

## **PREFACE—THE IRON AGE IN ISRAEL: THE EXACT AND LIFE SCIENCES PERSPECTIVES**

Israel Finkelstein<sup>1</sup> • Steve Weiner<sup>2</sup> • Elisabetta Boaretto<sup>2</sup>

In the original proposal entitled *Reconstructing Ancient Israel – The Exact and Life Sciences Perspective*, two of us (Israel Finkelstein and Steve Weiner) wrote, “If the microscopic data are well integrated into the macroscopic (archaeological) record, they will undoubtedly provide new insights into the study of Ancient Israel.” And this was what this 5-year (2009–2014) European Research Council (ERC) sponsored program (details below) was all about. New ground was broken on three fronts: conceptual, methodological, and in the generation of new data that indeed provide novel insights into the history and material culture of Ancient Israel in particular and the Iron Age Levant in general. The reviews presented in this special volume synthesize some of these new insights. The findings have been published in about 70 papers (see Appendix).

### **CONCEPTUAL BREAKTHROUGHS**

The archaeological record is, for the most part, fragmentary in that rather little of what existed originally is buried, what is buried undergoes change over time, and when excavated not all the interesting information is retrieved. We cannot do anything about the first two processes, but where we can improve and innovate is during the excavation. The approach we use is to explore as much as possible the entire archaeological record of a site, from the level of atoms to the levels of architecture and site organization, and to try to do this as much as possible during the excavation itself. An excavation is destructive; the more information that is obtained while excavating, the more informed can the excavation team (macro- and microarchaeologists) be, and the more they can use this information to adapt the excavation strategy and extract as much valuable data as possible. The macroscopic record can be seen with the naked eye down to a submillimeter level, but the remaining record, which spans no less than 10 orders of magnitude down to the atomic level, requires instrumentation. This integrated on-site approach is referred to by us as “microarchaeology.”

Another conceptual breakthrough is that the archaeological finds need to be mapped in four dimensions, with the 4th dimension being time. Albeit great improvements are being made with the mapping of the three spatial dimensions (use of total stations, 3D reconstructions, laser scanners, etc.), the 4th dimension, time, is still mapped, for the most part, using traditional means (stratigraphy, material culture assemblages, and links to supposed historical events and figures), even though for the last 65 years, a precise and accurate method for determining absolute time is available—radiocarbon. In our project, a great effort was made to place every site and find into an absolute chronological framework using radiocarbon dating (e.g. Toffolo et al. 2014 in the list below). By so doing, we opened up questions regarding the dynamics of the spread of ideas, materials, and people in the past, and made it possible to obtain reliable snapshot views of what was transpiring in a given region at a specific point in time (Boaretto in this issue).

One of the reasons we think it most appropriate to publish these reviews on the achievements of this project in many diverse fields in the journal *Radiocarbon*, is because we feel that absolute chronology really does “set the stage,” or define the framework for the essential 4th dimension of time. Obtaining accurate and precise dates, it turns out, depends to a great extent on using both the

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1. The Jacob M. Alkow Department of Archaeology and Ancient Near Eastern Civilizations, Tel Aviv University, Tel Aviv 6997801, Israel.

2. Kimmel Center for Archaeological Science, Weizmann Institute of Science, Rehovot 76100, Israel.

macroscopic and the microscopic records. So radiocarbon dating really permeates through many of the topics we addressed.

Eventually, archaeology is all about reconstructing history. Indeed, the history of the Levant in the Bronze and Iron Ages has traditionally been drawn according to three sets of evidence: macro-archaeological finds, the biblical record, and ancient Near Eastern textual material. The introduction of the microarchaeology “philosophy” (to differ from the usage of a single method at a given site) is another conceptual change in the way we work.

### METHODOLOGICAL BREAKTHROUGHS (“PUSHING THE ENVELOPE”)

Traditionally, many of the “micro” methods used in archaeology were developed in the earth sciences, with the one glaring exception of  $^{14}\text{C}$  dating, which was first applied to archaeology. With the new agenda of revealing as much as possible of the archaeological record in real time during the excavation (Figure 1), a method has an added value if the information can be obtained within a few minutes on site, or even from one day to the next, still during the active excavation. This is a unique requirement for archaeology, and thus new methods have to be developed specifically for these purposes. In our project, we developed several methods to enhance the on-site tool kit.

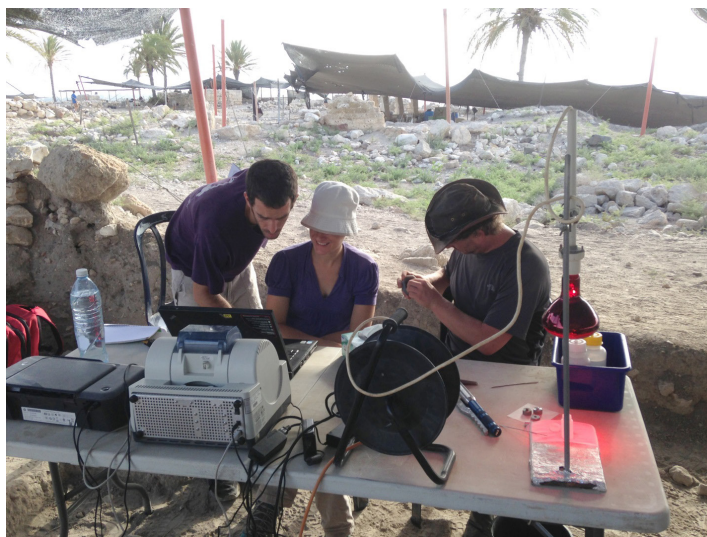


Figure 1 The on-site microarchaeological laboratory in operation in Area Q, Megiddo.

Immediate turnaround for on-site analysis: the key tool for the on-site analysis is Fourier transform infrared spectroscopy (FTIR), where just 5 to 10 min are required for each analysis. We developed two valuable tools using FTIR. The first assesses the atomic disorder of calcites that, if well preserved, enable us to differentiate between geogenic, biogenic, and anthropogenic calcite (plaster and wood ash). The same approach can be used for the carbonated hydroxyapatite mineral of bone, dentin, and enamel, in which the key issue is usually assessing state of preservation. By careful calibration of standard mixtures, we can use FTIR to assess proportions of quartz and clay, a tool that is often helpful for differentiating sediment sources and uses.

From one day to the next: We reported a new rapid method for counting phytoliths in sediments that has broad application in mapping past activities involving plants. In one application, we used this

method to define the boundaries of a small archaeological site that extend well beyond its architecture (Cabanès et al. 2012). A new prescreening method was established (Goldenberg et al. 2014) for determining whether ceramics of interest have preserved organic residues, which could then be extracted and analyzed. This requires the availability of an XRF on site. A relatively simple method was developed for producing small thin sections within 24 hr in order to examine the micromorphology of particularly important areas.

Home laboratory methods: elegant methods for revealing ink inscriptions on sherds were developed using spectral imaging (Faigenbaum et al. 2012 and in this issue; Sober et al. 2014). This alleviates the problem of the writing fading once the sherd is extracted from the sediments, and allows for a more objective interpretation of the text (Shaus et al. 2010). Raman spectroscopy was deployed in order to produce automated facsimiles of ink inscriptions (Shaus et al., forthcoming). In addition, we developed algorithms for comparing letters in order to identify different handwritings (articles in progress). In another field, a chemical method was developed for assessing phytolith preservation (Cabanès et al. 2011), which has now become a key issue in reconstructing the archaeobotanical record.

### **NEW INSIGHTS INTO THE IRON AGE IN THE LEVANT**

The eight reviews in this volume each address different topics, and synthesize the various observations, placing them into a broader framework.

A major contribution, which resonates far beyond ancient Israel, is our input on the absolute chronology of the entire Mediterranean region in the Iron Age (Toffolo et al. 2013). This issue has been fiercely debated and ours was an attempt to resolve it by  $^{14}\text{C}$  dating secure samples from several sites in Greece, representing a sequence of relative phases of the Iron Age.

One of the declared aims of this project was to integrate observations from more than one site, using different methods. A good example is the work in the Negev Highlands, which was aimed at better understanding the mode of life in this southern desert region during the Iron Age, as well as broader issues related to the history of the marginal areas of the southern Levant. Geoarchaeological studies, together with extensive archaeobotanical work on phytoliths, were all placed in an absolute chronological framework using  $^{14}\text{C}$  dating (Shahack-Gross et al. 2014; Shahack-Gross and Finkelstein, this issue). The project established that the predominant lifestyle during the Iron IIA involved livestock management. This is inconsistent with past theories regarding the importance of seasonal dry farming in the subsistence economy of the groups that inhabited the region. We also discovered an active trade route through this area, which involved the production of ceramics in the copper-production sites of Timna and/or Feynan (Martin and Finkelstein 2013; Martin et al. 2013). Our dating established a new paradigm regarding the historical setting of the wave of settlement in the Negev in the 9th rather than 10th century BCE.

Based on a comprehensive database of livestock frequencies and mortality profiles, we examined synchronically and diachronically conventional assumptions regarding animal husbandry in the southern Levant in the Late Bronze and Iron Ages (Sapir-Hen et al. 2014). Contrary to past assumptions, we proposed that changes in animal-husbandry strategies were dictated by historical factors rather than by environmental ones. The main shift in livestock husbandry reflects enhanced social complexity during a period of transformation in the territorial-political system from local kingdoms to imperial rule.

Destruction events are important in the archaeology of the southern Levant, both because of their historical significance and as they are well-defined marker horizons in multilayer sites. A detailed macro- and microarchaeological study of a late 9th century destruction horizon at Tell es-Safi (Nam-

dar et al. 2011) revealed information about the manner in which the space was used prior to the destruction, aspects of the destruction itself, and the postdestruction processes that may have continued for decades. A similar study, but on a much larger scale, focused on the huge so-called “red city” destruction layer at Megiddo, and is still ongoing.

Regarding the environment, our study of the pollen record in sediments extracted from the Dead Sea and the Sea of Galilee was carried out at an unprecedented resolution of a sample per 25–40 yr (Langgut et al. 2014 and this issue). This, and the study of Dead Sea levels (Kagan et al., this issue), shed light on the climatic history of the Levant, and in fact the entire eastern Mediterranean and Near East. Our work reveals a major dry event at the end of the Late Bronze Age, which seems to have played a major role in the “Bronze Age Collapse” in the late 2nd millennium BCE (Langgut et al. 2013). The pollen results are supported by two other records that relate to the same timespan (~1250–1100 BCE): a wave of destructions in many major sites and ancient Near Eastern texts that speak about drought, famine, movement of displaced people, and as a result destruction of cities. The pollen investigation also illuminated a “mini-crisis” in the early 2nd millennium BCE (~2000–1800 BCE), which affected the sedentary fringe areas from southern Israel and Jordan to northern Syria (Finkelstein and Langgut 2014).

The Philistines were a group among the Sea Peoples, who were on the move in the transition from the Late Bronze to the Iron Age, probably as a result of the climate crisis referred to above. Investigations of early Iron Age faunal assemblages from their urban centers in southern Israel indicate the importance of pig culture—far beyond the usual in the Levant. This fact drew much attention to the role of culinary practices in establishing ethnic boundaries and more specifically the pig taboo in biblical Israel. We carried out two pig-related studies (Sapir-Hen et al., this issue). Our archaeozoological investigations revealed a relatively large number of pig bones in lowland Iron II sites related to the Northern Kingdom (Israel). Based on this, we suggest that the pig taboo was a result of the Israel–Judah relationship in the later phases of the Iron Age more than the supposed Israel–Philistine conflicts in the early Iron Age (Sapir-Hen et al. 2013). Because of the cultural importance of pigs, and past clues that wild boars in Israel carry a European (to differ from Middle Eastern) genetic signature, we turned to ancient DNA of pigs (Meiri et al. 2013). Our first step verified that, indeed, the modern wild boar population in Israel is of European origin. We then checked pig bones from different archaeological periods and discovered that the first significant appearance of European pigs took place in ~900 BCE. We suggest associating the early arrival of European pigs with the migration of the Sea Peoples.

One of the biggest surprises in our work came from the analysis of molecules preserved in small rounded Phoenician flasks that date to ~1000 BCE (Namdar et al. 2013 and this issue). This study showed the presence of a molecule called cinnamaldehyde, which is only produced in large quantities in cinnamon tree bark. These trees grow in the Indian subcontinent and the Far East. The finds indicate the existence of long-distance trade from India and beyond to the southern Levant and further to the west in an early phase of the Iron Age.

Regarding trade, our study of shape and volume of trade containers (storage jars) from different phases of the Late Bronze and Iron Ages demonstrated that standardization in production of ceramics occurred in the Iron IIB (the 8th century BCE)—the period of Assyrian domination in the Levant and prosperity of Phoenician-led trade in the eastern Mediterranean (Finkelstein et al. 2011).

A major achievement of the project is the study of various aspects of bronze and iron industries in the Iron Age (Yahalom-Mack et al., this issue). First and most important for future fieldwork,

we demonstrated the possibility of identifying metallurgical activity not only according to objects found in a dig, but also in the residues it leaves in the sediments (Eliyahu-Behar et al. 2012). The metallurgy track shed new light on the gradual transition from bronze to iron, which culminated in the Iron IIA, in the 9th century BCE. And it illuminated two highly important facts—continuity in metal industry over a long time in the same quarters in multiperiod sites and the fact that iron production emerged from the bronze workshops (Yahalom-Mack et al. 2014 and forthcoming).

### LONG-TERM IMPACT

Long-term outcomes are usually not easily measureable or identifiable so soon after the completion of a research program. We hope that what will be said about this project in, say, 10 years from now, is that this was the turning point when archaeologists working in the Levant redefined excavation modes and research goals, taking into account the potential of integrating the microscopic and macroscopic archaeological records.

### MODE OF OPERATION

The project discussed here was supported by the European Research Council Advanced Grant no. 229418, titled Reconstructing Ancient Israel: The Exact and Life Sciences Perspective (RAIELSP). Principal and Co-Principal Investigators were Israel Finkelstein of Tel Aviv University and Steve Weiner of the Weizmann Institute of Science. The project was administered by Shirley Ben-Dor Evian and Yuval Gadot.

The project was organized into five main tracks, which included 10 subtracks (names of researchers in parentheses, name of track leader underlined) (Figure 2):

1. The time of Ancient Israel: focused on developing a detailed absolute chronology for the Iron Age in the Levant, and correlating Iron Age chronology in the southern Levant with that in Greece in particular and the Mediterranean in general (Elisabetta Boaretto, Michael Toffolo, and Alexander Fantalkin).
2. The genesis of Ancient Israel: (a) focused on the genetics of the local pig population from the Bronze Age through the Iron Age (Meirav Meiri); (b) tracking subsistence economy using mainly geoarchaeological approaches both in the Negev and in sites in central Israel (Ruth Shahack-Gross, Dan Cabanes, and David Friesem); (c) relating paleoclimate to settlement patterns by studying pollen in samples from the Dead Sea and the Sea of Galilee (Daphna Langgut, Thomas Litt, Mordechai Stein, Elisa Kagan, and Frank Neumann).
3. The life of Ancient Israel: (a) reconstructing trading patterns in the Negev using ceramic petrography (Mario Martin); (b) tracking trade networks and technological advances based on bronze and iron metallurgy (Adi Eliyahu and Naama Yahalom-Mack).
4. The mind of Ancient Israel: (a) the study of daily mathematics of dimensions in Iron Age pottery (Itzhak Beneson and Lena Zapasky); (b) the use of advanced imaging capabilities to decipher writing in Israel and Judah (Eli Piasetzky, Shira Faigenbaum, David Levin, Murray Moinester, Arie Shaus, Barak Sober, and Eli Turkel).
5. The identity of Ancient Israel: (a) study of preserved organic residues in pottery to reconstruct ancient trade routes (Dvory Namdar, Ayelet Gilboa, and Larisa Goldenberg); (b) study of animal bones to better understand subsistence economies and diet (Lidar Sapir-Hen, Guy Bar-Oz, and Lior Weissbrod).





Figure 2 Reconstructing Ancient Israel project retreat (Neve Ilan, 2013). Standing in the upper row, left to right: Michael Toffolo, Steve Weiner, Lidar Sapir-Hen, Ruth Shahack-Gross, Elisabetta Boaretto, Maayan Mor, Dvory Namdar, and Meirav Meiri; standing, middle row, left to right: Lior Weissbrod, Shira Faigenbaum, Zach Danseth, Mathilde Forget, Yuval Gadot, Na'ama Yahalom-Mack, Adi Eliyahu-Behar, Shirly Ben-Dor Evian, Dafna Langgut, Israel Finkelstein, Mario Martin, Larisa Goldenberg, Barak Sober, Arie Shaus, and Thomas Litt; sitting: Eli Piasetzky.

Fieldwork, including sampling, was conducted in the following sites (in the case of ongoing excavations, the name of the director appears in parentheses) (Figure 3):

Ashkelon (Dan Master, Harvard University), Tel Burna (Itzhak Shai and Joe Uziel, Bar Ilan University), Tel Eton (Avraham Faust, Bar Ilan University), Hazor (Amnon Ben-Tor and Sharon Zuckerman, the Hebrew University), Izbet Sartah, Megiddo (Israel Finkelstein and David Ussishkin, Tel Aviv University; Eric H. Cline, George Washington University), Moza (Shua Kisilevitz, Anna Eirikh-Rose, and Zvi Greenhut, Israel Antiquities Authority), Qubur el-Walaydah (Gunnar Lehmann, Ben-Gurion University), Ramat Rahel (Oded Lipschits and Yuval Gadot, Tel Aviv University; Manfred Oeming, University of Heidelberg), er-Ras (Yuval Gadot, Tel Aviv University), and Tell es-Safi/Gath (Aren Maeir, Bar Ilan University).

Samples were also taken from the following sites:

Israel: Acco (Danny Syon and Edna Stern, Israel Antiquities Authority), Azekah (Oded Lipschits and Yuval Gadot, Tel Aviv University; Manfred Oeming, University of Heidelberg), Beer-sheba (Zeev Herzog, Tel Aviv University), Tel Dor (Ayelet Gilboa, Haifa University; Ilan Sharon, Hebrew University), Gezer (Steve Ortiz, Southwestern Baptist Theological Seminary; Sam Wolff, Israel Antiquities Authority), Tel Halif (Oded Borowski, Emory University), Jerusalem (Doron Ben-Ami and Shlomit Weksler-Bdolah, Israel Antiquities Authority), Kinneret (Stefan Münzer, University of Bern; Juha Pakkala, University of Helsinki; Jürgen Zangenberg, University of Leiden), Tel Malhata (Itzhaq Beit-Arieh, Tel Aviv University), Negev Highlands sites, Patish (Pirhiya Nahshoni, Israel Antiquities Authority), Tell Qasile (Amihai Mazar, Hebrew University), Khirbet Qeiyafa (Yosef Garfinkel, Hebrew University), Tel Rehov (Amihai Mazar, Hebrew University), Tel Rekhesh (Akio Tsukimoto, Rikkyo University Tokyo; Hisao Kuwabara, Tenri University; and Yitzhak Paz, Ben-Gurion University), Beer Sheva, Horvat 'Uza, and nearby Horvat Radum (Itzhaq Beit-Arieh, Tel Aviv University) and Tel Yokneam (Amnon Ben-Tor, Hebrew University).

Cyprus: Idalion (Pamela Gaber, Lycoming College).



Figure 3 Reconstructing Ancient Israel project: sites where actual fieldwork was carried out and sites sampled.

Greece: Corinth (Guy Sanders, American School of Classical Studies in Athens), Kalapodi (Wolf-Dietrich Niemeier and Rainer C.S. Felsch, German Archaeological Institute in Athens), and Lefkandi (Irene Lemos, Oxford University).

Laboratory work was carried out at Tel Aviv University, the Weizmann Institute of Science (Rehovot), and the University of Bonn (Germany).

## APPENDIX: LIST OF PUBLICATIONS

## Published and accepted for publication

- Asscher Y, Lehmann G, Rosen SA, Weiner S, Boaretto E. 2015. Absolute dating of the Late Bronze to Iron Age transition and the appearance of Philistine culture in Qubur el-Walaydah, southern Levant. *Radiocarbon* 57(1):77–97.
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