

Identification of Lime Plaster in Iron Age Southern Levant Through the Use of Infrared Spectroscopy: A Preliminary Study

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INTRODUCTION

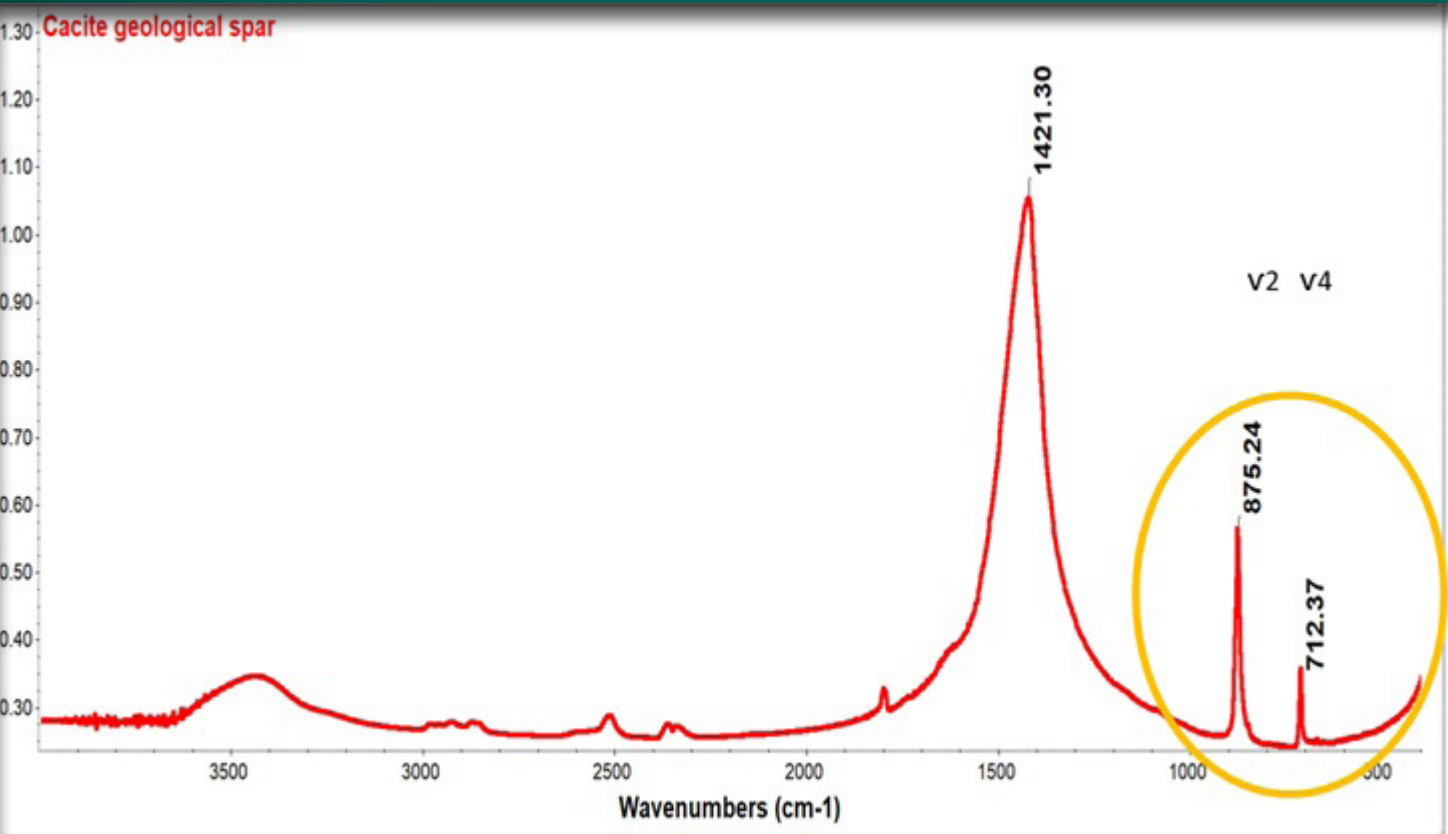
While pyrogenic lime plaster from the Neolithic Age has been well studied, little is known about the extent of use of lime plaster in the Southern Levant during the Iron Age. Calcite, or calcium carbonate, the principal mineral in plaster, comes in three forms that are chemically identical to pyrogenic lime plaster. These include limestone, chalk, and spar, and are all GEOGENIC. PYROGENIC lime plaster is manufactured in a process during which calcium carbonate in the form of the mineral calcite, found in limestone or chalk, is heated to about 700 degrees C, slaked with water, and mixed with additives. This mixture is used to cover walls, create floors and line installations, and when exposed to air, hardens into a form of calcite with a high degree of atomic disorder.

Samples of plaster collected from five Iron Age sites were examined in order to:

- a) distinguish between pyrogenic lime plaster and material that was simply pulverized and compressed geogenic rock material.
- b) determine in which context(s) pyrogenic lime plaster was used — floors, walls and ceilings (?), pits, installations, which could reflect different technological and/or aesthetic choices.

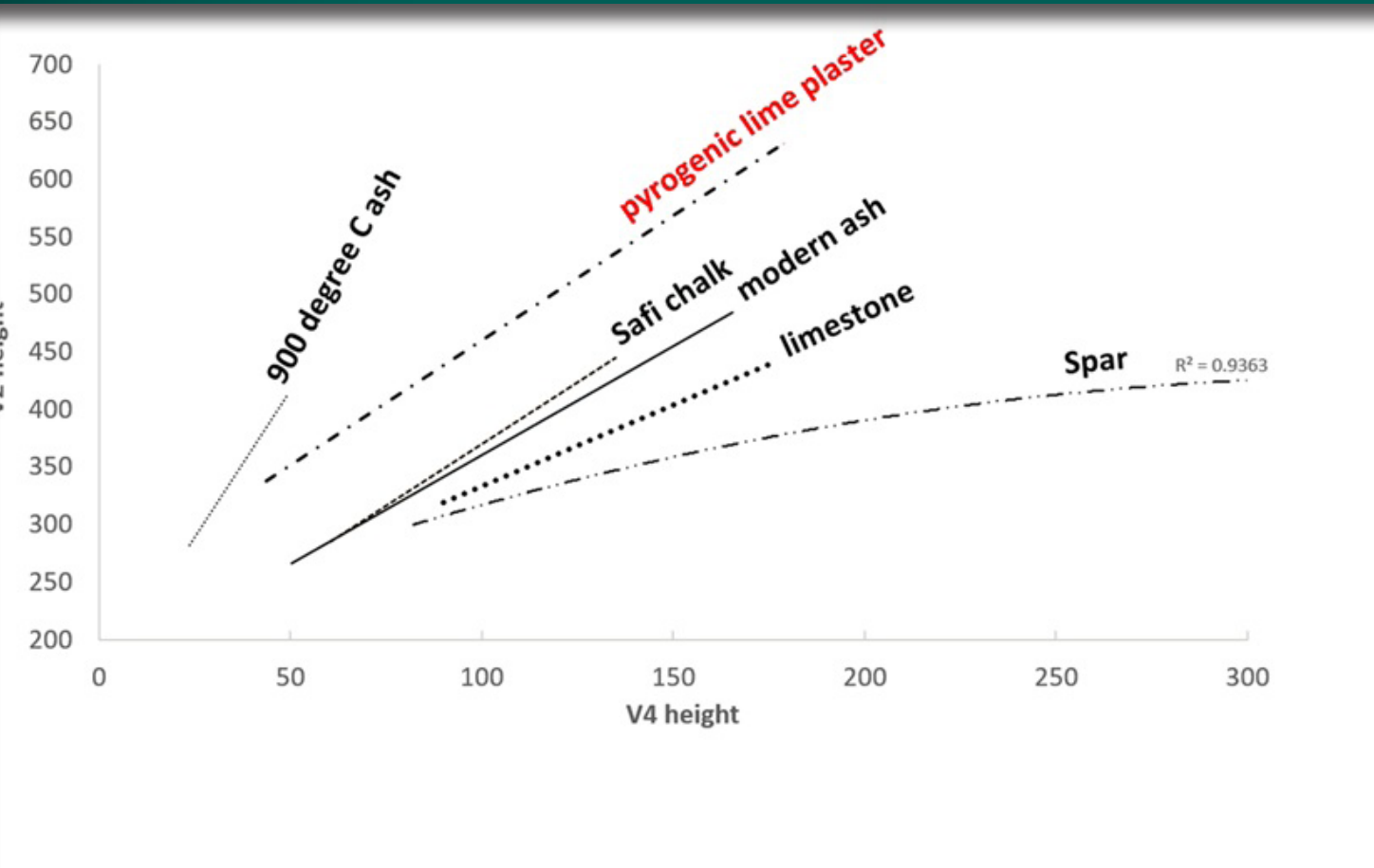
METHOD

Fourier transform infrared spectroscopy (FTIR) uses infrared radiation to generate a spectrum of atomic vibrational peaks unique to a given mineral. FTIR can distinguish between GEOGENIC plaster such as chalk or limestone, and PYROGENIC lime plaster, made by man. Samples were ground and mixed with potassium bromide, and pressed into pellets for examination by infrared spectroscopy (Nicolet IR 100, Thermo Scientific, resolution of 4 cm⁻¹ for 32 scans, interpreted with Omnic 9 Software; Baseline corrections and v2/v4 ratio were calculated with a macro kindly provided by Dr. Y. Asscher, Israel Antiquities Authority.)



The calcite FTIR spectrum has three unique peaks, v3=1420 cm⁻¹, v2=875 cm⁻¹, and v4=712 cm⁻¹.

The normalized ratios between the heights of peaks v2 and v4 differ between calcite types and can be used to distinguish between them (Regev et al., 2010b).



These ratios decrease with sequential grinding of a given sample, allowing a “grinding curve” to be plotted for each calcite type. Grinding curves were generated for each sample plotted on the template above.

The degree of atomic disorder of the calcite types increases from right to left.

THE SITES AND SAMPLE TYPES

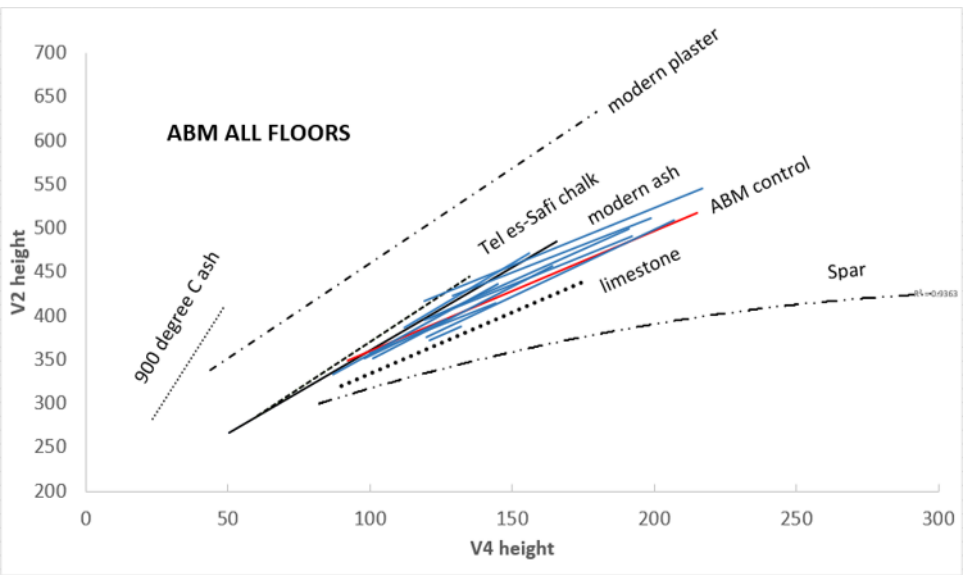
	Tel Abel Beth Maacah	Tel Rehov	Tel Batash	Lachish Gate (south)	Beth Shemesh Reservoir entrance
Period sampled	Iron I-Iron IIa	Post LB II-Iron IIa	LB IIb - Iron I, Iron IIb	Iron IIb	Iron IIb
Number of samples	46	21	9	33	13
Sample type	floors	floors	floor	floors	
	installations collapse	Installation/pit collapse	collapse	collapse	
				walls	
				altars	
				benches	
				niche	
					stairs

Tel Abel Beth Maacah

Only five of 46 samples are pyrogenic lime plaster

- The pyrogenic lime plaster samples come from the lining of a kiln, residue from a storage jar, and from a sample of collapse.
- All the sampled floors (n=5) are made of geogenic calcite. None are pyrogenic lime plaster.
- The unique sink installation from the cultic context in Area A is composed of layers of mud-plaster and not pyrogenic lime plaster.

Conclusion: The use of pyrogenic lime plaster was not widespread in Iron Age Tel Abel Beth Maacah.

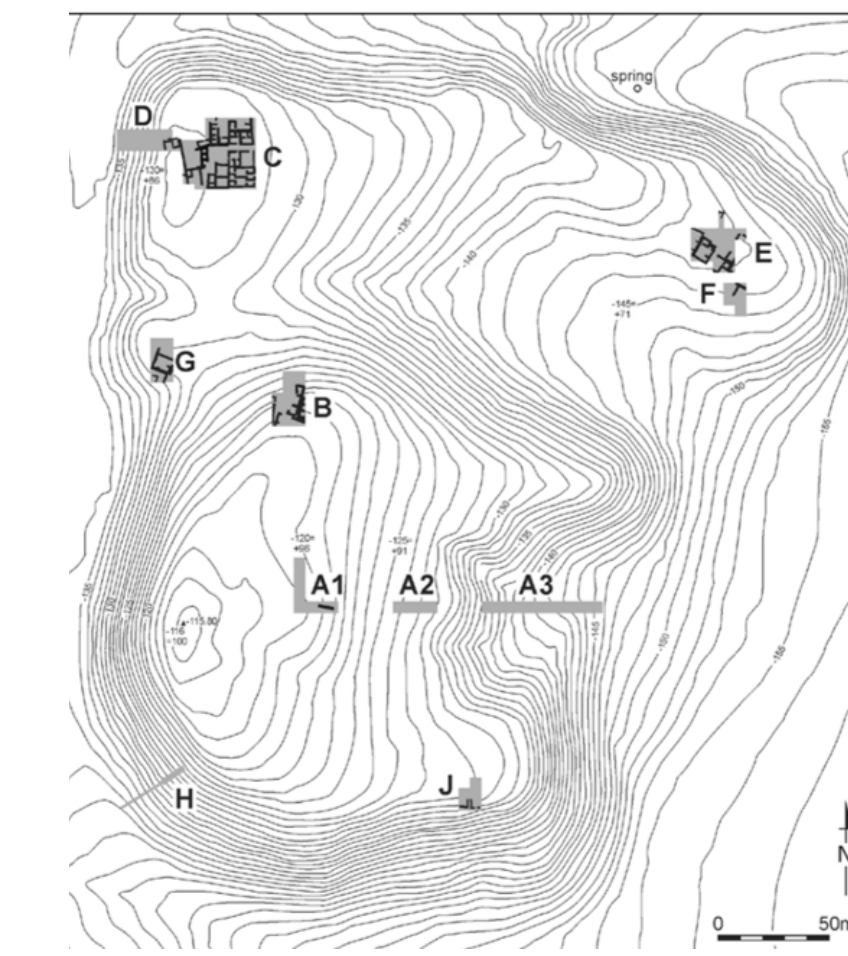
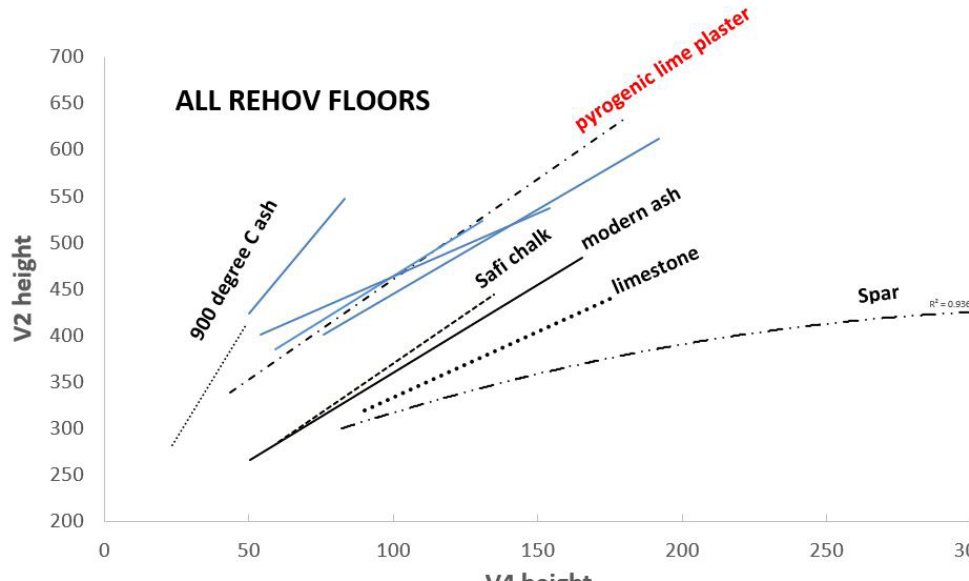


Courtyard of citadel in Area B at Tel Abel Beth Maacah

Tel Rehov

- All sampled floors (n=3) are pyrogenic lime plaster.
- The samples from two different pits are pyrogenic lime plaster.
- All the collapse samples have some pyrogenic lime plaster.

Conclusion: The use of pyrogenic lime plaster appears to have been widespread (over several excavated areas) at Iron Age Tel Rehov.



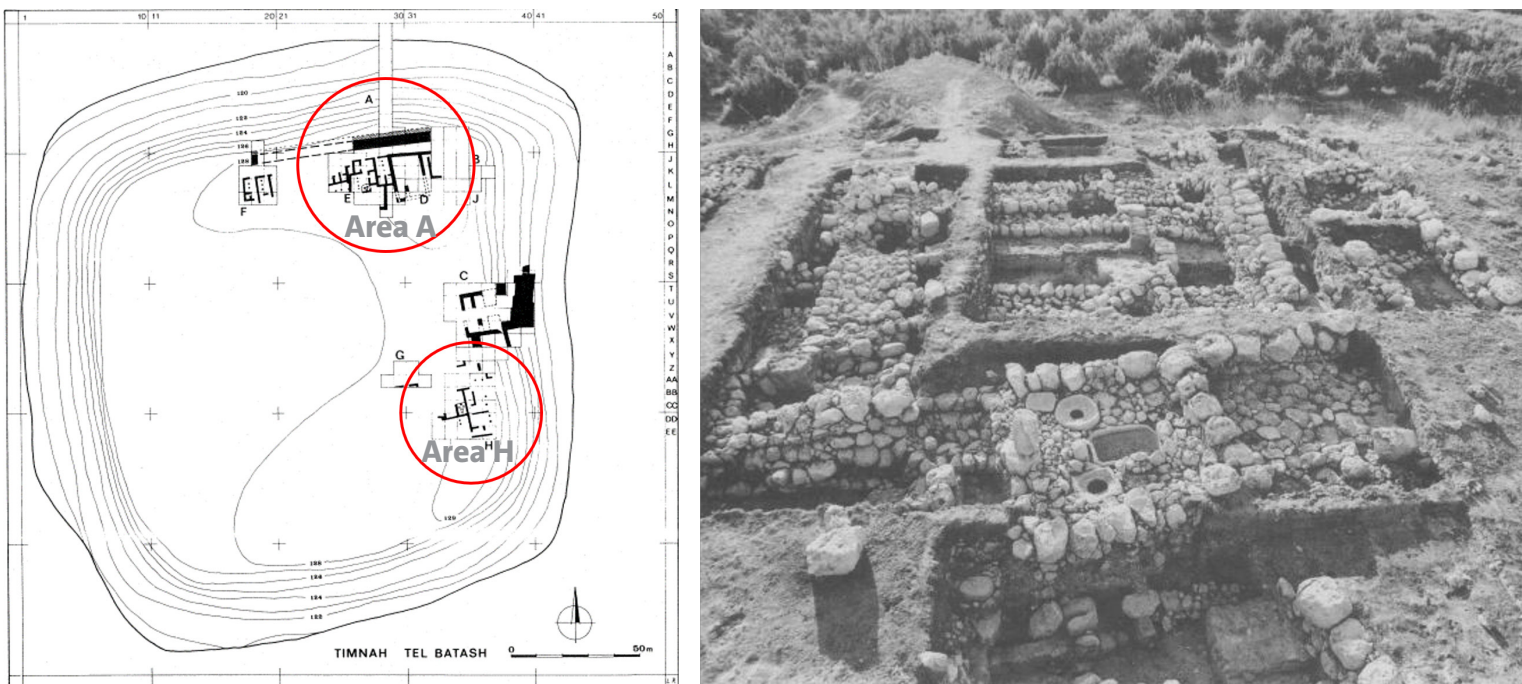
Tel Rehov 9th century

Tel Batash

- Six of the nine samples are pyrogenic lime plaster (mostly from collapse of walls and ceilings? and from one installation).
- The only floor sample was not pyrogenic lime plaster.

Conclusion: Pyrogenic lime plaster was likely used widely at Iron Age Tel Batash

All but one of the samples from Tel Batash are from Area H and one is from Area A.



Tel Batash, site map, Iron Age strata II-III

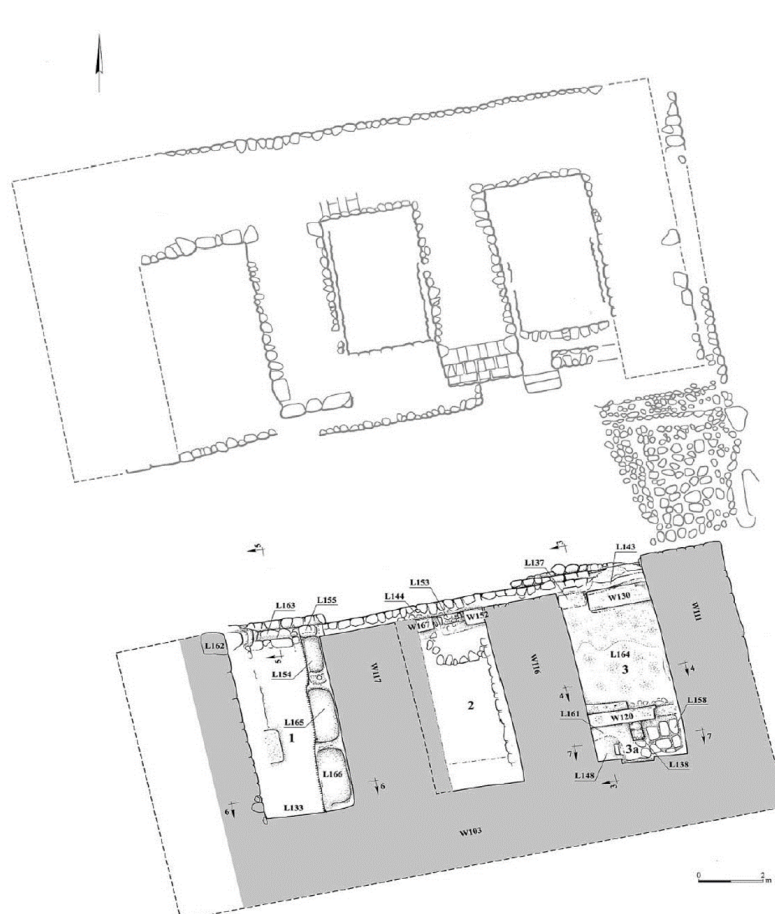
Reference:
Kelm, G. L., & Mazar, A. (1991). Tel Batash (Timnah) excavations: third preliminary report, 1984-1989. Bulletin of the American Schools of Oriental Research. Supplementary Studies, 47-67.

The Lachish Gate complex, southern half

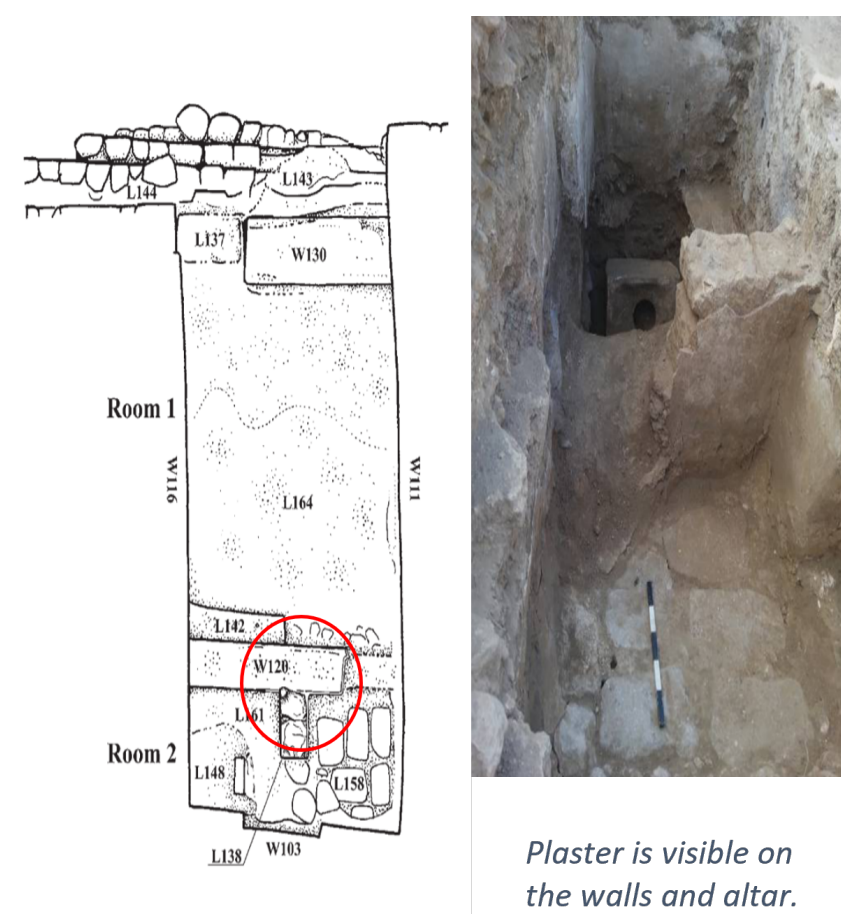
Samples were available from the western cell (walls and benches), the central cell (wall and collapse) and from the eastern “sacred cell” (altar, niche, floor, wall, collapse); see figure below.

- Nearly all the pyrogenic lime plaster samples are found in the “sacred area” of the eastern cell (Room 3a), with the altar. These include:
 - All three sampled floors
 - Two of four samples from the altar
 - Two samples of collapse
 - The niche
- Pyrogenic lime plaster is also seen in the northern bench in the western, “nonsacred” cell.

Conclusion: Pyrogenic lime plaster was used almost exclusively in the sacred area of the Iron II gate at Iron IIb Lachish.



The Iron IIA Gate Complex at Tel Lachish. The southern half is shaded.



The southeastern chamber of the southern gate at Lachish.

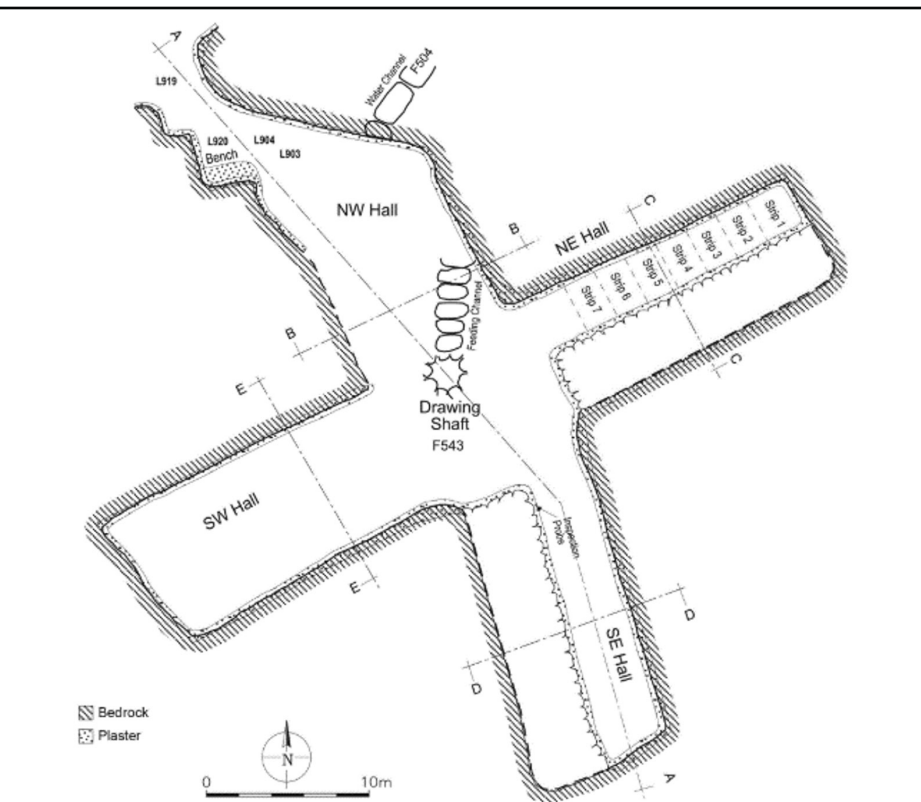
The double altar sits in Room 2 (3a) and is circled in red. Plaster is visible on the walls and altar.

Reference:
Ganor, S., & Kreimerman, I. (2019). An eighth-century BCE gate shrine at Tel Lachish, Israel. Bulletin of the American Schools of Oriental Research, 381(1), 211-236.

Tel Bet Shemesh The Iron IIb Reservoir

- The outer layers of plaster in the areas sampled (at the entrance to the reservoir, staircase 570) are all pyrogenic lime plaster.
- The northern and southern walls of the staircase differ: while all outer layers are pyrogenic lime plaster, the inner layers of the southern walls are chalk.
- Rough, pebbly patches may have been made of non-pyrogenic chalk paste
- The stairs are not coated in pyrogenic lime plaster; they are chalk

Conclusion: The walls of the reservoir entrance have several layers of plaster which have been applied at different times, on either side of the stairs. As only samples from the entrance were analyzed, at present, no conclusions can be drawn regarding the type of plaster used in the rest of the reservoir.



Tel Bet Shemesh reservoir

The plastered stairs and abutting plastered walls, view to the west from the bottom of the staircase

Modified from :
Bunimovitz, S., & Lederman, T. (2016). Tel Beth-Shemesh: A Border Community in Judah: Renewed Excavations 1990–2000: The Iron Age. Penn State Press. Figs. 5.29 and 5.32.



CONCLUSIONS

- Some pyrogenic lime plaster is seen in each phase of the Iron Age in the sites studied.
- The extent of the use of pyrogenic lime plaster in the studied Iron Age South Levantine sites varies; the use of true pyrogenic lime plaster may be rarer than previously thought.
- Except for Tel Rehov, where pyrogenic lime plaster was abundant, pyrogenic material was reserved for specific purposes.
- No evidence for hydraulic plaster was seen at any of the studied sites.
- Contrary to common perception, many floors are made of compressed chalk/limestone, and not of pyrogenic lime plaster.
- Further sampling is required in order to map the full spatial and temporal use of pyrogenic limestone in the region.