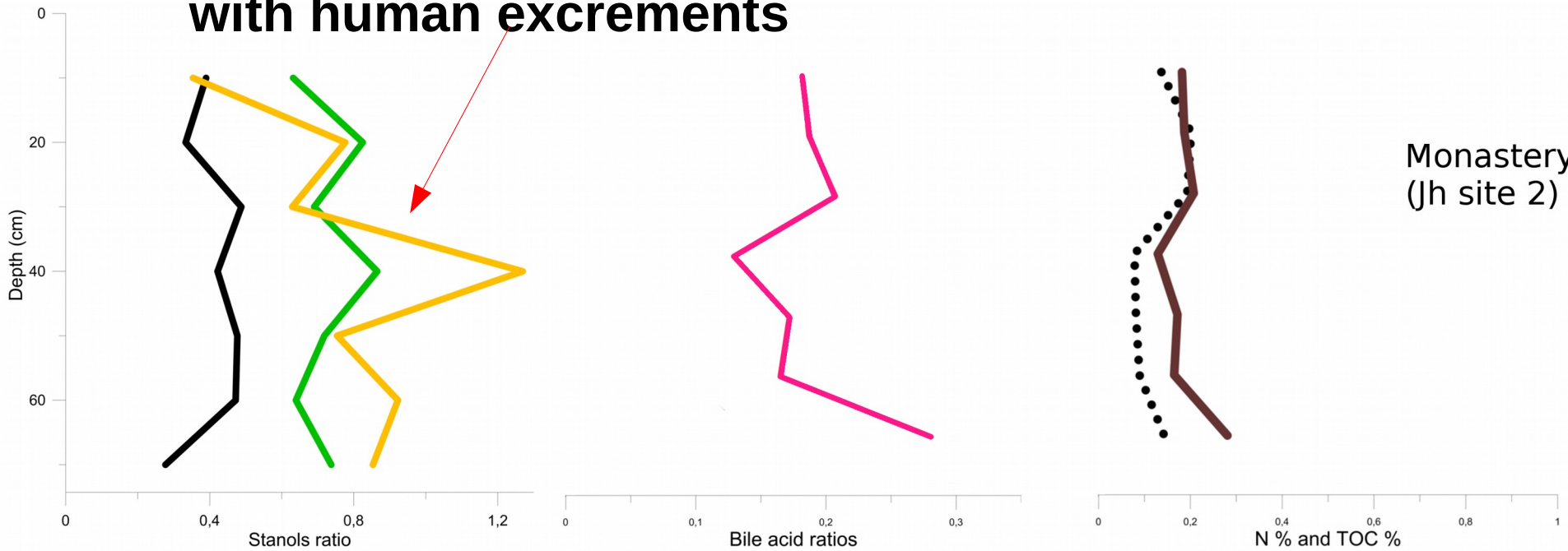
During antiquity:

- Planned manuring
 - Grazing limited
- likely agricultural use of terraces!

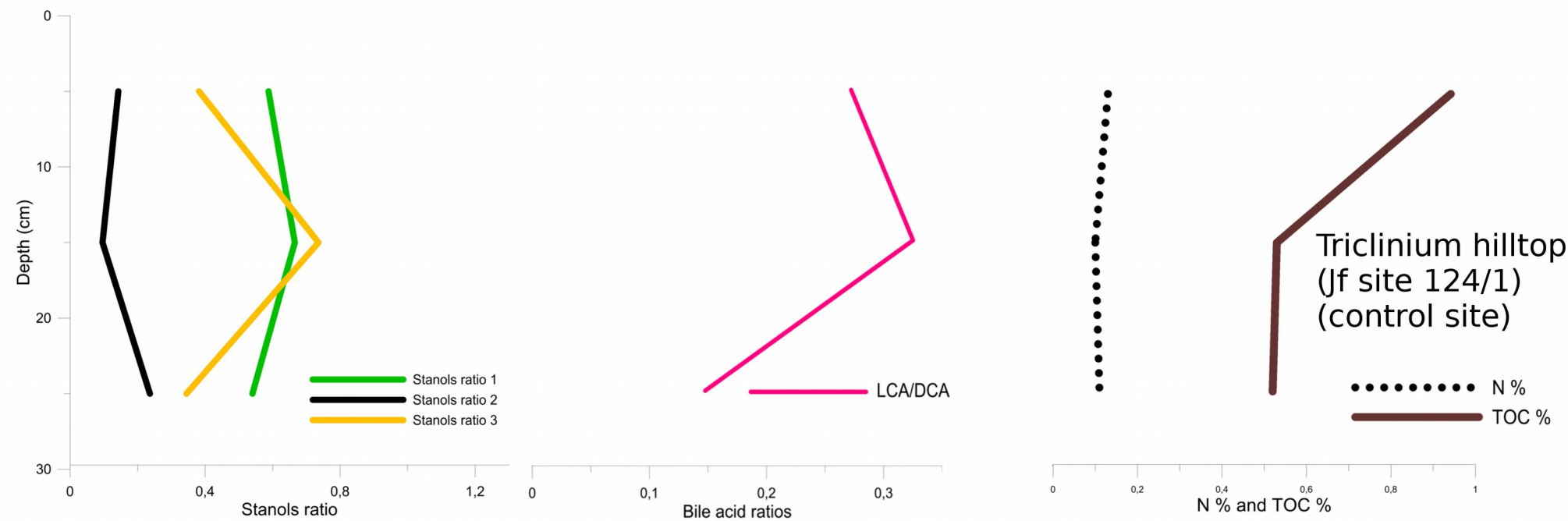


Intense manuring of monastery garden with human excrements

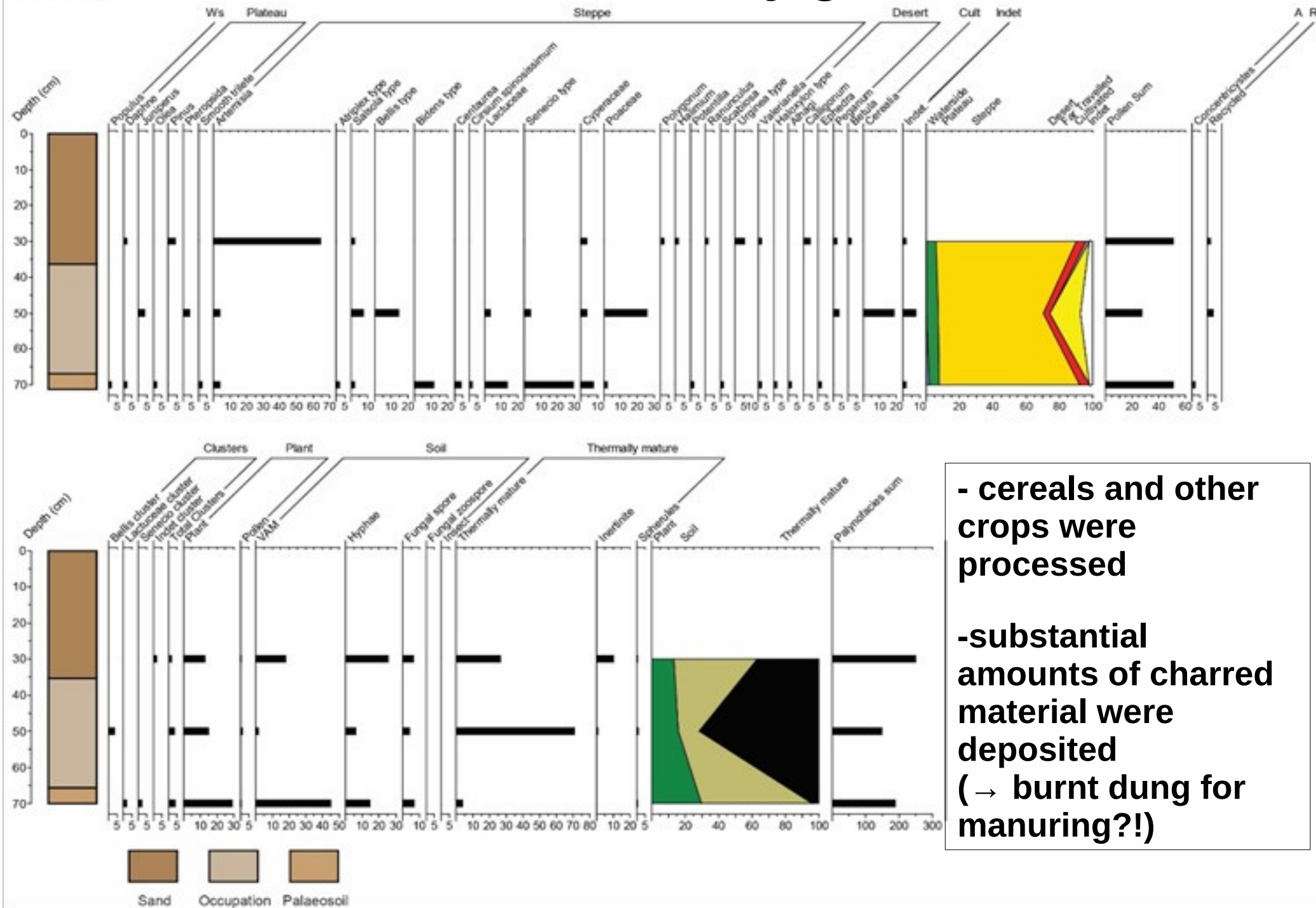
Monastery garden
(Jh site 2)



Triclinium hilltop
(Jf site 124/1)
(control site)



Pollen monastery garden



- cereals and other crops were processed

-substantial amounts of charred material were deposited
(→ burnt dung for manuring?!)



Conclusions

- Terraces were constructed from the Nabatean period onwards, partly used opportunistically until present day
- Harvested water *and* aeolian sediments → creating fertile soils
- Hydrological model suggests agricultural feasibility + significant reduction/storage of flash floods
- Biomarkers suggest manuring with human excrements → agricultural purpose seems likely
- Pollen and phytoliths suggest cereal agriculture + temporary standing water + burnt dung (most likely as manure)
- Terrace remains represent Petra's lost agricultural hinterland!