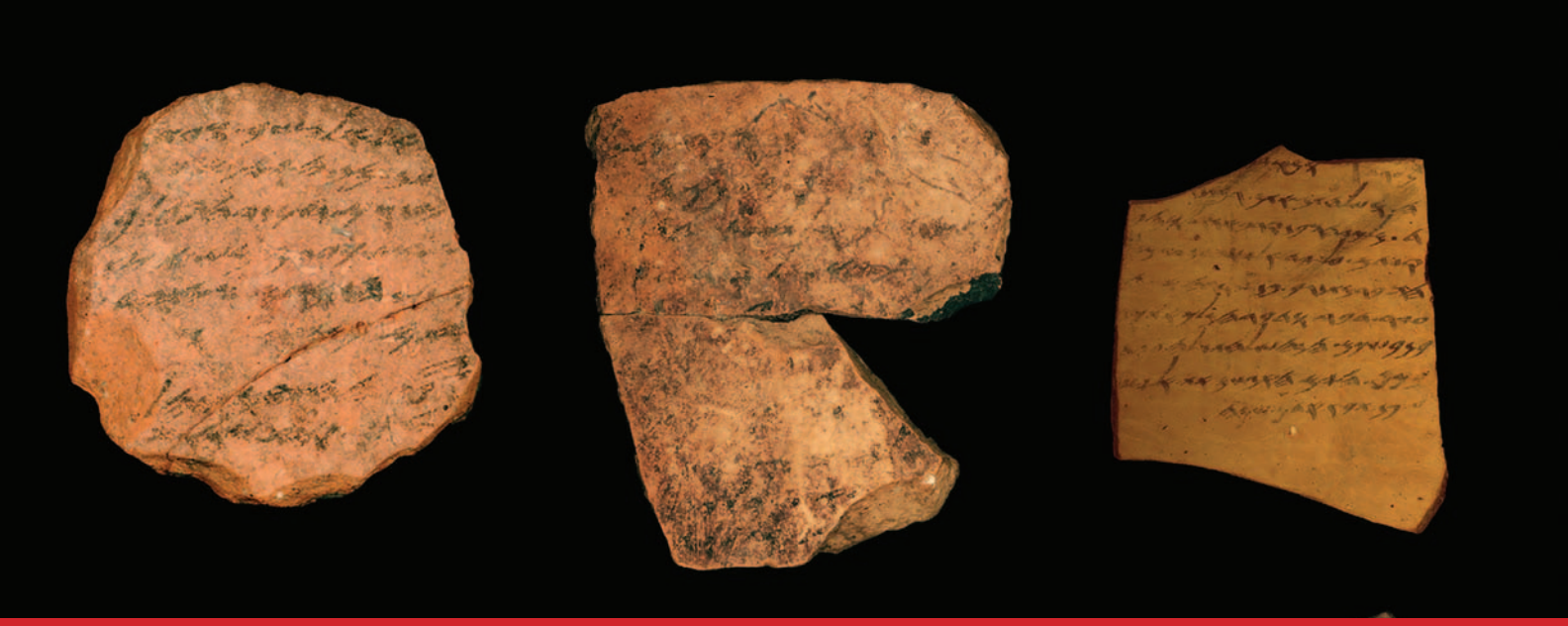

Literacy in Judah and Israel
Algorithmic and Forensic Examination of the Arad and Samaria Ostraca

Shira Faigenbaum-Golovin, Arie Shaus, Barak Sober, Yana Gerber, Eli Turkel, Eli Piasetzky, and Israel Finkelstein[1]

Hebrew ostraca from Arad in the Beer Sheba Valley, ca. 600 BCE. Photograph by Michael Cordonsky; courtesy of the Institute of Archaeology, Tel Aviv University and the Israel Antiquities Authority.

A highly discussed issue in the fields of Hebrew epigraphy and biblical research is the level of literacy in the Iron Age kingdoms of Israel and Judah (Rollston 2010; Davies and Römer 2013; Schmidt 2015). Treating this topic using biblical texts, for example, the references to scribes at the time of a given monarch, may lead to circular argumentation: The reality behind a given account may reflect the time of the authors, who could have lived centuries later and retrojected their own situation back onto earlier history. A preferable methodology is to consider the material evidence—the corpora of Iron Age Hebrew ostraca from archaeological excavations. The idea is to use algorithmic and forensic methods to distinguish between handwritings and thus the number of authors in a given corpus.

This study consists of two corpora representing different chronological and geographical settings:

- The ostraca from Arad (Aharoni 1981), dating to about 600 BCE and representing the military system of late-monarchic Judah. Here we worked in two tracks: algorithmic (Faigenbaum-Golovin et al. 2016) and forensic (Shaus et al. 2020).
- The Samaria ostraca, dated to the first half of the eighth century BCE (e.g., Rainey 1988). Here we worked only in an algorithmic track, enhancing the framework used for the study on Arad (Faigenbaum-Golovin et al. 2020).

This article introduces these methods and deals with the cultural-historical aspects of our results. For details regarding the mathematics the reader should refer to the references given above.

The Corpora

Arad

Arad in the eastern Beersheba Valley produced around 90 Hebrew ostraca (fig. 1; Aharoni 1981). They contain military commands regarding movement of troops and provisions (wine, oil, and flour) set against the background of the stormy events on the southern border of Judah before the fall of the kingdom in 586 BCE. The inscriptions include orders that came to the fortress of Arad from higher echelons in the Judahite military system, as well as correspondence with neighboring forts. Several inscriptions that mention the *Kittiyim*, apparently a Greek mercenary unit (e.g., Na'aman 2011), were addressed to a person named Eliashib—the fortress quartermaster.

Of the several corpora of Hebrew inscriptions (Ahituv 2008), Arad provides the best dataset for exploring the question of literacy in Judah in late-monarchic times. Most of the corpus represents a time span of the few years around 600 BCE; it has even

Figure 1. Ostraca from Arad (see Aharoni 1981): numbers 24 (A), 5 (B), and 40 (C). The poor state of preservation—including stains, erased characters and blurred text—limited the number of ostraca that could be analyzed. Photograph by Michael Cordonsky; courtesy of the Institute of Archaeology, Tel Aviv University and the Israel Antiquities Authority.

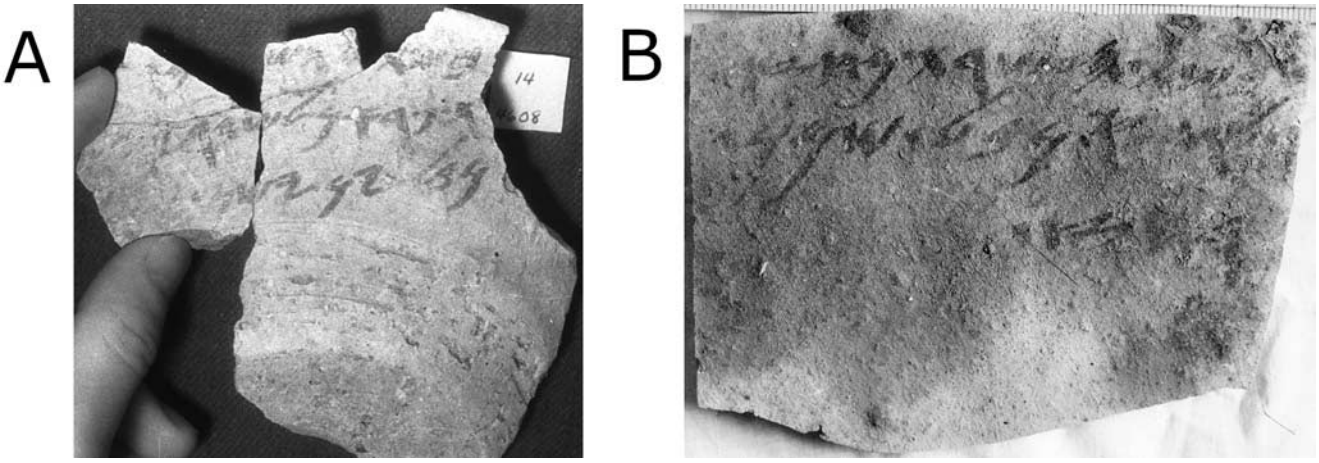

Figure 2. Examples of Samaria ostraca. Left, no. 14: "In the nin[th] year, from Gath Paran to Shemaryau a jar of aged wine"; right, no. 18: "In the ninth year from Hazeroth to Gaddiyau a jar of pure oil." After Ahituv 2008: 274–79; courtesy of the Semitic Museum, Harvard University.

been suggested that most of Eliashib's letters involve the registration of about one month's expenses (Lemaire 1977: 230–31). Furthermore, the ostraca come from a remote region of the kingdom where the spread of literacy is more telling than in the capital or major town. Finally, the inscriptions are connected to Judah's military administration and hence bureaucratic apparatus. Identifying the number of authors involved in this corpus can therefore shed light on the dissemination of literacy in Judah.

Samaria

Excavations at Samaria yielded over 100 short, administrative Hebrew texts, mainly ostraca (fig. 2; Reisner, Fisher, and Lyon 1924: 227–43; Kaufman 1966, 1992; Lemaire 1977: 23–81; Aharoni 1979: 356–68; Renz 1995: 89–110; Ahituv 2008: 258–312). Based on paleography and observations regarding the bowls on which the inscriptions were written, combined with information on regnal years, the inscriptions date to the first half of the eighth century BCE (Lemaire 1977: 39–43; Rainey 1988; Finkelstein and Sass in press). Together with contemporary inscriptions from Kuntillet Ajrud (Ahituv, Eshel, and Meshel 2012; for radiocarbon dating see Finkelstein and Piasetzky 2008) they make the richest evidence for writing in the Northern Kingdom. The Samaria ostraca were found in a fill laid in preparation for the construction of a large building (Kaufman 1982; Tappy 2016: 57–58), which was labeled by the excavators the "Ostraca House." They

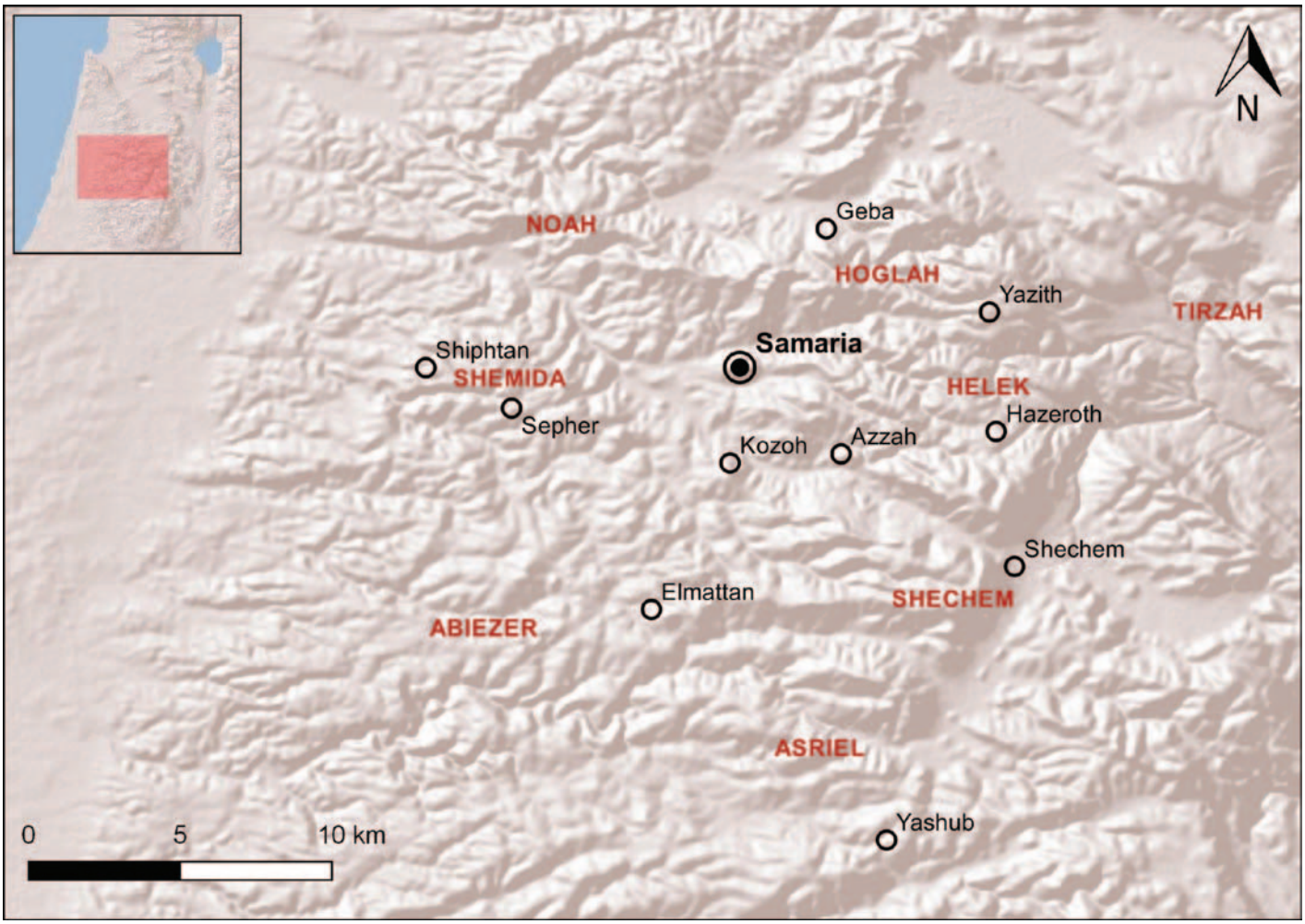

Figure 3. Map marking places (black) and clans (red) mentioned in the Samaria ostraca. Courtesy of the Digital Epigraphy Project, Tel Aviv University.

record the delivery of wine and oil to the capital from villages (or royal estates) in the countryside. The texts contain regnal years (citing years 9, 10, and 15), toponyms, and clan names (the latter matching the genealogy of the tribe of Manasseh in Num 26: 29–34; Josh 17:2–3) in the vicinity of Samaria (fig. 3), as well as commodity type (wine/oil) and personal name(s), probably the sender and/or the recipient (Aharoni 1979: 358–62).

The Samaria corpus is significant for reconstructing the history of the Northern Kingdom and the study of ancient Hebrew language and script. Of particular importance for our topic, early research did not clarify whether the ostraca were composed at various sites in the highlands around the capital (whence the provisions were dispatched) or were written in the capital when the shipments arrived. The former option would indicate dissemination of writing, at least in the administrative echelon of the Northern Kingdom, while the latter would provide evidence for the royal bureaucracy in the capital. A related issue is the number of individuals who authored the inscriptions: Theoretically, there could have been itinerant scribes who traveled between royal estates. Also disputed are issues related to the meaning of the textual data—the regnal years, identification of toponyms, clan system, and function of the individuals mentioned. Correlation between writers and these categories may indicate specialization within the scribes' milieu.

Methods

For the Arad corpus, we introduced an algorithmic framework capable of detecting statistically significant "separations" of authors within pairs of inscriptions. This allowed us to estimate *the minimal* number of writers. We then applied forensic methods of handwriting identification and compared the results. For Samaria, we enhanced the algorithmic procedure (that is, the Arad algorithm), with the goal of determining *the most likely* number of scribes within the corpus. In both cases the research was performed on digital images of the inscriptions.

Algorithmic analysis of ostraca is hampered by several factors. First, the poor state of preservation of many ostraca (see Faigenbaum et al. 2012). Second, imperfect digital images present a challenge for image segmentation and enhancement methods (Shaus, Turkel, and Piasetzky 2012). Third, in most cases Iron Age ostraca do not provide the number of characters necessary

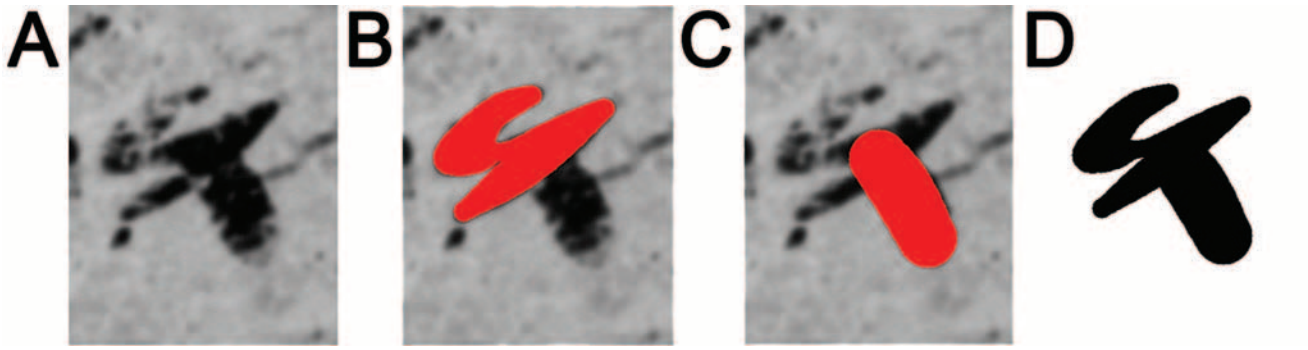

Figure 4. Restoration of the character *waw* on Arad Ostracon 24 (see Sober and Levin 2017). (A) The original image; (B, C) reconstructed strokes; (D) the resulting character restoration. Courtesy of the Digital Epigraphy Project, Tel Aviv University.

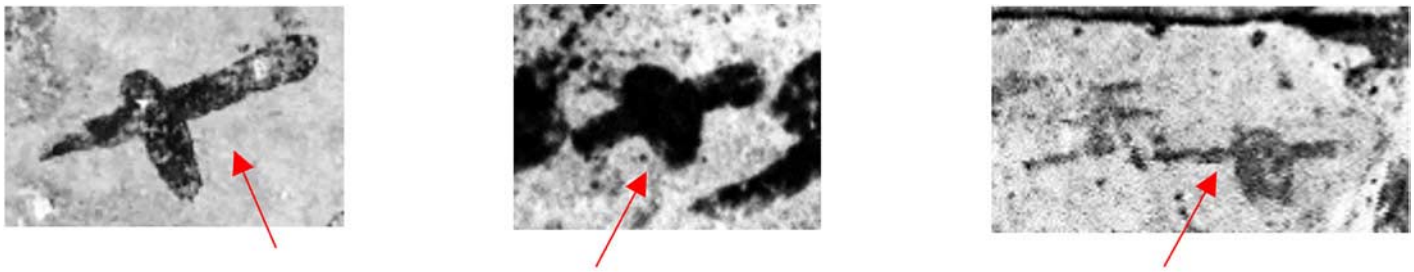

Figure 5. Forensic examination: examples of different shapes, slants, relative length, width, and intersection points of the horizontal and vertical shaft of the letter *taw*. Left: Ostracon 7; middle: Ostracon 1; right: Ostracon 24. Courtesy of the Digital Epigraphy Project, Tel Aviv University.

to establish firm conclusions regarding handwriting. Fourth, although the task of identifying writers has been addressed in previous literature (e.g., Bar-Yosef et al 2007; Bulacu and Schomaker 2007; Panagopulous et al. 2009), researchers presuppose a reference dataset with known authorships for training the computer to differentiate between writers, which is not available here. Fifth, recognizing hands via document analysis algorithms is a tantalizing problem even in modern writing (Louloudis, Gatos, and Stamatopoulos 2012). Consequently, we developed new methods for image processing and document analysis.

Arad: The Algorithmic Framework (Algorithm 1)

The database included 16 ostraca with a sufficient number of characters. Two of them are two-sided, thus 18 texts.

Our sequence for algorithm 1 consisted of three steps:

A. Restoring characters (example in fig. 4).
B. Extraction of characters' features, describing their different aspects (e.g., angles between strokes and character profiles), and measuring the similarity between these features.
C. Estimating the probability that two given ostraca were written by the same author.

Prior to implementing our methodology on the Arad corpus, it was thoroughly tested on modern Hebrew handwritings and found to be 98 percent accurate (see "SI Appendix" in Faigenbaum-Golovin et al. 2016 for details).

Arad: The Forensic Examination

Modern forensic handwriting examination relies on the fact that writing requires the individual to combine sensory-motor skills with personal inclinations. Thus, it can serve as a unique identifier for the writer (Morris 2000). Forensic handwriting analysis tracks features corresponding to specific individuals and uses them to determine whether the observed documents were written by a single or multiple hands (Hilton 1982; McAlexander, Beck, and Dick 1991; Huber and Headrick 1999). The procedure detailed below follows the protocol of modern forensic handwriting examination, adapted to ancient ostraca, using many common characteristics of ancient and modern Hebrew writing (e.g., basically the same language; same alphabet; mostly separated characters).

The process consists of three steps: analysis, comparison, and evaluation. Analysis includes a detailed examination of every inscription, if necessary, its multispectral images (Faigenbaum et al. 2012; Sober et al. 2014), according to the following features (for an example, see fig. 5; for details see supplementary material in Shaus et al. 2020):

- General appearance of the sherd: size, form, and type of pottery.
- Writing style: legibility, writing skill and flow, and line quality.

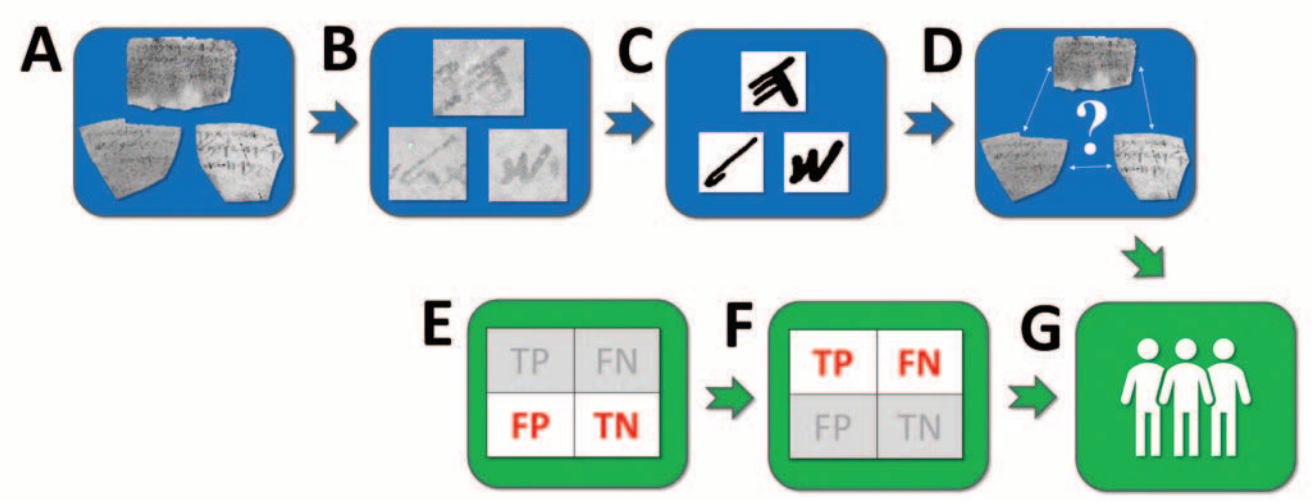

Figure 6. Samaria ostraca study, basic algorithmic flow: Stage 1 (Algorithm 1, developed for the Arad ostraca): (A) scanned negatives of Samaria ostraca; (B) segmenting their characters; (C) restoring the characters and extracting features; (D) performing handwriting comparison. Stage 2 (Algorithm 2, developed for the Samaria ostraca): (E) estimating error and success rates in the case of same scribe; (F) estimating error and success rates in case of different scribes; (G) estimating the most likely number of scribes. Courtesy of the Digital Epigraphy Project, Tel Aviv University.

- Arrangement and use of space: margins, spacing, alignment, and formatting.
- Size and proportions: absolute and relative size of the letters, alterations of size or height of upstrokes and downstrokes.
- Slant: general slant of the writing as well as absolute and relative slant of letters.
- Punctuation: presence, form, and position relative to the imaginary baseline of punctuation marks.
- Spacing between letters, strokes, words, and lines; relative position of letters vis-à-vis the preceding and following ones.
- Alignment of words and letters relative to an imaginary baseline.
- Letter shapes and range of their variations within a script.

Next is a comparison of writing features on different ostraca based on the aforementioned analysis. Consistent patterns and repetitions, characteristic to various inscriptions, are identified. Finally, an evaluation of identicalness or distinctiveness of writers is suggested using the scales of conclusions common in forensic handwriting analysis. The grades range from the definite conclusion of identity to the definite elimination of identity (McAlexander, Beck, and Dick 1991; ASTM-E1658-08 2008). Inconclusive grade is used when there are significant limiting factors in the investigated handwriting.

It should be stressed that by design, while the algorithmic methods are capable of distinguishing between different writers or otherwise remaining indecisive, the forensic expert is able to mark pairs of texts written by the same author.

Samaria: The Algorithmic Framework (Algorithm 2)

The study was conducted on two datasets, Samaria and Arad (explanation below). The main assemblage was a corpus of 31 legible Samaria ostraca with sufficient textual information and a low curvature of text lines. In addition, eight texts were used for enriching statistics of the characters. A second dataset contained the 16 ostraca from Arad.

The framework of algorithm 2 consisted of two consecutive stages. First, we used algorithm 1 (developed for Arad, see fig. 6A–D) to establish separations between authors of every pair of inscriptions within the corpus. This resulted in *the minimal number of writers* as well as *the total number of pairwise distinct separations* within the corpus. The purpose of the second stage (algorithm 2, for the Samaria study) was to establish *the most likely number of authors* within a given corpus. In other words, the general idea is to obtain a number of *hands' separations* within the corpus, and then provide a statistical estimate for the number of authors who could have written the inscriptions.

Assessing the error and success rates in the same/different writer scenarios for a given corpus requires another, independent set of documents, preferably from approximately the same period, medium, language, and script. The reference corpus should be accompanied by preestablished separations between their authors. In the Samaria study, we considered the Arad corpus, and the separations presented in Faigenbaum-Golovin et al. (2020: supplementary material), as the most suitable reference corpus for our simulations.

Considering the number of separations within the tested corpus, we calculated the probability that a given number of writers could have provided a given result, while taking into account the errors and success statistics. This resulted in the *maximum likelihood estimate for the number of writers*, with a confidence level of 95 percent (fig. 6G).

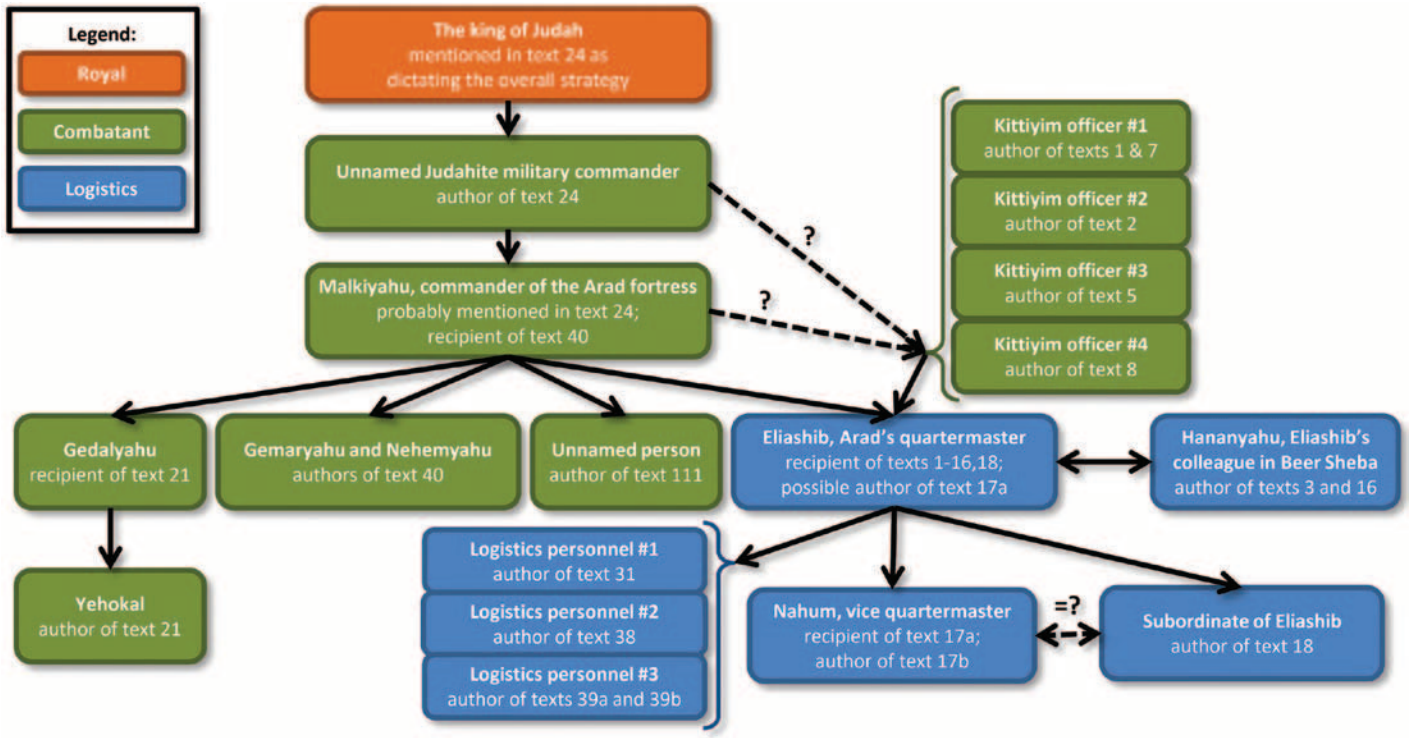

Figure 7. Reconstruction of the hierarchy among authors and recipients in the examined Arad inscriptions; also indicated is the differentiation between combatant and logistics officials. Courtesy of the Digital Epigraphy Project, Tel Aviv University.

Results

Arad: The Algorithmic Study

Using this computerized procedure, we analyzed 16 + 2 inscriptions from Arad (Ostraca 1, 2, 3, 5, 7, 8, 16, 17 + reverse, 18, 21, 24, 31, 38, 39+ reverse, 40, and 111; Aharoni 1981), which are relatively legible and have a sufficient number of characters. The results allow us to estimate the *minimal* number of writers in the tested inscriptions. Ostraca 7, 18, 24, 31, and 38 reveal that their authors are pair-wise distinct; another such quintuplet is 16, 18, 24, 31, and 38. In other words, it can be deduced that there are *at least five unique hands* in the tested corpus, and as many as seven (Shaus and Turkel 2017; Faigenbaum-Golovin et al. 2019).[2]

Arad: The Forensic Examination

According to the forensic analysis, texts 5, 8, 17a, 21, 24, 31, 40, and 111 were all created by different authors. Other distinct hands which can be added are: either Ostracon 1 or Ostracon 7; one of Ostraca 2, 3, or 16; either 17b or 18; and either 39a or 39b. All this makes 12 different authors. The forensic and the two algorithmic investigations exhibit no contradictions in their conclusions. At the same time, there are three cases where identicalness of authors was established by the forensic expert, but the algorithm remained indeterminate.

Additional observations:

- The forensic handwriting analysis suggests that the two sides of Ostracon 39, listing names of individuals, were written by the same scribe. On the other hand, Ostraca 31, 38, and 39—all listing names and most probably composed at Arad—were written by different writers (also supported by algorithm 1, which distinguishes between Ostraca 31 and 38). Thus, we obtain at least three different writers at Arad.
- The forensic analysis indicates a strong possibility that Ostraca 1 and 7 were composed by the same writer. The scribe is one of the military officials requesting supplies for the *Kittiyim*, possibly their Judahite commander or liaison officer. It also seems that among Ostraca 1, 2, 5, 7, and 8 (likewise dealing with supplies to the *Kittiyim*), all texts except 1 and 7 were written by different hands (2 and 5 were also "separated" by Algorithm 1). Thus, it is conceivable that leading the *Kittiyim* into desert reconnaissance missions was the responsibility of at least four literate Judahite military officers.
- According to the forensic analysis, Ostraca 3 and 16 were composed by the same writer. Both of these inscriptions mention Hananyahu, possibly a quartermaster at Beer Sheba, about 25 km to the west of Arad; they were seemingly written by him.

Samaria: The Algorithmic Study

Our algorithm was applied to 31 legible Samaria ostraca with sufficient textual information and a low curvature of text lines (Ostraca 2, 5, 6, 7, 8, 12, 14, 16a, 17a, 18, 19, 20, 21, 22, 24a, 29, 35, 36, 38, 42, 43, 45, 51, 52, 53, 54, 55, 56, 57, 59, and 62). In addition, characters from eight other ostraca (11, 15, 17b, 33, 34, 40, 44, and 61) were used for enriching the letter dataset. Note the double-sided Ostraca 16, 17, and 24, with the recto denoted as "a" and the verso denoted as "b." All available letters that appear in sufficient quantities were utilized: Hebrew *bet*, *yod*, *lamed*, *mem*, *nun*, *resh*, *shin*, and *taw*. In total, 293 legible characters were restored, based upon computerized images of the inscriptions.

Most of the Samaria ostraca pairs could not be compared due to the brevity of the inscriptions (9.5 legible characters on average). Nevertheless, 138 comparisons were performed, yielding ten pairwise separations. The *most likely number of writers in this case is two*.

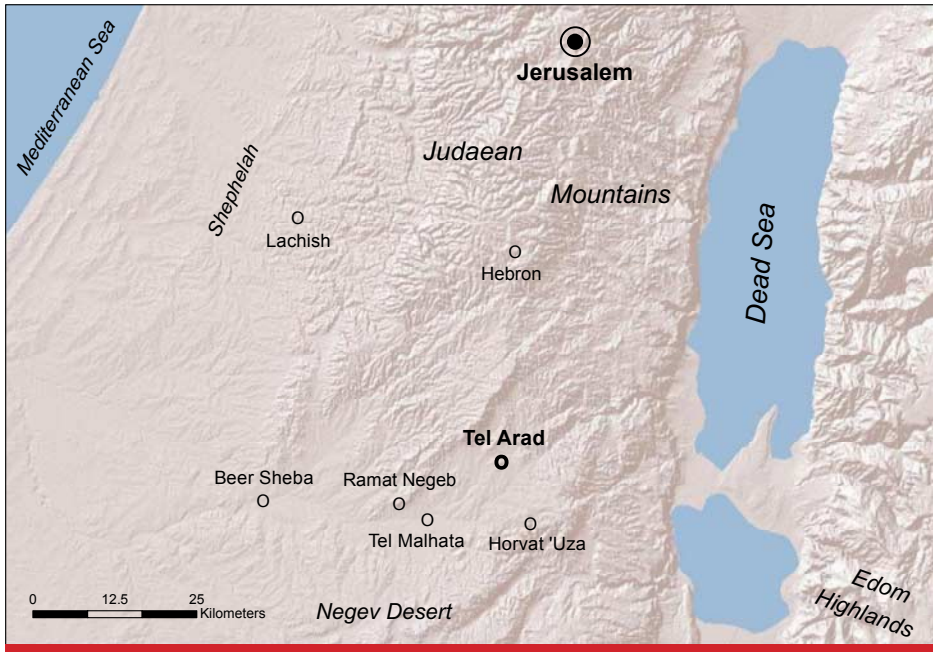

Figure 8. Map of the Judahite Negev, indicating places that have yielded Hebrew ostraca. Courtesy of the Digital Epigraphy Project, Tel Aviv University.

Discussion

Arad

Identifying the military ranks of the authors can provide information regarding the spread of literacy within the Judahite army. Based on the content of the letters, our proposed reconstruction of the hierarchical relations between the signees and the addressees of the inscriptions is as follows (fig. 7):[3]

1. The king of Judah: mentioned in Ostracon 24 as dictating the overall military strategy.
2. An unnamed military commander: the author of Ostracon 24.
3. Malkiyahu, probably the commander of the Arad fortress, mentioned in Ostracon 24 and recipient of Ostracon 40.[4] In the same rank, the four officers of the *Kittiyim* (authors of texts 1 and 7; 2; 5; and 8).
4. Four subordinates of Malkiyahu: (A) Eliashib the quartermaster of the Arad fortress, the addressee of Ostraca 1–16 and 18. (B) Gedalyahu, recipient of Ostracon 21. (C) Gemaryahu or Nehemyahu author of Ostracon 40. (D) An unnamed person, author of Ostracon 111. Note that Hananyahu (author of Ostraca 3 and 16) was probably the quartermaster of Beer Sheba, having the same rank as Eliashib (yet probably not a subordinate of Malkiyahu).
5. Three subordinates of Eliashib: one addressing him as "my lord" in Ostracon 18; another named Nahum, probably the assistant quartermaster, recipient of 17a and author of 17b; and a third who listed names of soldiers in Ostraca 31, 38, and 39.

Following this reconstruction, it is reasonable to deduce a significant proliferation of literacy among the Judahite army ranks ca. 600 BCE. A contending claim, that the ostraca were written by professional scribes, can be dismissed with two arguments. First, the existence of *three distinct* writers in the tiny fortress of Arad. Second, the textual content of the inscriptions: Ostracon 1 orders the recipient (Eliashib) "write the name of the day"; Ostracon 7 commands "and write it before you"; and in Ostracon 40 (reconstructions in Aharoni 1981: 70–74; Na'aman 2003), the author mentions that he had written the letter. Thus, rather than implying the existence of scribes accompanying Judahite officials, the written evidence suggests a high literacy rate in the entire Judahite chain of command.

The dissemination of writing within the Judahite army around 600 BCE is also confirmed by the existence of other, mostly military-related groups of ostraca from the Negev (fig. 8): Horvat ʿUza, Tel Malḥata, Horvat Radum, Tel ʿIra, Aroer, Tel Masos, and Kadesh Barnea (summary in Ahituv 2008; see Na'aman 2015). The rich evidence from the Negev (good preservation because of dry weather conditions) can be supplemented by the military correspondence within the corpus of ostraca from Lachish in the Shephelah (Torczyner 1938), as well as by ostraca found in other locations in Judah (e.g., Mendel-Geberovich et al. 2019), including Jerusalem (Faigenbaum-Golovin et al. 2015).[5] We assume that in all these locations the situation was similar to Arad, with even mundane orders written occasionally. In other words, the entire army apparatus, from high-ranking officials to humble vice-quartermasters of small, peripheral desert outposts, was literate, being able to communicate in writing. Evidently,

in order to support this bureaucratic apparatus, an appropriate educational system must have existed in Judah (Lemaire 1981; Rollston 2006; Demsky 2012).[6]

Our algorithmic work revealed a minimum of five to seven authors in the 16 Arad ostraca. The forensic examination notes 12 different "hands" within this corpus. Even if some of the texts were sent to Arad from other locations, there are still at least three writers among the 20–30 military personnel stationed at this small, remote fortress. Extrapolating these data to the entire Arad corpus and then to the military system in the southern Judahite frontier, to military posts in other sectors of the kingdom, to central administration towns such as Lachish, and to the capital Jerusalem—a significant number of literate individuals can be assumed to have lived in Judah ca. 600 BCE.

The spread of literacy in late-monarchic Judah provides a possible setting for the compilation of literary works. True, biblical texts could have been written by a few and kept in seclusion in the Jerusalem temple, and the illiterate populace could have been informed about them in public readings and verbal messages by these few (e.g., 2 Kgs 23:2, referring to the period discussed here). However, widespread literacy offers a better background for the composition of ambitious works such as the early layers of Deuteronomy and the Deuteronomistic History, which formed the basis for the Josianic Judahite ideology and theology (e.g., Cross 1973: 274–288; Na'aman 2002; Römer 2005).

Judging from archaeological data, the destruction of Jerusalem by Nebuchadnezzar in 586 BCE brought about decline if not cessation of this significant Hebrew literary activity for the next four centuries (Finkelstein 2016).

Samaria

Our work identified two scribes in the 31 tested Samaria ostraca, which seem to span a maximum of seven years (assuming a single monarch). The ostraca contain various documentation characteristics (i.e., year, commodity, name of person, clan, and toponym; Aharoni 1979: 358–62). We tried to find correlation between the two writers and these characteristics. The clustering results were inconsistent and did not create even an approximate division according to any particular characteristic. As a result, and in light of the short span of regnal years mentioned (9–15, or a single year following Rainey 1988), we suggest that the two writers were contemporaneous and performed similar duties.

Although the shipments originated from various locations in the highlands around the capital and mention different clans, the fact that they were written by only two individuals seems to indicate that the scribes were located at Samaria rather than in the countryside. We cannot rule out the possibility that the two scribes were traversing the countryside, documenting shipments on demand; but such a possibility seems less plausible in the case of shipment of agricultural goods in a well-organized kingdom. Note that the only contemporary corpus—that of Kuntillet Ajrud in the remote northern Sinai Desert (Ahituv, Eshel, and Meshel 2012)—is also related to the royal administration of Israel. This seems to portray a royal bureaucratic apparatus at least at Samaria if not in the entire kingdom.

One may ask why the Samaria ostraca do not refer to earlier or later years of Israelite monarchs. To answer, we first note that the ostraca were found out of stratigraphic context, in a fill prepared for the construction of the "Ostraca House" (Kaufman 1982) and possibly even beyond (Tappy 2016: 57–58), meaning that there is no way to trace their original provenance. Theoretically, they may represent one collection of records, while other collections may have been disposed of in other places. In any event, the dating of the Samaria ostraca can be narrowed according to the reference to year 15 in some of them (Lemaire 1977: 80). Only five kings ruled at Samaria for a period of 15 years or longer: Ahab 871/873–852 BCE; Jehu 842–814; Jehoahaz 817–800; Joash 800–784; and Jeroboam II 788–747. Since earlier letter shapes were in use in the days of the first two or three—possibly proto-Canaanite and paleographically earlier(?) Rehov inscriptions (Finkelstein and Sass 2013; Sass and Finkelstein 2016; for Rehov, Ahituv and Mazar 2014)—Joash and Jeroboam II are the most likely. This is supported by the typology of the bowls on which many of the inscriptions were written; they date to the early Iron IIB (early eighth century BCE; Finkelstein and Sass in press). Judging from the prosperity of the kingdom, Jeroboam II is the more plausible, though the fact that the latest year referred to is 15 may point to Joash. Still, one may hypothesize that the Samaria ostraca represent a phase in the development of the Northern Kingdom's bureaucracy. During the days of Joash or the first years of Jeroboam II, Hebrew writing had already been sufficiently developed to enable recording on ostraca; later, during the peak prosperity of the kingdom, the system could have changed to a more efficient recording system, perhaps using papyri.

The high level of standardization in the format of the Samaria texts may support the proposed bureaucratic apparatus, perhaps even some sort of administrative centralization. Still, at some point between the years 10 and 15 a change in the documentation formula occurred: Ostraca belonging to year 9 or 10 contain commodity type and neglect the clan feature, whereas ostraca belonging to year 15 neglect the commodity type and contain the clan name. Since the two scribes are contemporaneous, this change may be attributed to a new/different administration directive, rather than to the scribes' preferences. In addition, there is a noticeable increase in the number of inscriptions pertaining to year 15: There are nene inscriptions bearing the year 9; 14 recording the year 10; and 29 bearing the year 15. If the sample we have is representative, this may indicate increased activity during the later years of the given monarch(s).

Another notable consequence of the Samaria ostraca research pertains to paleography. Apart from the two Samaria scribes, the only significant evidence for writing with ink on clay sherds in the Northern Kingdom are fragments of an inscription from Beit-Shean (see Mazar 2006: 505–13) and the inscriptions from Kuntillet Ajrud in northeastern Sinai (Ahituv, Eshel, and Meshel 2012). The latter site is small (a single building) and short-lived, meaning that the number of scribes there must have been restricted. Archaeologically (ceramic evidence) and paleographically, these inscriptions date to the same period, and represent a handful of scribes. Hence, it is doubtful if one can construct a

reliable paleographic system for the Northern Kingdom based on these finds.

Summary

In Judah, literacy spread down the military system to the quartermaster of the remote fortress of Arad and possibly to his assistant. Extrapolating from Arad to other forts and towns and to the capital Jerusalem, this seems to portray a significant level of literacy in the entire kingdom.

The evidence from Samaria seems to represent palace administration. It is not sufficient to draw conclusions on the level of literacy in the Northern Kingdom before the Assyrian takeover. The dearth of written material in contemporaneous places in Israel, including administration centers such as Megiddo, Gezer, and Hazor, seems to indicate that despite military and economic prosperity, literacy in Israel was still in its infancy.

It seems that over the course of the 150 years that separate the two corpora, one can observe development from a writing milieu centered mainly around the royal court (and possibly cult institutions) in Israel to a broad proliferation of literacy in the entire territory of the kingdom of Judah. Apart from a natural growth in literacy, this development was probably influenced by the century of Judah's incorporation as a vassal kingdom into the Assyrian imperial administration.

Acknowledgments

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Notes

1. Shira Faigenbaum-Golovin, Arie Shaus, and Barak Sober carried out the algorithmic work and are first co-authors in this article. Yana Gerber conducted the forensic examination of the Arad ostraca. Eli Turkel supervised the algorithmic work. Eli Piasetzky and Israel Finkelstein directed the project.

2. In our first Arad publication (Faigenbaum-Golovin, Shaus et al. 2016, before the development of Algorithm 2), we reached a minimum of four authors and added two according to considerations related to the content of the texts. Here we present results based solely on the improved algorithmic study.

3. This is the updated hierarchy, taking into account the information from both the algorithmic and forensic investigations (Shaus et al. 2020) and hence more nuanced than Faigenbaum-Golovin et al. 2016: fig. 4.

4. Contrary to the excavator's dating of Ostracon 40 to Stratum VIII of the late eighth century (Aharoni 1981: 74), it should probably be placed a century later, along with Ostracon 24 (see Na'aman 2003 for details).

5. Lachish Ostracon 3, also military correspondence, represents the most unambiguous evidence of a literate officer. The author seems offended by a suggestion that he is assisted by a scribe.

6. Additional evidence for dissemination of literacy in the Judahite society seems to come from the Meẓad Hashavyahu ostracon (Naveh 1960), which contains a complaint by a corvée worker against one of his overseers. Even if the inscription was composed with the aid of a scribe, the awareness of the power of writing is the important factor here.

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Shira Faigenbaum-Golovin is a PhD student at the Department of Applied Mathematics, Tel Aviv University. Her research strives at designing approximation tools for manifolds embedded in high dimensions, as well as developing machine learning and image processing algorithms, aiming to answer long-debated questions in digital humanities.

Arie Shaus is an alumnus of Adi Lautman Interdisciplinary Program for Outstanding Students. He obtained a PhD in Applied Mathematics from Tel Aviv University in 2018. His interests include image processing, machine learning, and biblical archaeology.

Barak Sober is a Phillip Griffiths Assistant Research Professor of Mathematics at Duke University. His current research ranges between development and analysis of geometry-based algorithms in high-dimensional data sets and their application to archaeology and art investigation.

Yana Gerber is a retired superintendent and senior questioned document examiner, Division of Identification & Forensic Science, Israel Police. She currently is a private expert and consultant in handwriting research and applications, and an expert witness in Israeli courts.

Eli Turkel is currently professor emeritus in the applied mathematics department of Tel Aviv University. His main interests are in computational methods related to partial differential equations. He has published extensively in computational fluid dynamics including far field absorbing boundary conditions and preconditioning for fast convergence. In recent years he has also worked in inverse problems and image processing with deep learning and applications to archaeology.

Eli Piasetzky is a professor of Physics at Tel Aviv University and the incumbent of the Wolfson Chair in Experimental Physics. His current research is Experimental High Energy Nuclear Physics and application of physics and mathematics methods to archaeology.

Israel Finkelstein is professor emeritus of archaeology at Tel Aviv University, a member of the Israel Academy of Sciences and Humanities and a foreign member of the French Académie des Inscriptions et Belles Lettres. He finished his PhD in 1983, taught at the University of Chicago and the Sorbonne and spent research years at Harvard and the Hebrew University. Finkelstein conducted many field projects, among them the excavations at biblical Shiloh and the celebrated site of Megiddo.