EARLY METALLURGY, INTERACTION, AND SOCIAL CHANGE: THE JABAL ḤAMRAT FĪDĀN (JORDAN) RESEARCH DESIGN AND 1998 ARCHAEOLOGICAL SURVEY: PRELIMINARY REPORT

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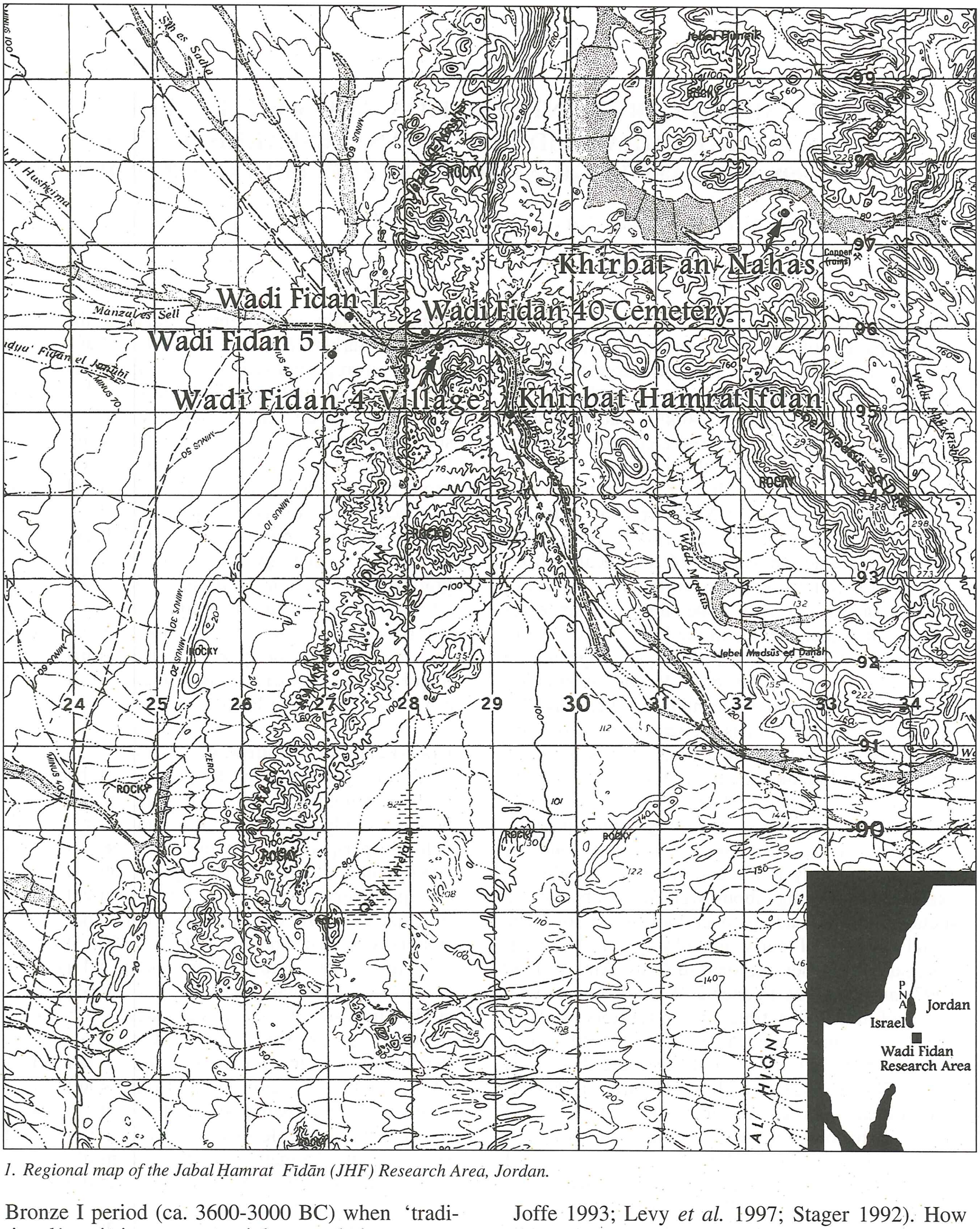
Introduction

This paper outlines the research design and preliminary survey results for the large-scale archaeological excavation and survey work now being carried out in the ca. 240km^2 Jabal Ḥamrat Fīdān (JHF) جبل حمرة فيدان research area, southern Jordan. The JHF marks the 'gateway' to the Faynān (فينان) copper ore district, one of the richest ore sources in the eastern Mediterranean (**Fig. 1**). The primary aims of this diachronic project are rooted in interaction studies of the local polities who lived within the environs of this rare south Levantine natural resource zone, their exchange relations with other regions in the Levant and ancient Near East, and how these interactions impacted on social change. Over the past decade, interaction studies have focused on center-periphery models that enable archaeologists, geographers, historians and other researchers to analyze the spatial organization of human societies (cf. Champion 1989; Schortman and Urban 1994). Through the lens of ore extraction and early metallurgy through time, this project will use the 'natural resource zone' as the locus of analysis for exploring how trade and exchange can bring about significant changes in social relations leading to cultural evolution. The social context of early metallurgy has been investigated in other regions such as Africa (Holl 1997) and Anatolia (Yener 2000), but in narrower spans of time. The time frame for this study is broad and spans the Pre-Pottery Neolithic (ca. 7500–6000/5500 BC) through the late Iron Age (ca. 1000–586 BC). The Jabal Ḥamrat Fīdān research area is particularly amenable to this kind of social archaeological study because it lacks the 'tyranny' imposed by the large multi-period mound sites so common in the Middle East which inevitably slow up data collection. Instead, the main sites to be excavated are relatively shallow, usually represent single periods and have already provided evidence of abundant archaeo-metallurgical materials. As the study area lies some 12km downstream from the main settlement area along the Wādī Faynān (Barker *et al.* 1997; 1998), it has not suffered from repeated sedentary occupations contributing to deep stratigraphic build-up, which characterizes Faynān. These factors ensure the rapid success of data acquisition for the Jabal Ḥamrat Fīdān project goals. Central to the success of the project is the close interdisciplinary collaboration of specialists in archaeometallurgy, archaeobotany, archaeozoology, biological anthropology, paleoenvironment, geology and geophysics, and Geographic Information Systems (GIS). Close collaboration will contribute directly to the over-all anthropological goals of the project, which focus on changing core-periphery relations through the major periods of social transformation in the southern Levant (cf. Levy 1998).

Core-Periphery Models: Overview

From a global perspective, core-periphery studies have primarily examined the impact of relations between early pristine states and their less developed peripheries. However, as Marcus (1994: 418) points out, one of the biggest problems is that core/periphery models are generally static; they imply that the core was always a core and the periphery always peripheral. In terms of social evolution, this can be remedied by taking a long-term, diachronic, regional approach to center-periphery studies in which it is assumed that at certain points in time 'peripheries' can shift to become independent or innovative core areas themselves. This is particularly appropriate for the southern Levant which never witnessed pristine state formation of the type and scale usually associated with centers of state formation such as central Mexico (Drennan *et al.* 1990; Millon 1981; Santley 1989), the Indus Valley (Kenoyer 1991; Possehl 1990), southern Mesopotamia (Adams 1981; Algaze 1993; Pollock 1992; Zagarell 1986), and Egypt (Hoffman 1979; Hassan 1988). In the southern Levant, it is only during the beginning of the Early



1. Regional map of the Jabal Ḥamrat Fīdān (JHF) Research Area, Jordan.

Bronze I period (ca. 3600-3000 BC) when 'traditional' pristine state–periphery relations crystallized with the establishment of Egyptian colonies in southern Palestine (cf. Brandl 1992; Esse 1989; Falconer and Savage 1995; Gophna 1995a; Joffe 1993; Levy *et al.* 1997; Stager 1992). How then can center-periphery models be applied to a larger sequence of cultural evolution? In particular, how can diachronic center-periphery models be used to explain some of the major social evolutionary transformations associated with the changes from autonomous Neolithic village societies in the southern Levant to the rise of the earliest historically documented Iron Age state systems? Some of the central interaction issues to be investigated in this study can be summarized below.

The Pre-Pottery Neolithic B Interaction Sphere

By beginning the investigation of copper ore procurement and exchange in the Pre-Pottery Neolithic (PPN) period, this study applies the notion of core-periphery interaction systems to pre-state level societies. Traditionally, these less complex societies were beyond the purview of core/periphery studies. However, as Peregrine (1991) has shown for Mississipian chiefdom organizations, it is possible to identify pre-state core-periphery systems, which were based on the manufacture and trade of prestige-goods. Exchange of goods and services within core-periphery systems can be linked to the dynamics of political economies that ultimately contribute to social evolution (Johnson and Earle 1987: 11). In the Near East, the recognition of copper ore exploitation and regional exchange networks in Anatolia at sites contemporary with the Levantine PPNB period make interaction models particularly applicable (Ozdogan 1995a; 1995b; Esin 1995). More importantly, Bar-Yosef and Belfer-Cohen's (1989; 1991) hypothesis of a 'PPNB interaction sphere' with large villages in the core settlement area of the Mediterranean zone, and smaller settlements in the semi-arid/arid zones, make core/periphery studies a useful heuristic device for examining the early role of ore procurement and exchange on regional social change during this formative period. A wide range of non-perishables circulated in this system including seashells, bitumen, obsidian, turquoise, "Dabba/Ḍab'a" marble (greenstone) and copper ores (Anati 1962; Bar-Yosef and Alon 1988; D. Bar-Yosef 1991; Cauvin 1991; Dixon *et al.* 1968; Garfinkel 1987; Rollefson 1988; Rollefson *et al.* 1992). Copper ore exploitation will provide a lens for examining PPNB production and exchange of one of these materials because it can be readily traced to source areas. By excavating sites near the copper ore source and using archaeometallurgical methods outlined below, the following details concerning the PPNB Interaction Sphere will be examined: a) the regional extent of copper ore use, b) determination if ores were acquired by inhabitants of other PPNB sites by long distance procurement or exchange, c) identification of direct vs. down-the-line vs. distance-decay models of trade (Renfrew 1975), d) did local inhabitants control access to these goods as early as the PPNB or not? e) the nature of traded materials (finished products, raw material, or both), f) the role of the Jabal Ḥamrat Fīdān PPNB sites at the 'gateway' to the copper district and contemporary neighbors within the Interaction Sphere system, g) does intrasite spatial analysis point to changes in the nature, organization and extent of production over the time span of the PPNB (Hietala 1984) and h) when does it originate (in PPNA?).

Some of the archaeometallurgical aims of these excavations will be to define the role of copper ores during the early Neolithic and their input/role concerning the beginnings of metallurgy. Was copper ore heat-treated before the spread of extractive metallurgy in the fourth millennium? Did developments in pyro-technology, as seen in PPN abilities to produce plaster, contribute to the beginnings of metallurgy in the Faynān district? PPN plaster has been found in Faynān (Simmons and Najjar 1997) and in Wādī Fīdān (Adams pers. com.). On the other hand, native copper was used and heat-treated in contemporaneous sites in southern Anatolia (Maddin *et al.* 1991). Native copper was used in Anatolia as early as the 10th millennium BC. In the southern Levant, there is no clear evidence that metal was known in the Neolithic and the development of metallurgy seems to have been different than in the north. The only copper object from the Neolithic period in the southern Levant known, thus far, comes from Tall Ramad in Syria, probably imported from Anatolia and not from Wādī 'Arabah. In the Levant, copper ore seems to have been used in this period for cosmetic purposes and for making beads. It was traded to other sites such as Nahal Hemar, Yiftahel, and Bayḍā (Garfinkel 1987). Recent claims for Neolithic copper smelting at Timna by Rothenberg and Merkel (1995) are interesting, but not convincing (Adams 1998). The new excavations at sites Wadi Fidan A and C (WFD 1 and 61) will provide a unique opportunity to investigate the material composition of the copper ores used, the spatial organization of production and the facilities used in the production process. In addition, we hope to examine the issue of developments in pyro-technology and the relationship of plaster production to any traces of PPN heat treatment of copper ores.

Chalcolithic vs. Early Bronze Age Control of Metallurgy

In the southern Levant, smelting and casting technologies originated in the Chalcolithic period (ca. 4500-3600 BC) and were used to produce both utilitarian and spectacular prestige metal work that circulated amongst chiefly elites (Levy 1998). Large-scale excavations of Chalcolithic sites in the northern Negev desert by Levy and Alon (Levy 1987; Levy and Alon 1987; Alon and Levy, in press) and archaeometallurgical studies of materials from those and other Negev excavations indicate that the Faynān district was the main source of copper ore used for utilitarian tools, while the source for alloy based prestige metal work remains a mystery (Hauptmann 1989b; Levy and Shalev 1989; Tadmor *et al.* 1995). This highly attenuated production and exchange system (Joffe 1993) involved procurement of ore in Faynān, and its transport to Chalcolithic settlements in the Negev desert where smelting and casting activities took place. To date, there is no evidence of Chalcolithic smelting or casting in Faynān. As indicated by recent excavations and radiocarbon dates, the key early metallurgy site in the Faynān district, Wadi Fidan 4 was initially mistakenly ascribed to the Chalcolithic period (Adams and Genz 1995; Hauptmann *et al.* 1996). This pattern supports the identification of a Negev 'monopoly' over metallurgy during the Chalcolithic, including the procurement process of ores from Faynān. One of the goals of the first systematic surveys (see **Table 2** below) in the study area and reported on here, was to identify Chalcolithic sites in the region, which might challenge this model.

The first local control of Faynān's rich copper ore district occurred in the following Early Bronze I period (ca. 3600-3300 BC) when there was a major social devolution in the southern Levant and Chalcolithic chiefdoms disappeared. The collapse took place in the shadow of growing Egyptian 'pristine' state formation (Hassan 1988). While most early EB I settlements in western Palestine were characterized by ephemeral pit dwellings and caves, some Faynān copper made its way to lower Egypt (Ma'adi: Rizkana and Seeher 1989) via sites on the Negev coastal plain (Gophna 1995a; Hauptmann 1989a). On the other hand, recent work at Wadi Fidan 4 in Faynān shows a more developed contemporary social organization evidenced by on-site metal production associated with more complex building structures than their early EB I counterparts in Palestine. This regional shift in metal production is being examined at the Wadi Fidan 4 village through archaeometallurgical studies of the metal working installations, slags, crucibles, prills, and other objects obtained in 1997 in relation to published Egyptian and Palestinian data.

By the end of the EB I (ca. 3600–3000) and Early Bronze II-III (ca. 3000–2200 BC; Gophna 1995b), the rise of the earliest urban centers in the southern Levant can be directly linked to traditional models of core/periphery systems (Levy *et al.* 1997; Adams 1999). How metal circulated between Levantine EB polities, its function in promoting social evolution, and its social role between the Levant and Egyptian core civilization has been a source of debate. To date, due to the paucity of EB excavations in Faynān (cf. Wright *et al.* 1998), little is known about the local organization of Early Bronze Age metal production or its contemporary links with the core areas of civilization. Even on the local pan-regional scale of Levantine interaction, Faynān's role in promoting, maintaining, or inhibiting social change is unknown. For example, it has been argued that EB II urbanism in the Negev desert at Tel Arad (Ilan and Sabbane 1989) can be explained by that site's control of the south Levantine metal trade. Hauptmann's (1989a; 1999) evidence of EB II industrial scale metal processing facilities in Faynān, recent geophysical surveys and excavations at the archaeometallurgically-rich EB II–IV site of Khirbat Ḥamrat Ifdān/ Fīdān (خربة حمرة إفدان/فيدان) in the study will provide important data for challenging Arad's centrality in the EB pan-Levantine metal (Adams 1999). Using new EB excavation data from the study area, alternative models based on shifting core-periphery interaction will be examined.

Finally, by the end of the Early Bronze Age a period of social collapse characterizes western Palestine and to a much lesser extent Jordan (cf. Early Bronze IV, ca. 2200–2000 BC). The nature of EB IV interaction between permanent urban sites in Jordan and seasonal village occupations in western Palestine has be a source of intense debate (cf. Dever 1998; Falconer 1995; Palumbo 1991; Richard and Boraas 1988). While EB IV metal objects have been examined as indicators of social rank (Palumbo 1987), the control of EB IV metal production and exchange, as a catalyst for social transformations has not. Preliminary explorations of EB IV deposits at Khirbat Ḥamrat Ifdān (KHI) have produced a rich corpus of casting molds (Adams 1999), metal working areas, and other features, which can be used to monitor these issues. Recent large-scale excavations at KHI have produced an extraordinary assemblage of EB archaeometallurgical materials (Levy, Adams and Najjar 1999).

Metallurgy and the Formation of the Iron Age Edomite Kingdom

In southern Jordan the emergence of the first historically documented archaic state level societies occurred during the Iron Age, ca. 1200–586 BC (Bienkowski 1992b; Herr 1997). During the

Late Bronze Age (ca. 1500–1200 BC) the Egyptian 'Execration Texts' indicate that outsiders already knew the area as Edom (Kitchen 1992). According to Bienkowski (1992b: 8), most scholars believe that Edom remained largely nomadic until perhaps the seventh century BC, supporting biblical evidence (Bartlett 1992) that it was only in the eighth and seventh centuries BC, after Edom's independence in the mid-ninth century BC that biblical writers became aware of Edom as a state power. The emergence of the Edomite state has been closely linked to Arabian trade. Edom's geographical location at the outlet of the west Arabian 'incense route' to the Mediterranean port of Gaza has been used to support this hypothesis based on the assumption that the main trade item was incense (Eph'al 1982; Finkelstein 1992a). However, the search for an explanation of Edomite state origins has occurred within an archaeological vacuum clouded by reliance on biblical sources. While Bienkowski (1992) alludes to the resumption of mining activities in Faynān as contributing to improve economic circumstances in the region, the lack of hard archaeological data has precluded an examination of the role metallurgy played in this process. Recent excavations in Wādī Fīdān at Wadi Fidan 40 by Levy and Adams (Levy *et al.* 1999a) of an Iron Age cemetery with thousands of burial monuments provide the first large archaeological sample to evaluate this problem. Amongst other questions, these data and new information from the Iron Age excavations at Khirbat an-Naḥās (خربة النحاس) metal production center will be used to assess: a) the role of nomadic populations in the evolution of the Edomite state, b) the structure of local versus outside control of metallurgy, c) trade in metal with other Iron Age polities, and d) how the local social structure changed when the area came under the control of the expanding Neo-Assyrian empire/core civilization in the eighth–seventh centuries BC (Millard 1992).

Key Dimensions of Core-Periphery Relations and Test Implications

The requirement of brevity necessitates that only a broad outline is presented of the key dimensions of core-periphery relations to be investigated in this project. Core-periphery interaction opens socio-economic explanations of cultural evolution beyond the local level. Dissatisfaction with neo-evolutionary explanations which often put ecological factors to the exclusion or near-exclusion of variables linked to pan-regional interaction help explain the burgeoning growth of core-periphery studies in archaeology (cf. Chase-Dunn and Hall 1991; Frank and Gills 1996; Kohl 1989; Rowlands *et al.* 1987; Schortman and Urban 1994; Wallerstein 1974). As Kohl (1989:218) points out:

> "the development or cultural evolution of any society is dependent upon its relations with other societies; that cultures are open, not closed, systems; and that studies – be they based on excavations of a site or settlement data from surveys of precisely defined, well-demarcated, but bounded areas - that fail to consider broader patterns of interaction are necessarily incomplete and partial."

It is within this context, that the 'deep-time' investigation of social archaeology and early metallurgy in the Jabal Ḥamrat Fīdān is cast. Central to an analysis of core-periphery relations is the identification of shifting patterns of asymmetric interaction. As Yoffee (1998) points out, scholars cannot assume a teleological step-like pattern of unilineal social evolution from simple hunting and gathering bands to archaic states. Social evolution, as Flannery suggests (1995), refers to the reorganization of society at a different level of complexity and not all societies passed through the same evolutionary sequence of growth, stability, and collapse. To achieve a more robust understanding of late prehistoric and early historic social evolution in southern Jordan which goes beyond neo-evolutionary studies, two frameworks of investigation will be utilized: 1) local adaptation models which seek to explain subsistence and settlement strategies against shifting paleoenvironments through time in the Jabal Ḥamrat Fīdān (cf. Henry 1995) and 2) changing core-periphery relations which can be identified by comparing archaeometric, biological anthropologic, and other diachronic data sets from Jabal Ḥamrat Fīdān with other regions in the Levant and greater Near East.

At certain points in time, settlement in the Faynān district formed an integral part of local complex social systems, such as the Iron Age Edomite kingdom and perhaps as early as the EB I (see below). However, the degree to which core civilization hegemony played in the region during the Bronze Age is open to debate. It is ironic that to date, the role of metallurgy in the formation, maintenance and collapse of the Edomite kingdom has not been investigated (cf. Bartlett 1989, 1992; Bienkowski 1992b; LaBianca and Younker 1998). The rich potential of the Wadi Fidan 4 Cemetery and Khirbat an-Naḥās for answering this question is outlined.

How was trade and exchange of ores and metal organized through time? There are two main possibilities that focus on *local vs. foreign* control of resource extraction and metal production. These are not mutually exclusive and could change through time. While difficult to outline all of the issues to be examined in the study area for center-periphery relations from the Neolithic to Iron Age, the following are a sample of test implications to be examined in this project:

Selected Test Implications for Neolithic PPNB Interaction Sphere: Ores and Related Products

i) Intra-site spatial analysis of study area sites would help differentiate outside vs. local preparation of ores, beads and related materials for export.
ii) Quantitative studies of ore retrieved from the study area excavations could help determine abundance of this commodity relative to other PPNB sites resulting in the production of fall-off curves to test for down-the-line and other trade models.
iii) Evidence for local central-place redistribution of ores to the PPNB interaction sphere can be tested by comparing assemblages from the study area with other Faynān district PPNB sites (cf. the Ghuwayr site).

Post-Neolithic Test Implications for Foreign Core Dominance

i) There should be evidence of formal socio-economic links between the center and periphery that indicate the integration of the resource rich Faynān district into the expanding economy of core civilizations/powers through time. This can be identified through the discovery and analysis of epigraphic data such as stamp impressions, potter's marks, inscriptions, standardized trade items such as ingots and other artifacts.
ii) The presence of officials or representatives of core civilizations could be recognized in the archaeological record through the presence of symbols of rank and power in the Jabal Ḥamrat Fīdān region.
iii) There should be evidence of a well-established core civilization administrative hierarchy reflected in the social organization of settlements in the southern Levant. One data source would be the analysis of human remains found in burial contexts in the study area. For example, what can ancient DNA tells us about social relations between Edomites (Bienkowski 1992b; Smith 1998), Israelite, and other communities which existed in the Late Iron Age southern Levant?
iv) An imposed colony could be evidenced by monumental or administrative architecture imposed on the local landscape by core civilizations. Support for this implication, if applicable, could be found in core-style tombs, architecture, and other built structures.
v) A formal colonial presence would be evidenced by the establishment of core settlements such as trading posts or administrative centers along trade routes and near resource concentrations in the study area.
vi) There should be evidence of differences in agro-pastoral production strategies between the resource concentration zone and other settlement areas of the southern Levant indicating shifting patterns of economic specialization. Identifying the shifting role of pastoral societies (Henry 1992; Khazanov 1994; Zeder 1991) in the study area through time should shed light on this implication.
vii) Local elites in the Jabal Ḥamrat Fīdān should emulate core ideological systems through the acquisition of prestige objects from the core.
viii) Core dominance of trade and exchange should be evidenced through the establishment of core administrative systems in the study area. This would be evidenced through petrographic studies of pottery, seal impressions, metal and stone objects to identify patterns of exchange between regions.
ix) "Colonists" whether they be Early Bronze (EB) Canaanites from Palestine, EB Egyptians, or Iron Age Neo-Assyrians should reside in the study area. Domestic spatial patterns of consumption, discard, food preparation, the use of living space would evidence this, which differ from local patterns, and ancient DNA studies.
x) There should be evidence of increasing social complexity as a direct result of contact with core civilizations.
xi) Although not a necessary condition for core dominance of the resource zone, there could be evidence of military conquest or control in the study area.

Post-Neolithic Test Implications for Local Autonomy (cf. Stein 1998)

i) Local Jabal Ḥamrat Fīdān economy should be geared toward a general subsistence base with little evidence of specialization and little trade.
ii) Local elites should emulate core ideology but display evidence of their independence.
iii) Evidence for change in social complexity should not display rapid or "punctuated"

abrupt changes in the local archaeological sequence in the periphery.

iv) Exchange between center and periphery should be of low volume. The only core civilization exchange goods should be those with high ratios of value to weight (or bulk; e.g. Stein 1998).

v) There should be symmetry in exchange relations with no evidence of core domination.

vi) In the periphery societies, there should be no major changes in the intensity of production in agropastoral or craft specialization (Levy 1992).

Research Area: Environment, History of Research and Major Sites to be Excavated (1999-2000)

The Jabal Ḥamrat Fīdān Research Area (Area = 240km²)

The study area (**Fig. 1**) is located southeast of the Dead Sea and forms part of the territory known since biblical times as 'Edom'. The name 'Edom' is derived from a Semitic root meaning 'red' after the local red Nubian sandstone (Bartlett 1992). The Jabal Ḥamrat Fīdān is an igneous granite rocky ridge running 8km NE/SW which rises some 150 meters above the Wādī 'Arabah floor, around 15km east of the Jordan–Israel border (Rabb'a 1994). This ridge, along with Jabal al-Minshār (جبل المنشار) to the north, blocks the entrance to the Faynān region. A portion of Wādī al-Ghuwayb (وادي الغويب) is also included in the study area. The vegetation of this desert environment is characterized as Saharo-Sindian with isolated pockets of Sudano-Deccan (Horowitz 1979; Zohary 1962). Average annual rainfall is 70.7mm. A perennial stream flows from the 'Ayn al-Fīdān spring in the center of the study area westward to the Wādī 'Arabah. Sudanian tree species such as *Acacia raddiana, Acacia tortilis, Ziziphus spin-christi* and others are common (Danin 1998: 35). A GIS study of the area is planned for the near future to delineate archaeological sampling zones in a more accurate fashion. The following briefly summarizes the general geomorphologic breakdown of the area into relevant sampling strata. It highlights where survey and excavation work has taken place and is planned in the near future (see **Fig. 1**).

A. Prime Study Area Survey Stratum

Approximately 84 square kilometers (35% of research area). Composed largely of an alluviated plain between the eastern edge of the Jordan Graben and the Jabal Ḥamrat Fīdān. This area has been heavily alluviated in the later phases of the Holocene (i.e. the pottery Neolithic tall of Tall Wādī Faynān up-stream from the research area has ca. 2-4 meters of alluvial deposit over it; see **Table 1** below for radiocarbon dates), and is in the process of being cut down again by new wadi channels. The area is covered in its eastern edges by large alluvial fans, and approximately 30% of the entire area is covered or partially covered by active dune systems. Also included in this stratum are the scattered and dissected wadi terraces along the main wadi drainages east of the Jabal Ḥamrat Fīdān. The major sites to be excavated are located here and the project geomorphologist will study all wadi profiles.

B. Secondary Study Area Survey Stratum.

Circa 60 square kilometers (25% of research area), this stratum consists of the flat alluvial plain to the west of Jabal Ḥamrat Fīdān. This area is more disturbed in parts by recent activities, such as road building and quarrying, but areas along the wadi systems are likely to produce useful survey. Recent wadis also now dissect many parts of this 'plain'.

B2. Secondary Study Area Survey Stratum

Approximately 60 square kilometers (25% of research area). Mountainous or steppic areas along the sides of the various *Jibāl*, Jordan Graben, and higher terraces. Long term prospects are good here, and have already produced most of the mining and major smelting sites (Hauptmann 1989a; 1989b; 2000).

C. Tertiary Study Area Survey Stratum.

Circa 36 square kilometers (15% of research area). Primarily wadi bottoms, and secondary drainages. The project geomorphologist will study wadi profiles in these areas.

History of Research

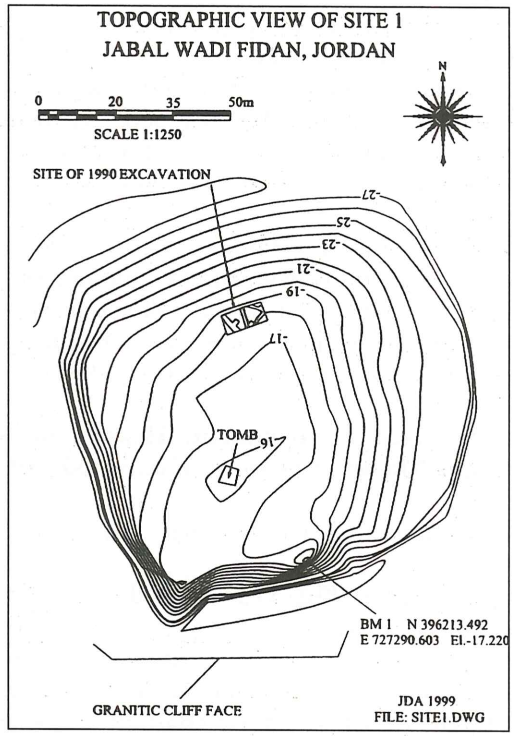
Since the late 19th century, a limited amount of exploration and archaeological research has been carried out in the Jabal Ḥamrat Fīdān (Frank 1934; Glueck 1935; 1937; Kitchener 1884; Musil 1907). The major sites in the study area were identified in unsystematic surveys by T. Raikes (1980; 1985) and visited by other scholars (MacDonald 1992). Similar selective surveys and test excavations aimed at archaeometallurgical issues were made by the German Mining Museum (Hauptmann 1986; Keesmann *et al.* 1984; Hauptmann *et al.* 1985; Hauptmann and Weisgerber 1987) in the 1980s in the Faynān district that includes our research area. This 10 year research program produced new and significant information concerning the history of metal working, mining, and smelting in this part of the Levant. R. Adams (1998) carried out test excavations at the major sites to be investigated and Adams and H. Genz (1995) at the Early Bronze I village site of Wadi Fidan 4. In 1997, T. Levy and Adams (Levy, Adams and Najjar 1999) carried out the first large-scale excavations in the region at Early Bronze and Iron Age sites. Over the past four years, the Faynān district has been the focus of renewed interest for paleoenvirnonmental, economic and culture historical research by several British teams (Barker *et al.* 1997; 1998; Finlayson and Mithen 1998; Freeman and McEwan 1998; Findlater *et al.* 1998; Wright *et al.* 1998). A. Simmons and M. Najjar (1997) have initiated major early Neolithic research at al-Ghuwayr (الغوير), ca. 15km up-stream from contemporary sites in our research area.

Major Sites to be Excavated

Unlike the center of settlement in the Faynān district (the Wādī Faynān) where intense occupation has created complex, disturbed multi-layer stratigraphy, the sites in the Jabal Ḥamrat Fīdān are mostly represented by single periods with easily accessible shallow archaeological horizons. These factors will insure success in making broad horizontal exposures and retrieving the interdisciplinary data needed to test the diachronic models outlined above. At present, there is no need to excavate EB I deposits given the large sample of material obtained in 1997 (Levy, Adams and Najjar 1999). Perceived occupation gaps such as the Middle Bronze Age and other periods will hopefully be filled with data from the planned systematic surveys. To help plan the excavation sampling strategy for selected sites in the study area, geophysical surveys play an integral role in the JHF research design. The 1997 geophysical results are described for Wadi Fidan 1, 4 and 120 below. In 1999, additional geophysical surveys will be carried out at WF 51 and Khirbat an-Naḥās to help establish sampling strategies at those sites. The following is a description of the major sites to be investigated in the 1999–2000 Phase I investigation in the JHF.

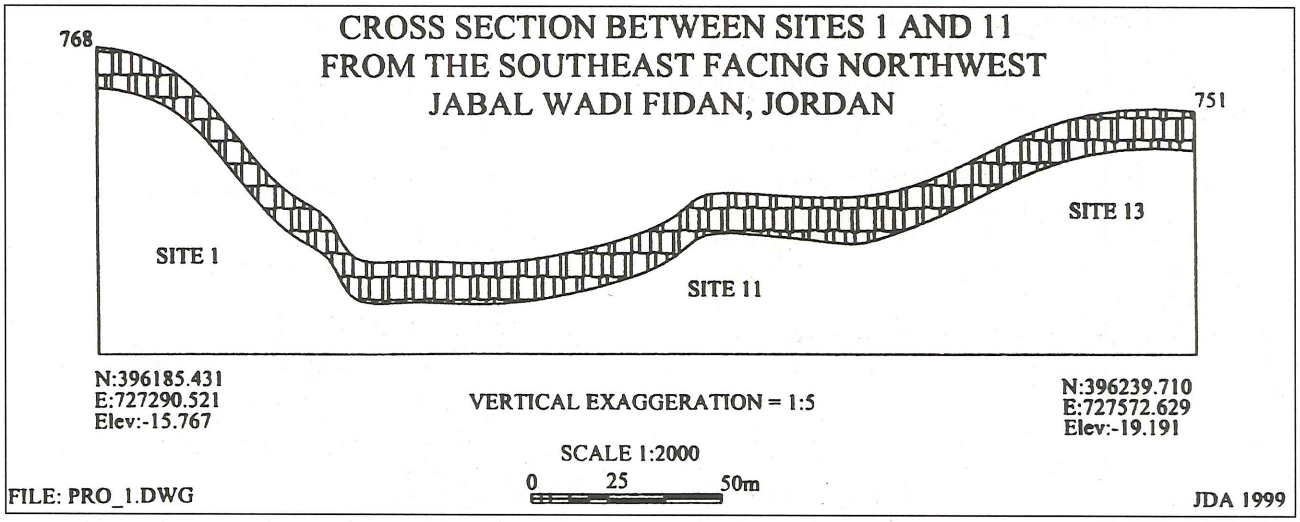
Pre-Pottery Neolithic

WF 1 – Wadi Fidan A. The site lies at the mouth of Wādī Fīdān, and at the extreme western end of the Faynān drainage system, where it empties into the broad plain of Wādī 'Arabah (**Figs. 1, 2**). Following initial survey of the site by Raikes, it was also investigated by both the Deutsches Bergbau Museum and by MacDonald (MacDonald 1992; Neeley 1989; 1992). All of these surveys noted the



2. *Topographic map of WFD 001, PPNB site, JHF Research Area.*

presence of surface architecture, extensive flint scatters, and suggested a dating of the site to the Pre-Pottery Neolithic. Two small trial trenches by Adams revealed extremely well preserved stone wall architecture on the site, many of them still standing to ca. two meters in height, as well as extensive and well preserved fauna and archaeobotanical samples (Richardson 1992; Colledge 1994). The stone built architecture is typical for the late Pre-Pottery Neolithic and the primary structure excavated had a well preserved plaster floor, evidence of red painted plaster walls, and a stone built oven set against one wall. The site was dated by means of both flint typology (Byblos points) and radiocarbon dating (ca. 7575–6700 cal. BC, see **Table 1**), both of which indicate a date within the Pre-Pottery Neolithic B. Excavations at PPNB Site A (now called WFD 001) were carried out in 1999 and focused on its role in the exchange of copper ores which have their origin in Faynān and have been found at contemporary sites all over the southern Levant (cf. Bar-Yosef and Belfer-Cohen 1989; Bar-Yosef and Alon 1988; Garfinkel 1987; Levy, Adams and Najjar 1999; Rollefson *et al.* 1992). The 1998 JHF site survey identified what seems to be an extension of WF 1 to the northeast of the site across the wadi. This site was labeled WFD 11 and its relation to WFD 001 is shown in cross-section (**Fig. 3**). If this is part of WF 001, it indicates the intensity of post-PPN ero-

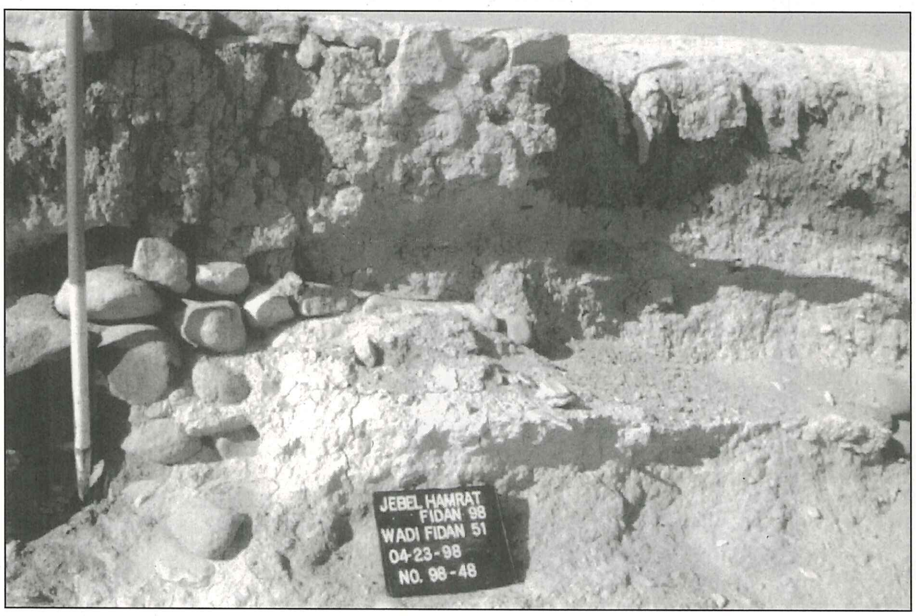


3. Cross-section of WFD 001, WFD 11 along Wādī Fīdān.

sion in this part of the wadi and the likelihood that WF 1 was a much larger settlement in the PPN than originally assumed. Geophysical surveys in 1997 (see below) indicate extensive building structures at this site and have helped identify where future work will take place. Using the full range of data from both Sites A and C, research will focus on exchange models aimed at reconstructing dimensions of the Levantine 'PPNB' interaction sphere (Bar-Yosef and Belfer-Cohen 1989) and other interaction and subsistence models.

Chalcolithic

WF 51. Archaeometallurgical research over the past two decades have shown conclusively that the majority of copper ore found at northern Negev Chalcolithic sites comes from the Faynān district (Hauptmann 1989a; Shalev and Northover 1987). Given the extensive evidence for Chalcolithic metal production in the Negev including ores, crucibles, prills, metal finds, etc., it is ironic that in the Faynān source area for copper ore, no definitive Chalcolithic sites had been found in the region until recently. The 1998 survey in the Jabal Ḥamrat Fīdān has helped to close this lacuna through the discovery of site WF 51, the first early Chalcolithic settlement in the Faynān district (**Figs. 1, 4**) that may have some affinities with Tall Wādī Faynān excavated by Najjar *et al.* (1990). The site is situated on the south bank of Wādī Fīdān where it empties into Wādī Arabah. Remains of Chalcolithic pottery, flint, and architecture extend over an area of ca. 1.55ha. The ceramics and lithics found on the site surface are remarkably close in stylistic

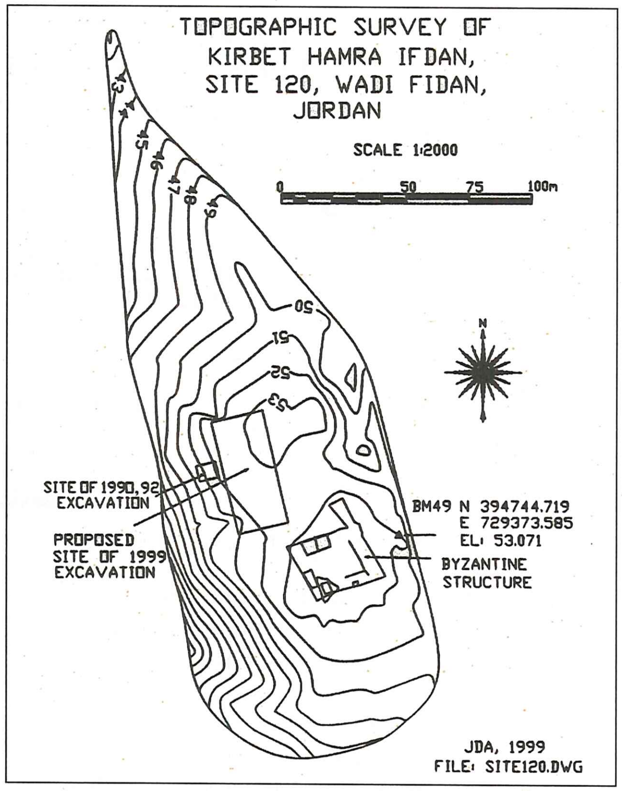


4. Photograph of WFD 51, a Chalcolithic settlement site. Note wall feature in section.

affinity to artifacts found at Gilat in the northern Negev desert (Alon and Levy, in press) (**Fig. 5**). Site 51 provides important data for testing models concerning the control of the Levantine copper trade (cf. Levy 1998) during the Chalcolithic period. To facilitate the archaeological sampling of the site a geophysical survey was carried out in 1999 (Herbst 1999). Given the radiocarbon date for the site (**Table 1**), the affinities of the material to both Gilat and Tall Wādī Faynān, we have tentatively ascribed it to the early Chalcolithic period.

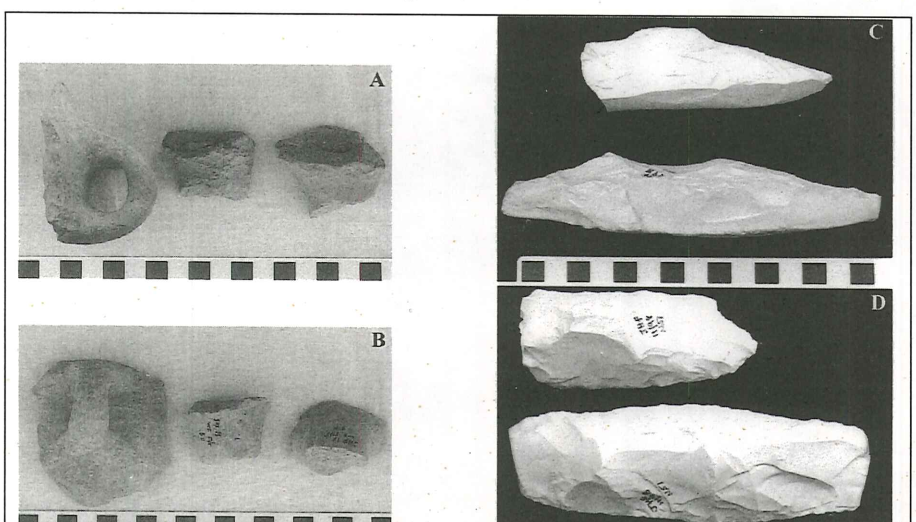
Early Bronze II–IV

WF 120 – Khirbat Ḥamrat Ifdān/ Fīdān (خربة حمرة إفدان/فيدان). The site of Khirbat Ḥamrat Ifdān lies in the center of Wādī Fīdān, near the spring of ʻAyn al-Fīdān (Adams 1992; 1999) (**Figs. 1, 6**) and will form the major focus of the 1999–2000 excavations. This ca. 3.25-hectare island in the middle of the wadi lies approximately twenty meters above the current wadi bed, on the top of a Pleistocene conglomerate inselberg. Two small trial trenches (Adams 1999) on the slope indicate the presence of rich archaeological Early Bronze II–IV deposits reaching a depth of up to 3m. These soundings and 1997 geophysical survey indicate that throughout its history the site was primarily a metallurgical processing site related to the copper industry. The upper phases of the excavation revealed a well-preserved two-room structure; radiocarbon dated to the last half of the third millennium BC, or the closing phases of the EB III (**Table 1**). The material culture of the site is dominated by finds related to the smelting and fabrication of copper. A major corpus of casting molds were found here (Adams 1999) which have links with a series of copper ʻingots' from EB IV sites in the Negev and Northern



6. Topographic map of WFD 120 (Khirbat Ḥamrat Ifdān) illustrating 1990, 1992 probe and 1999 excavation area.

Sinai. This close connection between western Palestine and the later EB Age sites of the Faynān area has also recently been supported by an extensive petrographic study. Geophysical surveys in 1997 point to a plethora of building structures and extensive sheets of what appear to be subsurface slag spills (see below). Large-scale excavations will provide key data on the procurement, control, organization, production and exchange of metal during the first periods of urbanism and early ʻin-



5. A & B: Detail of Chalcolithic churn handle and other pottery sherds from WFD 51; C & D: Cross-section and plan view of bifacial tools found at WFD 51.

Table 1: Radiocarbon determinations for Research and Adjacent Area. All calibrations are Stuiver and Reimer 1993, Calib Program REV 3.03. All samples, with the exception of Wadi Fidan 4 Cemetery (pomegranate seeds), are from charcoal.

Lab Number	Period	Site and Context	14C date BP	14C dates cal. BC cal. 1 sigma
HD 13777	PPNB	Wadi Fidan A, Wadi cut 3/1	8220±117	7420-7035
HD 13530	PPNB	Wadi Fidan A, Square 6, Locus 11	8272±354	7575-6700
HD 12335	PN	T. Wādī Faynān, W. Profile, -2.5m	6370±42	5330-5265
HD 10576	PN	T. Wādī Faynān, W. Profile, -4 m	6408±114	5430-5250
Beta 118580	PN/Ch	WF 51, L. 106	6260±40	5250-5210
HD 12338	PN	T. Wādī Faynān, Sq. Fa II, -0.2 m	6150±68	5195-4930
HD 13775	PN	T. Wādī Faynān, Sq. B2, L. 6, -0.8m	6132±50	5195-4940
HD 12337	PN	T. Wādī Faynān, Sq.A, L.23, -1.4m	5740±35	4675-4575
HD 16376	EB I	Wadi Fidan 4, Area A, Context 50	4684±50	3610-3365
HD 16378	EB I	Wadi Fidan 4, Area A, Context 22	4422±50	3255-2925
HD 16379	EB I	Wadi Fidan 4, Area A, Context 5	4576±45	3365-3140
HD 16380	EB I	Wadi Fidan 4, Area D, Context 14	4702±35	3615-3375
HD 16327	EB I	Wadi Fidan 4, Area D, Context 9	4718±25	3615-3380
HD 13975	EB II	Barqa al-Ḥaṭiya, House 1, Locus 13	4376±57	3080-2910
HD 13976	EB II	Barqa al-Ḥaṭiya, House 1, Locus 3	4267±43	2910-2875
HD 16533	EB III	Khirbat Ḥamrat Ifdān, Tr. 1, Locus 114	4044±40	2585-2490
HD 16534	EB III	Khirbat Ḥamrat Ifdān, Tr. 2, Locus 209	3914±45	2460-2320
HD 10577	EB II-III	Faynan 9 (smelting ovens, slag heap -0.3 m)	4140±109	2880-2500
HD 10993	EB III	Faynan 9 (EB III smelting ovens 7 and 8)	3981±50	2560-2455
HD 10994	EB III	Faynan 9 (EB III smelting oven 25)	3973±85	2575-2345
HD 10548	EB IV	Faynan 9 (EB III smelting oven 24)	3812±77	2395-2135
HD 13978	Iron II	Khirbat an-Naḥās, House 1	2704±52	900-805
Beta-111366	Iron II	Wadi Fidan 40, Cemetery, Grave 92	2800±70	1015-845

dustrialization' in the Levant. This will contribute to wider issues of center-periphery relations during the Early Bronze Age. For example, Ilan and Sabanne (1989) suggest the origin of EB urbanism in the Negev region of the Levant be explained by the emergence of urban Arad as the controlling center of the metal trade at this time. Excavations at Khirbat Ḥamrat Ifdān, located in the main ore resource zone, will test this and other hypotheses for the late Early Bronze Levantine temporal sequence. Recent excavations at KHI have shown it to be the largest EB III metal production site in the ancient Near East (Levy, Adams and Najjar 1999).

Iron Age

Khirbat an-Naḥās (خـربة النحـاس). The name of the site literally means 'ruins of copper', and indicates both the size and importance of this site for understanding the history of copper metallurgy in the southern Levant. The site lies in the upper (eastern) reaches of the Wādī al-Ghuwayb, on a large terrace on the south bank of the wadi, and is approximately 10 hectares in size, making it one of the largest pre-industrial copper working sites in the Near East (Glueck 1935) (**Fig. 1**). Several teams have periodically surveyed the site in the past, which show the main periods are from the Iron Age and Roman/Byzantine period. Hauptmann has calculated approximately 200,000 tons of copper slags (yield = 20,000 tons of copper) in the Faynān district dating to these two periods alone, and much of it comes from Khirbat an-Naḥās.

Recent research by the German Mining Museum has largely concentrated upon exploration of the mines, slag heaps and smelting installations, through small soundings, and surface collection. The site was the focus of extensive work on calculating fuel resources in ancient smelting, which combined radiometric dating of slag heaps, characterization of slag contents (Hauptmann 1989a; 1989b), and a program of plant physiology aimed at determining species used for fuel (Engel 1993; Engel and Frey 1996). The only stratigraphic excavation on occupation portions of the site were conducted in 1990 by the Germans under the direction of V. Fritz (1996) who dug one late Iron Age structure at this large industrial site. This produced a useful ceramic corpus and a single radiometric date (**Table 1**) pointing to the rich potential for further horizontal exposure of the site. The radiometric date from the site places the building complexes in the Iron II period (cal. BC 900 - 805) and roughly contemporary with the recently excavated Iron Age cemetery by Levy, Adams and Shafiq (1999) (**Table 1**) at Wadi Fidan 40, located ca. 4.5km southwest of Khirbat an-Naḥās (**Fig. 1**). This industrial production center will provide a key for examining Edomite state formation, shifting center-periphery relations between Edom and other Iron Age polities in the Near East and other issues.

Geophysical Survey (1997)

There were several factors that influenced the selection of specific geophysical techniques implemented in the Jabal Ḥamrat Fīdān. Foremost among these were the known subsurface features of archaeological interest, a lack of *a priori* information about the geological characteristics of the sites, and time constraints for completion of the geophysical surveys. While there are many possible techniques that can be applied, each class of techniques will exploit certain differences between the physical properties of buried features and their surroundings. When such differences are large, geophysical methods that exploit those properties can be expected to perform well; however, when these differences are small, these methods will likely fail. While it may appear to be a rather straightforward exercise to execute these evaluations once features of interest have been identified, this is rarely the case. For example, metal detectors are tools of choice for treasure hunters because this type of tool responds to changes in electrical conductivity. Since coins, a primary target of treasure hunters, have a much higher electrical conductivity than soil, the existence and location of shallow buried metal is usually unequivocal in metal detection. One of the primary targets of interest in the Jabal Ḥamrat Fīdān was buried stone walls. While metal detectors are too insensitive to detect buried walls, these walls may exhibit a difference in electrical conductivity with respect to the host soil that can be exploited by more sophisticated geophysical techniques. If the buried walls consist of stones that are rich in a metal ore, then the walls will be manifested as a relative high in electrical conductivity. In contrast, if the walls are composed of low electrical conductivity rock, such as limestone, sandstone or granite; and the electrical conductivity of the soil is elevated by moisture, the walls may occur as electrical conductivity lows. A third and more likely option in the Jabal Ḥamrat Fīdān is that there will be no difference in electrical conductivity between the stones and the soil. The supporting arguments for this option are that: 1) this is an arid region so that the electrical conductivity of the soil is not elevated by moisture and 2) the stones are likely native meaning that the soil surrounding the stone walls originated as native rock and consequently the stone and dry soil are electrically identical.

Three types of geophysical measurements were performed in the Wādī Fīdān. These include: magnetometry, ground penetrating radar, and electromagnetic induction (EMI). These were selected from the suite of possible geophysical methods because the instruments are relatively compact and easily transported, provide rapid spatial coverage, and all had some previous success at locating the targets of interest at Wādī Fīdān. Along with the above cited objective of locating buried stone walls, a secondary objective was the location of ore bodies that were potential copper sources associated with metal working activities at the Wādī Fīdān sites. It was this second objective that motivated the selection of the EMI tool. Historically, these tools have been used in exploration for ore and, more recently, have been modified for use in problems related to environment management and locating buried utilities. Like the previous metal detection example, EMI responds to local variations in the electrical conductivity and, as such, can be used for the detection of ore bodies as well as buried metal objects and ground water plumes having a high ionic content. EMI methods have never been used for locating buried stone walls and, based on arguments given above, they were considered to be a long shot, at best, for this purpose in the Jabal Ḥamrat Fīdān. Time constraint prevented the application of geophysics at candidate ore body sites and all efforts were dedicated to the detection and location of buried stone walls. For a variety of reasons magnetometry and ground penetrating radar failed to delineate any subsurface rectilinear features suggestive of these targets. Surprisingly, EMI proved quite successful in this application.

The EMI tool used at Wādī Fīdān is the GEM-2 (Won *et al.* 1996). This tool is lightweight and looks like a two-meter long ski with an onboard data logger. The standard means of data acquisition is to establish boundaries of a study region and then walk with the tool along closely spaced parallel lines over the entire specified region. Data are acquired at fixed time intervals, typically within the range of five to ten samples per second, as the tool is transported over the site. This procedure provides a quite high spatial data density at nearly regular spacing over the ground surface. The data acquisition rate is far too high to allow the operator to review the data as it is acquired so that it is stored on the onboard data logger for subsequent transfer and display on a personal computer. Once displayed, interpretation is generally quite simple by visual inspection. For example consider a spherical conducting object buried somewhere in a homogenous low electrical conductivity medium. The display of the GEM-2 data is basically some form of a two-dimensional (horizontal) distribution of the subsurface electrical conductivity. In such a display, the buried spherical conductor will appear as 'bulls eye' pattern in the data display with the center of the bull's eye occurring directly above the spherical conductor.

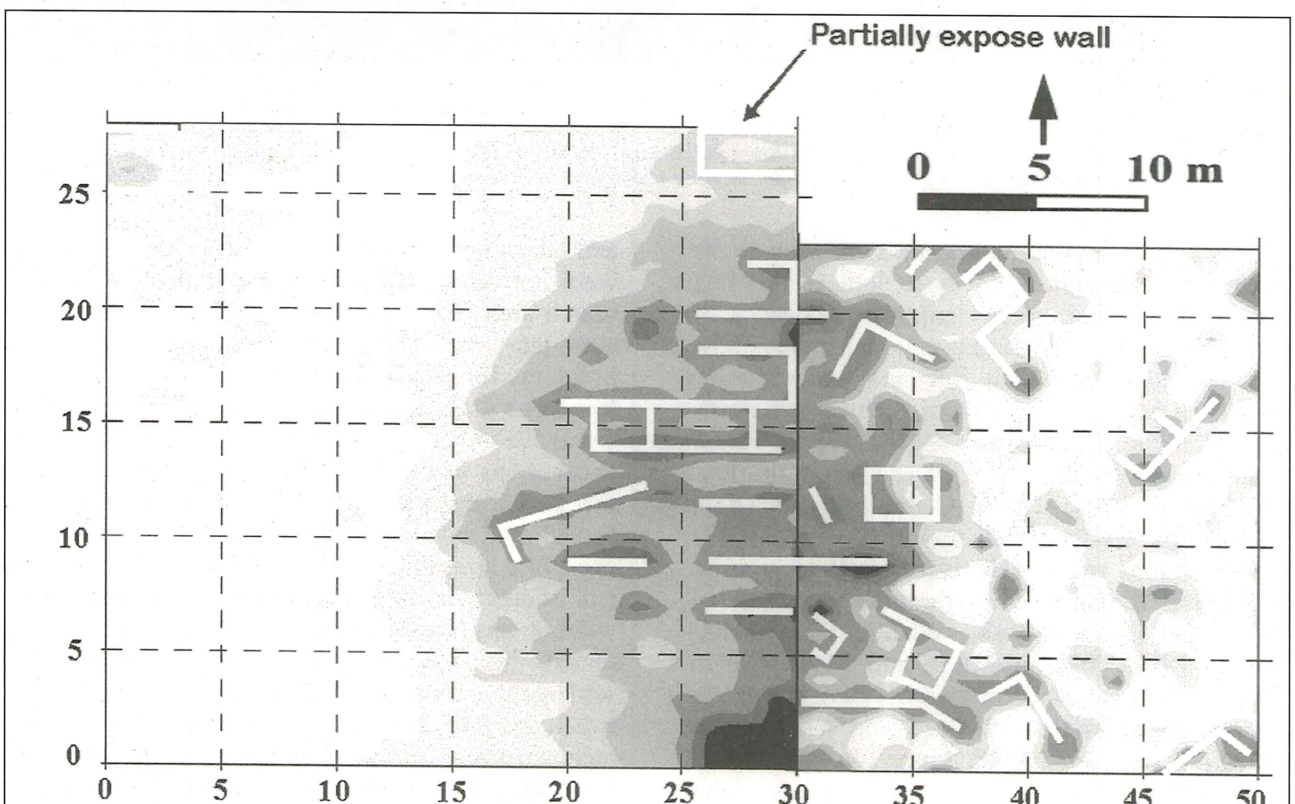
The GEM-2 tool can be operated over a range of user-specified frequencies. The lower the operating frequency the greater the depth of penetration and the lower the horizontal spatial resolution. The actual output from the tool is a depth-weighted average of the subsurface electrical conductivity over the depth of penetration. Consequently, low operating frequencies provide information over a greater depth; however, the strongest response will come from features occupying a relatively large fraction of this depth. Conversely, higher operating frequencies provide better resolution of shallow lateral variations in electrical conductivity but little or no information about deeper features.

GEM-2 EMI data were acquired at two frequencies, 2430 and 9210kHz, at the three Wādī Fīdān sites that were sampled. Parallel lines were established every meter in one direction and data were acquired by walking with the GEM-2 along each of these lines. Data logging was automatically performed at fixed time intervals and, for the specified temporal sampling and walking rate, measurements were made at a spacing of about 35cm in the walking direction. Thus, EMI measurements were made over horizontal measurement cells dimensioned 1m by 35cm. The GEM-2 data acquired at 2430kHz only revealed only one linear feature having a relatively low conductivity indicative of a buried stone wall at one site (Wadi Fidan 4). At this frequency, the penetration depth was too great to provide the resolution needed to delineate such shallow features. In fact, if the conductivity low evident in this data is a buried wall; it is likely to be quite massive.

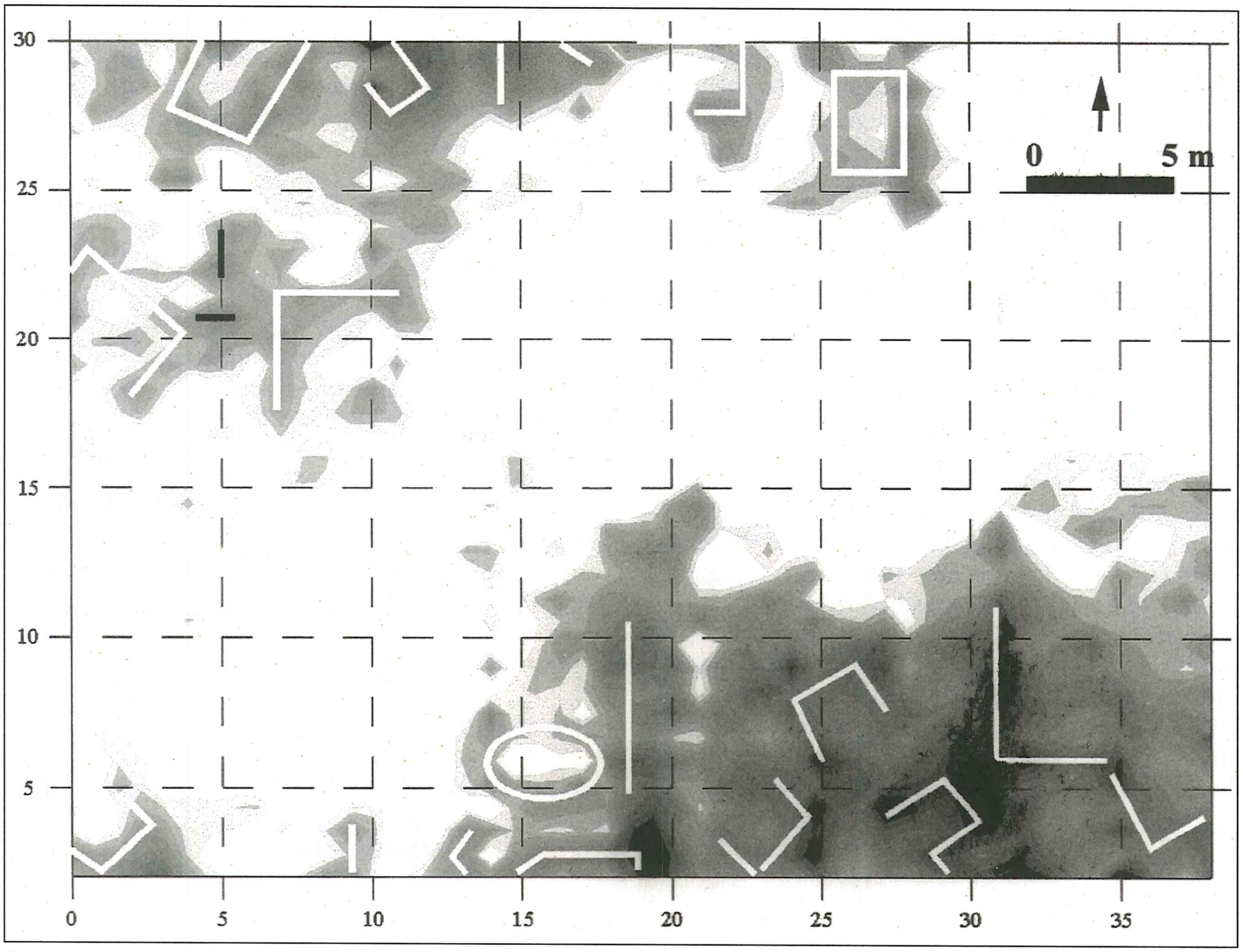
Data acquired at 9210kHz revealed a pattern of linear and rectilinear features indicative of buried stone walls at Wadi Fidan A (WFD 001), Wadi Fidan 4, and KHI (WFD 120) sites respectively. At the WFD 001 site, there exists a partially exposed stone wall and the 9210kHz data revealed a relative low suggesting the continuation of these walls into an undisturbed area (**Fig. 7**). At the Wadi Fidan 4 (WFD 4; **Fig. 8**) and Khirbat Ḥamrat Ifdān (WF 120; **Fig. 9**) sites, several stone walls had their tops flush with the ground surface. All of these appeared in the 9210kHz EMI data providing further evidence that the pattern of EMI responses are indeed buried stone walls. The geophysical maps illustrated in **Figs. 7, 8, and 9** indicate the layout of the unexcavated walls at the sites discussed here.

Archaeological Survey (1998)

An integral part of the JHF project is to reconstruct the social landscape in which early met-

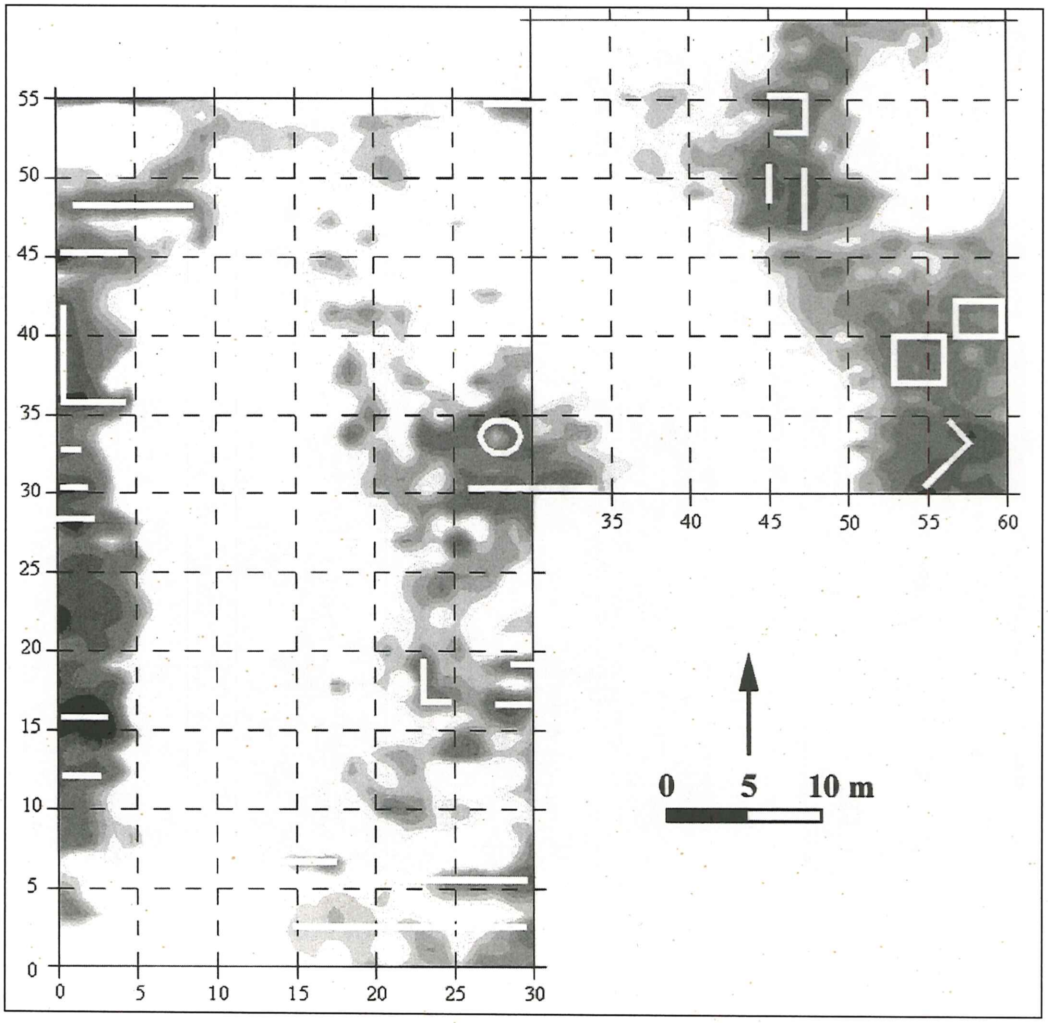


7. EMI (Electro Magnetic Induction) data acquired at the WFD 001 site rendered as gray levels. The buried stone walls appear as relative lows and are rendered in black and shades of gray. The superimposed white lines are the interpreted location of walls. All dimensions are in meters.



8. *EMI data acquired at the Wadi Fidan 4 (WFD 4) site rendered as gray levels. The buried stone walls appear as relative lows and are rendered in black and shades of gray. The superimposed white lines are the interpreted location of walls. All dimensions are in meters.*

allurgy and cultural evolution took place in southern Jordan. The quickest way to achieve this goal is through regional surveys and over the past ca. 30 years, a number of important regional surveys have been carried out in Jordan. Reconnaissance surveys have been made in the southern Aghwār and northeast ʻArabah (MacDonald 1992), Wādī Ziqlāb (Banning and Fawcett 1983), Dead Sea plain (Rast and Schaub 1974; 1980), Central deserts (Betts 1988; Clark 1987), Jarash region (Leonard 1987), Maʻān-ʻAqaba region (Henry *et al.* 1981; Jobling 1981), the Jordan Valley (Ibrahim *et al.* 1976), Wādī ʻIsāl (Jacobs 1983), Wādī al-Ḥasā (MacDonald 1988), Wādī al-Mūjib and Moab (Miller 1988), Arḍ al-Karak (Worschech 1985), the southeast ʻArabah (Smith *et al.* 1997) and Wādī Faynān (Barker *et al.* 1997; 1998; Finlayson and Mithen 1998; Freeman and McEwan 1998). In the Jabal Ḥamrat Fīdān, while scholars such as Musil (1907), Glueck (1935; 1937), MacDonald (1992), Raikes (1980), Hauptmann (1986), Adams (1999) and others have surveyed in the area, these projects were not aimed at systematic coverage of the research area. The lack of systematic settlement pattern data for the JHF created major interpretive problems for our research team in 1997 when the first large scale excavations were carried out at WF 4 and WF 40 (Levy *et al.* 1999). For example, the excavations in the Early Bronze I village at WF 4 revealed a densely packed settlement with widespread evidence of metal working activities. However, like an artifact removed from its archaeological context, in 1997, WF 4 was an isolated site without any local settlement pattern context. To remedy this and clarify the regional dynamics of settlement within the study area and relations between the JHF and the greater Levant, a pedestrian reconnaissance survey was carried out from April 19 to May 1, 1998. Previous Levantine surveys by Levy and Alon (1987) and others show that in the desert zones, agricultural-based settlement usually occurs within 500 meters of seasonal (wadi) drain-

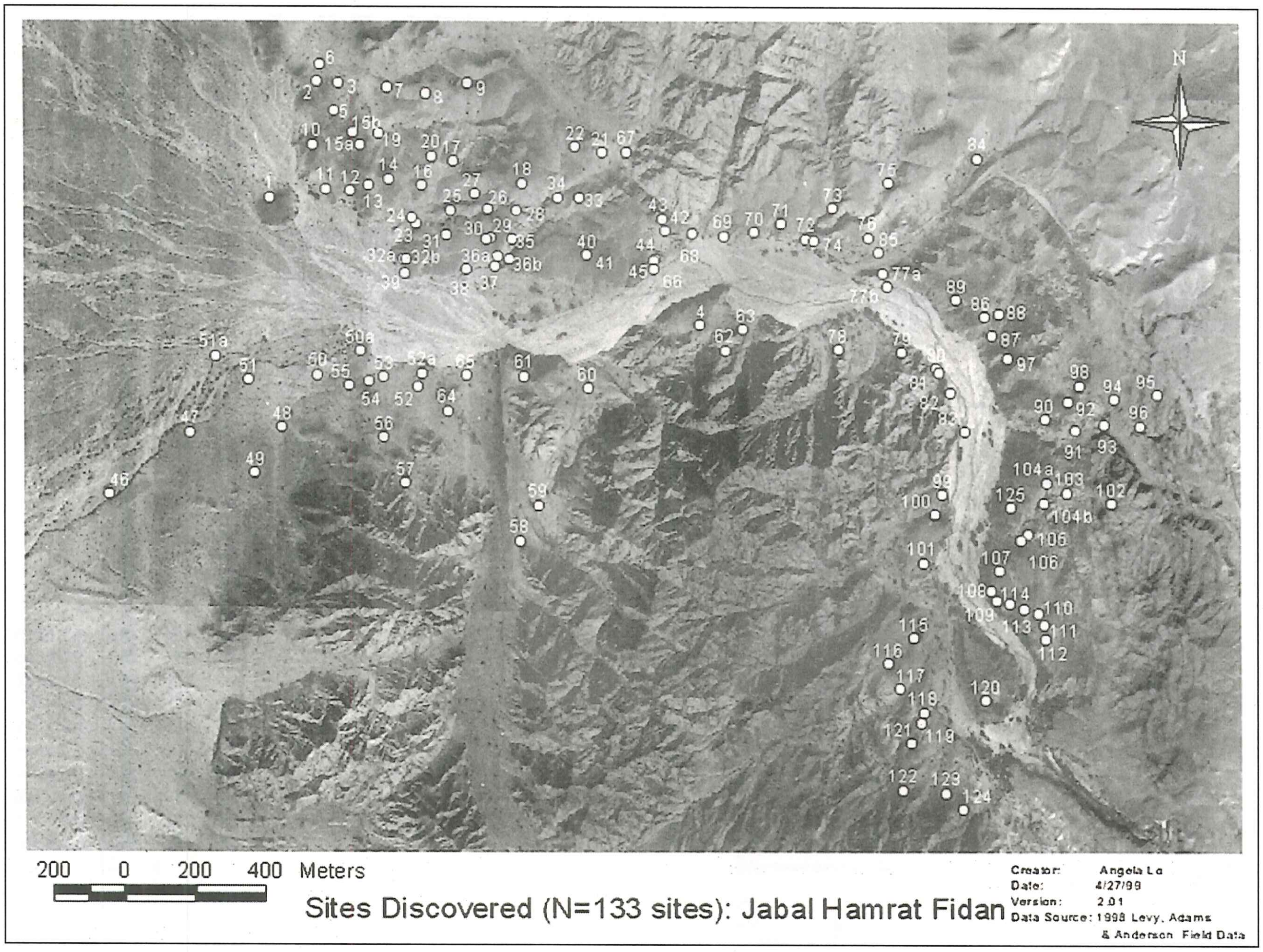


9. *EMI data acquired at the Khirbat Ḥamrat Ifdān (WFD 120) site rendered as gray levels. The buried stone walls appear as relative lows and are rendered in black and shades of gray. The superimposed white lines are the interpreted location of walls. All dimensions are in meters.*

ages. Therefore, it was decided to limit the first JHF season (10 days of field work) to a systematic reconnaissance survey of the Wādī Fīdān drainage system aimed at making a 100% coverage of all those areas located within 500m of the drainage channel over a distance of ca. 10km (**Figs. 1, 10**).

In theory, some kind of random sample-based survey might produce a more representative picture of ancient settlement in the study area. Random sample surveys have been most successfully applied in the Southwestern U.S. (cf. Mueller 1974) where time and money were of less concern than in the Jabal Ḥamrat Fīdān. In the Mediterranean, scholars such as Cherry (1983) succeeded in applying random transects for intensive reconnaissance surveys. As discussed above, the 240km^2 JHF research area was divided into four general sampling strata based on general geological/geomorphological setting. With limited time and funding in 1998, random sampling was viewed as inappropriate for our short-term survey. Given the known character of Levantine arid lands settlement demonstrated for the Negev and other regions outlined above, it was deemed more fruitful to focus our survey on those landscapes in the immediate vicinity of the few known ancient sites identified by earlier researchers. In this way, the survey boundary could realistically be drawn as a 500m length from the right and left banks of the Wādī Fīdān drainage.

To our surprise, the survey area contained many more sites than we anticipated in the planning stage of the fieldwork. A total of 125 sites spanning the Paleolithic through Islamic periods were recorded during the 10-day survey (**Fig. 10; Table 2**). The density of sites (28/km^2) in the relatively small survey area (=4.5km^2) was much higher than anticipated. This resulted in forcing our team to spend considerable time recording these ubiquitous sites. Thus, instead of covering our projected 10km stretch of the Wādī Fīdān, we were only able to survey a 4.5km length in the 10-day period. A site was considered a distinct spatial clustering of artifacts, features, structures, and ecofact remains, as the residue of human activity (Renfrew and Bahn 1996). **Table 2** presents a list of the sites recorded



10. GIS Photo-composite location map of the Jabal Ḥamrat Fīdān, focusing on the Wādī Fīdān with all 125 sites recorded in the 1998 survey.

in the 1998 survey including their identification number, elevation, size, UTM coordinates (Northing and Easting), notes, possible site function, and period. While most were single period sites, approximately 20% had multiple occupations. The histogram (**Fig. 11**) illustrates the distribution of sites by period in the survey area.

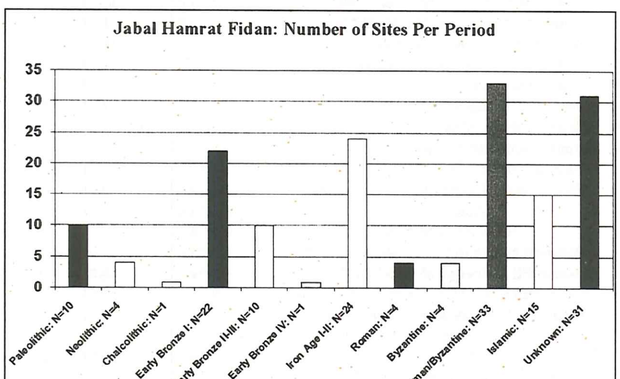
The survey methodology was aimed at making a 100% pedestrian survey of the Wādī Fīdān sample universe (**Fig. 10**). The goal was to identify every site in the area, map the archaeological and topographic features, photograph the sites, collect representative samples of material culture (flint, pottery, metallurgical remains), fill out a Geographic Information System (GIS) form for each site and make descriptive notes. To accomplish this, the field survey team usually consisted of nine individuals: seven field walkers and two EDM (Electronic Distance Measurer) surveyors. The field walkers would spread out in a line placing themselves at 50 meter intervals from each other so that each team member was responsible for a ca. 50m wide transect. The team would then systematically comb the landscape looking for sites until a ca. 500m stretch was investigated. Once a site was located, the entire team would work on recording it. While topographic maps on a scale of 1:50,000 are available for the area, high quality (1:7,000) aerial photographs measuring approximately 1m^2 were used instead. The location of sites and features could be easily plotted by hand on these aerial photographs using a permanent thin-line black marker. The center of the site was flagged with orange plastic tape and its position marked so that the EDM survey team could map the site the following day. While the site was photographed with a SLR and Digital camera, two team members worked on site forms and aerial photos. Other team members would systematically comb the site looking for datable artifacts and metallurgical remains placing the material in labeled plastic bags. A logbook was kept listing each site with notes on size, photograph number, and notes. A rotation system was enacted so that a field walker from one day of

Table 2: *Site survey data from the Jabal Ḥamrat Fīdān Survey, 1998.*

ID	ELEVATION	HECTARES	NORTHING	EASTING	NOTES	FUNCTION	PERIOD
1	-14.6	0.05000	396160.0	727310.0	Island in mouth of western W. Fidan	settlement	Neolithic
2	-20.0	0.00100	396500.3	727392.9	Island in mouth of western W. Fidan	hamlet?	EB I
3	-32.5	0.00010	396531.3	727423.3	Northern slope of island in mouth of W.	N/A	EB I
4	17.0	0.00006	3959840.2	728509.4	Early Bronze I village w/ extensive meta	village	EB I
5	-16.2	0.00010	396387.4	727525.8	On wadi baut west of saddle btwn 2 islan	N/A	EB 1
6	-37.3	0.23000	396575.3	727418.5	Edge of alluvial plain, building complex	hamlet	EB II-III
7	-38.0	0.00100	396571.3	727472.0	Two circular features observed	agricultura	Iron
8	-23.2	0.16700	396501.1	727626.3	Eight tumuli on ridge	cemetery	EB I
9	-15.6	0.00020	396510.1	727741.9	Rock cairns in small saddle opposite WF	N/A	N/A
10	-17.9	0.02860	396354.8	727410.5	Four small cairns	cemetery	Iron
11	-23.1	0.08000	396227.0	727452.9	Wall lines possibly, part of room	hamlet?	Neo/EBI
12	-22.4	0.00030	396221.8	727519.3	Opposite PPNB site A; due east, Bedouin	camp	Islamic
13	-19.2	0.00700	396238.0	727570.9	Along trail leading from site 11 to main	cultic	EB I/Iron
14	-11.9	0.00560	396255.9	727628.3	Small circular cairn	cultic	Iron
15a	1.0	0.00053	396353.1	727546.9	Three large standing stones	cemetery	N/A
15b	-15.7	0.00023	396387.1	727526.5	Two cairns	cemetery	Iron/ N/A
16	-9.1	0.00062	396239.3	727720.3	On small plateau overlooking main wadi	cemetery	EB I/ N/A
17	-5.7	0.00835	396302.5	727812.0	On saddle btwn two hills	cemetery	N/A
18	26.2	0.00370	396243.6	728000.3	Hilltop north of wadi, tumuli and lithic	cemetery	Rom/Byz
19	-29.3	0.17000	396378.2	727595.3	Tert. wadi flowing northward, numerous w	hamlet	Iron
20	-3.0	0.00010	396320.4	727748.3	Hilltop above site 19, copper ore scatte	N/A	Iron/ N/A
21	16.4	0.01800	396332.6	728231.5	Bedouin cemetery	cemetery	Islamic
22	9.9	0.18000	396352.1	728150.9	Tumuli fields, Ca 14 observed	cemetery	EB II-III
23	-17.3	0.21600	396095.2	727689.1	On hillside at mouth of wadi, channel sy	agricultura	EB I
24	-19.4	0.07400	396140.1	727700.3	Mouth of small wadi opening into W. Fida	cemetery	Rom/Byz
25	-13.6	0.01850	396165.6	727800.0	Sandstone conglomerate overhang, Bedouin	storage	Islamic
26	-6.3	0.00760	396170.0	727905.7	Rock shelter, room	storage	Byz.
27	-9.8	0.01200	396212.8	727864.2	Small wadi with wall and cairn feature	agricultura	N/A
28	9.4	0.00140	396165.8	727989.6	Highest point of plateau; beneath site 1	N/A	N/A
29	1.9	0.00850	396097.6	727909.6	Long isolated wall on plateau hammada	cultic	Rom/Byz
30	1.7	0.06200	396083.1	727899.3	Large plateau at opening of wadi, extens	N/A	Paleolithic
31	-4.0	0.02060	396095.3	727789.1	North side of plateau, cluster of rock c	N/A	EB I/ Byz.
32a	-10.9	0.00480	396029.3	727667.8	Western end of plateau, tumuli	cemetery	N/A
32b	-8.1	0.00150	396009.1	727737.7	Western end of plateau, tumuli	cemetery	N/A
33	7.4	0.13370	396197.8	728162.6	Spur btwn WF4 cemetery and tumuli field	cemetery	N/A
34	-2.8	0.00010	396202.1	728105.3	Terrace wall	agricultura	Rom/Byz
35	-6.6	0.02560	396089.3	727974.6	North side of secondary wadi, stone cavi	rock shelte	Islamic
36a	-11.2	0.00004	396032.9	727934.9	Mouth of secondary wadi, cave sealed wit	storage	Islamic
36b	-9.5	0.00008	396024.2	727967.0	Mouth of secondary wadi, small cave seal	storage	Islamic
37	-13.3	0.00280	396005.2	727922.3	South bank of secondary wadi, channel wa	agricultura	Rom/Byz
38	-16.1	0.02840	395998.8	727842.5	Natural indentation in pleistocene congl	storage	Rom/Byz
39	-17.4	0.12000	395980.4	727697.8	Feature cut into south face of spur at m	agricultura	EB II-III
40	12.5	0.69000	396074.8	728144.3	Pleistocene terrace overlooking w. fidan	cemetery	Iron
41	13.5	0.15000	396054.9	728162.6	Same plateau east of 1997 WF4 cemetery (	N/A	Paleolithic
42	40.5	0.00010	396107.1	728409.0	Sloping plateau above and to the north o	cemetery	N/A
43	33.0	0.07700	396147.6	728408.8	Overhang on north side of hilltop, small	rock shelte	Islamic
44	23.0	0.00860	396025.7	728378.2	Southern end of hilltop overlooking WF 4	N/A	Rom/Byz
45	22.5	0.00056	396021.7	728377.5	Series of five tombs	cemetery	N/A
46	-31.6	0.45000	395362.5	726857.5	Colluvial terrace above Wadi Araba floo	hamlet	Neo/ Rom./Byz
47	-28.6	0.20500	395537.5	727063.5	Colluvial terrace above Wadi Araba floo	hamlet	EB I/ Rom/Byz
48	-23.3	0.10000	395559.1	727320.3	Pleistocene conglomerate rise in colluvi	campsite?	EBII-III/Iron/Rom/
49	-21.3	0.99000	395446.7	727264.9	SW of spring; W of JHF, series of C-sha	campsite	Rom./Byz
50	-21.5	2.46000	395693.9	727436.9	Largest site found, buildings, field sys	caravansera	Rom./Byz
50a	-16.7	0.09750	395764.3	727541.9	NE section of site 50 just on edge of te	watchtower	Rom./Byz
51	-27.8	1.55000	395700.8	727204.6	South side of W.F. - Numerous walls, pot	village	Chalcolithic
51a	-27.0	0.09500	395751.3	727134.1	Small outlier of site 51 w/ large quanti	lithic work	Chalcolithic
52	-17.5	0.14190	395666.6	727708.8	Terrace along WF west of site 50, numero	settlement	EBII-III/Iron/Rom/
52a	-17.4	0.58680	395703.3	727719.3	Slope of pleist. Outcropping in site 50	industrial	EB II-III/ Iron/ R
53	-16.9	0.82000	395671.5	727603.5	Numerous slag, Ca. 100 small cairns	industrial	Rom./Byz
54	-15.2	0.14800	395651.3	727526.9	Terrace of WF west of 53 and east of 50,	cemetery	Iron/Rom./Byz
55	-17.5	0.26600	395642.1	727585.8	Hilltop with dolomite outcropping, cairn	cemetery	Islamic
56	-10.8	0.40500	395525.8	727601.2	Small hilltop south of Wadi Fidan, Gilat	N/A	EBI/Rom/Byz
57	-9.4	0.06660	395605.5	727792.9	Alluvial/Colluvial terrace of monzo gran	find spot	Rom./Byz
58	14.2	0.50000	395228.3	727997.5	Granite rubble strewn terrace, numerous	industrial	Iron
59	9.7	0.83000	395336.2	728054.2	Granite rubble strewn terrace west of WF	industrial	EB I/ Rom./Byz
60	-6.4	1.07500	395673.3	728178.3	Alluvial/Colluvial terrace south WF, eas	settlement	Roman
61	16.5	2.70000	395692.7	727997.8	Pleist. Terrace, between granite outcrop	settlement	Neolithic
62	28.8	0.00160	395767.7	728579.7	Square tumuli	cemetery	Iron
63	2.7	0.33600	395821.9	728627.7	Series of house clusters	hamlet	EB I
64	5.7	0.00060	395997.9	728379.6	Between Industrial site 53 and 61, metal	Industrial	Iron
65	-12.2	0.02950	395697.9	727844.7	Between EB copper prod, 52A and 61, engr	cemetery	Byz./Islamic
66	-0.2	0.00740	395385.5	727676.3	Cave across from WF4, under WF40, storag	cave	Islamic
67	8.2	0.09860	396322.3	728303.4	Floor of secondary wadi, top of small ca	tumuli	Iron
68	0.1	0.05130	396097.4	728488.8	Mouth of pass leading to 67, 4 tumuli	cemetery	Islamic
69	-1.5	0.12140	396095.7	728570.2	west of 68, series of tumuli	cemetery	Rom/Byz
70	22.9	0.00090	396103.4	728661.7	Pleist. Hamada on north side of Wadi Fid	cemetery	EB I
71	21.9	0.00100	396094.1	728699.6	South end of Hamada, across drainage fro	N/A	N/A

Table 2. *Continued*

ID	ELEVATION	HECTARES	NORTHING	EASTING	NOTES	FUNCTION	PERIOD
72	24.1	0.00040	396127.7	728737.9	southern end of hamada, large robbed tum	cemetery	N/A
73	18.1	0.00060	396084.9	728809.1	hamada, tumulus set back from wadi	tumulus	N/A
74	25.4	0.00021	396171.4	728888.0	mouth of sec. drainage and assoc. terrac	rock shelte	Roman
75	33.1	0.02020	396244.0	729043.5	top of hamada, 3 tumuli, each 4 m. diame	tumuli	EB I
76	27.3	0.03820	396083.9	728983.3	Small hill overlooking WF and site 77, 1	cemetery	N/A
77a	18.1	0.33700	395949.8	729020.8	conglomerate hillock by sec. Wadi, enclo	fortificati	Iron
77b	1.8	0.45690	395987.1	728976.3	terrace below 77, enclosure	fortificati	EB I
78	8.3	1.09000	395771.0	728881.4	Multi-period site, numerous walls, 1 pos	settlement	EB II-III/ Rom/Byz
79	10.3	0.07100	395764.2	729077.6	Colluvial terrace east of 78, located ne	hamlet	EB I
80	9.5	0.01590	395716.2	729181.9	M. granite spur leading to spring n. of	agricultura	Byzantine
81	9.9	0.00005	395707.8	729185.8	M. granite peak on west face of site 80	N/A	EB II-III/ Iron
82	12.1	0.00260	395664.1	729212.3	Secondary drainage; possible rect.bldg.	rooms	Rom/Byz
83	16.8	0.05070	395540.4	729256.3	Secondary drainage, garden system	garden/bust	Rom/Byz
84	32.7	0.00415	396315.6	729296.5	Shallow rock shelter, find spot	find spot	EB II-III
85	10.6	0.00056	396046.3	729014.7	Small cave across secondary drainage fro	N/A	Roman
86	38.2	0.44700	395879.4	729281.0	Pleist. Hamada east of Glueck' KHI (77),	N/A	Paleolithic
87	40.8	0.00890	395806.6	729330.4	Pleist. Plateau just east of Glueck's KH	N/A	Iron
88	42.0	0.18920	395881.3	729342.9	Eastern end of hamada east of 77, 7 tumu	cemetery	N/A
89	36.0	0.00250	395914.1	729237.8	West end of hamada, 4 tumuli	cemetery	Iron
90	45.2	0.00940	395557.6	729470.1	southern end of hamada overlooking WF, s	cemetery	N/A
91	50.8	0.07050	395552.0	729599.1	Hamada surface 40 m west of WF 90, 2 tum	cemetery	N/A
92	49.3	0.01300	395562.0	729531.7	Hamada NE of Wadi Fidan, some retouched	N/A	Paleolithic
93	40.1	0.19430	395570.6	729443.0	NE of hamada containing 90,91,92; small	cemetery	N/A
94	54.1	0.29898	395631.8	729653.0	Plateau downslope of 93, across 2 wadi i	cemetery	N/A
95	47.1	0.05110	395645.2	729802.9	Ridge in wide drainage basin, west of oa	fortificati	N/A
96	52.5	0.02953	395556.3	729753.5	Ridge approx. 60 m west of 95, find spot	find spot	Iron
97	14.7	0.00450	395744.8	729383.2	Mouth of secondary wadi emptying into WF	fortificati	Rom/Byz
98	32.6	0.27220	395632.3	729552.7	Possible camp site	N/A	Rom/Byz
99	34.0	0.00081	395354.2	729196.5	Rock shelter on southern bank of WF, in	rock shelte	EB I
100	47.9	0.08200	395286.8	729162.1	Hamada surface above 99, lithic scatter	N/A	Paleolithic
101	50.3	0.36710	395173.5	729123.0	hamada surface east of 100, large tumuli	cemetery/cu	EB I
102	49.7	0.01961	395336.2	729673.1	Bedouin camp, opposite 95	Bedouin cam	Islamic
103	49.7	0.05120	395364.3	729529.1	Hamada overlooking WF to the southwest,	N/A	Paleolithic
104a	46.4	0.00160	395397.1	729486.4	Hamada containing site 103, tumuli clust	tumuli	Paleolithic
104b	46.7	0.02140	395334.3	729481.5	Tumuli on south side	cemetery	N/A
105	36.7	0.00480	395248.1	729434.3	Saddle between 2 sections of hamada, rec	cultic	Islamic/ N/A
106	45.7	0.00910	395229.1	729420.8	Small hamada overlooking WF, 15 small tu	cemetery	Roman
107	16.2	0.00160	395320.5	729380.9	Terrace beside WF, beneath conglomerate	industrial	Rom/Byz
108	23.5	0.01590	395078.5	729328.7	Rock shelter/interface of m.g. and pleis	rock shelte	Rom/Byz
109	31.7	0.00210	395055.8	729350.4	Largest cave on north side of wadi. NW o	cave	Paleolithic/ N/A
110	58.4	0.02310	395024.3	729466.1	High point on hamada, across from KHI, I	cultic ?	EB I
111	57.1	0.00155	394992.4	729480.3	Hamada surface just below and west of 11	N/A	N/A
112	60.2	0.18480	394939.0	729485.5	Western extent of hamada containing site	cultic ?	Iron
113	49.8	0.00015	395036.6	729424.1	Hamada surface on plateau, lithic scatte	N/A	Paleolithic
114	48.2	0.01310	395050.1	729383.8	Hamada, cluster of small tumuli	cemetery	N/A
115	45.6	0.00950	394970.5	729110.5	Lower plateau of hamada across from KHI,	cemetery	N/A
116	55.5	0.00250	394880.6	729036.3	High point on hamada, across sec. Wadi	tumuli	N/A
117	55.2	0.15570	394797.1	729072.5	High point on hamada, across sec. Wadi	cultic ?	EB I
118	50.8	0.07460	394720.9	729121.5	Lower end of hamada N. of 117 across fro	cemetery	Rom/Byz
119	48.9	0.04020	394743.6	729144.1	Lower plateau across from KHI, lithic sc	N/A	Paleolithic
120	53.3	0.00020	394776.1	729318.5	Khirbet Hamra Ifdan site. EBIV= village,	village	EB II-IV/ Rom/Byz
121	55.7	0.01320	394650.8	729100.7	Large rect.bldg., similar to WF 101, 112	N/A	Rom/Byz
122	63.5	0.00021	394521.8	729082.1	Hillock of sand and M.granite, 1 tumuli	tumulus	Rom/Byz
123	56.5	0.00690	394507.9	729203.4	Sandy hillock covered with granite wash,	cemetery	Iron
124	61.2	0.03030	394460.0	729249.5	Sandy hillock covered with granite wash,	cemetery	Rom/Byz/Islamic
125	16.8	0.00010	395380.8	729399.7	Small wall feature	agricultura	N/A



11. Histogram illustrating number of sites per period along the Wādī Fīdān, JHF Research Area, Jordan.

fieldwork would join the follow-up EDM survey team the next day to show them all the sites discovered the previous day. As part of the team, a digital laboratory supervisor and an archaeological lab supervisor worked mostly in the base camp. The former shared time between fieldwork and the camp where digital photographs were made of artifacts collected in the survey, an Excel database was maintained for the survey data, and EDM survey data was archived. Each evening, all the new sites recorded on the 1:2,500 aerial photographs were transferred to a smaller aerial photograph measuring 50cm^2 and used by the EDM team enable them to identify sites discovered the previous day.

Field Survey Methodology and Cartography

The field survey method comprised three discrete parts that depended on use of an Electronic Distance Measurer (EDM) survey instrument. A Leica TC600 Total Station was the instrument used in the 1998 survey. First, a survey 'loop' of benchmarks was established in advance of the pedestrian surveyors. These benchmarks were generally 20cm lengths of re-bar pounded into cracks of granite outcroppings along the terraces. Having set the Total Station on BM1 (benchmark 1), which had been given 'local' (arbitrary) coordinates, and using a compass bearing for a backsight, BM2 was tied in, and then occupied. From BM2, BM1 was backsighted, and BM3 was surveyed. In this way, the benchmarks in a 1.5km loop were surveyed, terminating with the surveying of BM1 from the last benchmark of the loop.

As the 'misclosure' between the coordinates of the first benchmark, and the coordinates of the same point at the loop's terminus was not great (1:46,000), the loop was subjected to a 'Compass Rule Adjustment'. This system treats the 'misclosure' as a distance and bearing, which can be divided by the number of benchmarks, and apportioned evenly between them. The coordinates of each benchmark were thus adjusted to .002m. These coordinates were then transformed to UTM (Universal Transverse Mercator, European Datum, International WGS84 Spheroid) coordinates with reference to a Map Sheet (3051 11 Series K737 1:50,000) produced by the Jordanian Ministry of the Economy. The original 'local' or arbitrary coordinates were transformed to UTM by the necessary shift and rotation.

The 'EDM site survey' represented the second part of the survey methodology. Once the loop was surveyed, adjusted, and transformed, the archaeological sites found in the pedestrian reconnaissance could then be surveyed with the Total Station. While the loop construction required the Total Station crew be one day ahead of the pedestrian crew, the 'EDM site survey' required the Total Station crew to be one day behind. The EDM site survey involved setting up the Total Station on one of the benchmarks established in the loop, backsighting an adjacent benchmark, and then collecting discrete archaeological points within the line of sight of the Total Station. Each point was collected and stored electronically as one line of code, which included a point number, northing, easting, elevation, and description. The perimeter of each site was first surveyed, followed by the various archaeological features that comprised the site, such as walls, cairns, tombs, etc. When everything within the line of sight of the Total Station had been surveyed, the Total Station would be moved to the next benchmark, and the process repeated, until all the sites identified by the pedestrian crew in the area of the first loop had been surveyed.

Having completed the surveying of these sites, a second loop, starting from the midway point of the first loop, was then surveyed. The relative precision (1:130,000) required again a compass rule adjustment. The process of setting up the Total Station on benchmarks and surveying archaeological sites was then repeated over the area of the second loop.

The third part of the EDM survey methodology involved the creation of 'maps' or 'plans' of what had been surveyed. At the day's end, the data (in the form of an ASCII file) from the data Texas Instrument collector were 'downloaded' into a laptop computer. This file was then imported into a CAD (computer aided drafting) program. The perimeters were drawn and placed on a given layer, and then the archaeological features drawn. Areas were recorded, as well as the center point of each site, and recorded in a spreadsheet. At the survey's end, these various files consisting of one day's work, were imported into AutoCAD, and combined to make one composite regional drawing. The final stage was to combine the Area Map created by the Total Station survey, with the composite photograph of the area. In AutoCAD, the composite photograph was imported, scaled, rotated, and shifted to agree with the Area Map (**Fig. 3**).

Geographic Information System (GIS) Research

GIS is the spatial analysis of data. The field of archaeology has tremendous potential for the exploitation of GIS technology, and the JHF project is certain to produce some groundbreaking developments. As seen in the GIS plots presented here, to date, progress has been linear and two-dimensional. During the 1999 field season, we applied GIS to the actual excavation of three sites (WF 1, WF 51, and WF 120; Levy *et al.* 2001). Using a Toshiba laptop computer, advanced 3-D modeling techniques were applied to digital data collected with EDM technology in the field. This enabled JHF archaeologists to visualize on-going excavations in real time, and make more informed field decisions.

The five steps involved in building the JHF GIS are:

Scan and digitize base maps

There is a shortage of digital coverage for this region. We have searched for satellite imagery of various types, but have held off until the launch of the Carrera satellite in the spring of 1999 by Space Imaging Corporation. This new space vehicle (SV) promises commercial multispectral imagery at 1m resolution. In the meantime, we have used Jordanian 1:50,000 topographic and geological maps, and Corona aerial imagery as a base. The actual paper maps were sent to Horizons Technology of San Diego for scanning and geo-referencing. The end product is returned on a CD with sectional extraction software which supports a number of projections and datum, ours being UTM projection, European 1950 datum. The Corona imagery was manually scanned in sections in the archaeology lab, photocomposed in Photoshop, and imported and geo-referenced in the GIS Lab. Geo-referencing of imagery in ArcView was done using the Total Alignment System ArcView extension, by Urban Information Systems; another San Diego based firm.

Acquire UTM coordinates for sites, plot sites

The project surveyor supplied all site coordinates obtained in the field from the EDM. Early in the project discrepancies surfaced on a number of control sites, which at first appeared to be errors in the coordinates. Later, it was discovered that the map scanning company had used the wrong datum, and the errors were subsequently corrected to +/- 1mm. All coordinate data was moved across the Internet from Canada to San Diego using FTP to ensure data quality. After several models, and iterations of coordinate sets, the final set of sites was declared. Import of coordinate data into ArcView was done using the Avenue script gps2shape.ave.

Prepare tabular data for import into ArcView GIS

Once all sites were plotted, a relational system of merging site data to site vector elements was worked out using a key field to join tables in ArcView. Some fields in the site data were re-coded from the original to improve the query functions used in ArcView, and to simplify table merges.

Analyze site data

As most sites have not yet been intensively excavated, most of the data pertains more to perceived site type, conditions, chronological placement, terrain, etc. rather than actual finds data. All of this data has been coded and can be searched spatially. Using a master data file, the ArcView Query builder was used to parse out subsets (e.g. site type = Chalcolithic, function = cemetery, etc.) into discrete spatial themes. Using this finite element approach to build the spatial model, we now have quite a number of themes, which can be enabled and disabled within ArcView to view chronological and functional movement in the area through time. After future seasons, when more artifact data is acquired, the richness of the model and query functions will increase dramatically.

Generate maps, imagery and histograms

At this stage in the project, the real value of the GIS lies in real-time analysis at the workstation. For publications, Hewlett Packard 1120c 11x17 printer is used for printed output. As more imagery becomes available we will look at a larger format plotter.

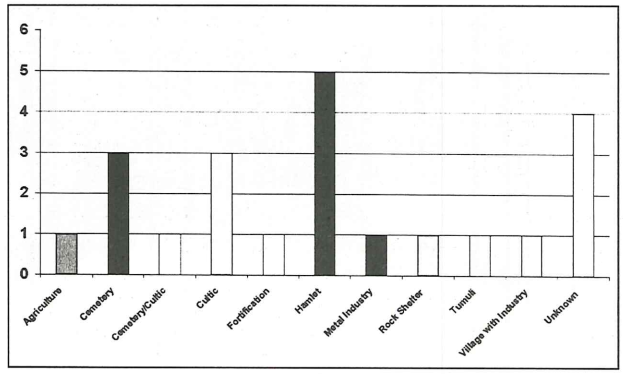
Future GIS Directions

In terms of GIS applications in Jabal Ḥamrat Fīdān, the most promising development will be 3D analysis. We now have a working 3D model that begins with a surface; either a terrain model or even the scanned and geo-referenced topo-maps and Corona imagery. By using a system of z-values and offsets, a geometric model of site, locus, and basket elements is created below the surface. Each component is fully searchable and results can be exported in tabular, 2D, 3D, and Virtual Reality Modeling Language (VRML) formats.

Interpretation of Settlement Patterns

By melding together three forms of essential data related to ancient settlement patterns in the JHF study area (i.e., reconnaissance survey observations, EDM digital survey data, and GIS analyses) it is now possible to begin to reconstruct the social landscape in which the major Neolithic, Early Bronze Age, Iron Age and other occupations interacted on the local level in the Jabal Ḥamrat Fīdān region. While it only took 10 days of intensive reconnaissance fieldwork to collect data on 125 sites in the study area, roughly ten months of laboratory work was necessary to iron out all of the protocols to tie together these different databases. This kind of research was made possible by use of the Internet on campus at UCSD and between San Diego, Bristol, and Canada.

While a total of 125 sites were recorded during the survey, some 20% of these had multiple occupations. As seen in the histogram (**Fig. 11**) showing the number of sites per period, when multiple occupations are factored in, a total of 159 sites are represented in the survey area spanning the Paleolithic through Islamic periods. In this preliminary report the basic site data are presented in **Table 2.** During the survey, site function was attributed for each archaeological locality based on the presence of different material attributes used to define function. A range of site functions were used in the survey including: agricultural installation, camp site, cemetery, cultic, fortification, hamlet, metal industry, settlement, tumuli, village with industry, unknown, etc. Central to the research design of the JHF project are the settlement pattern results for the Neolithic, Chalcolithic, Early

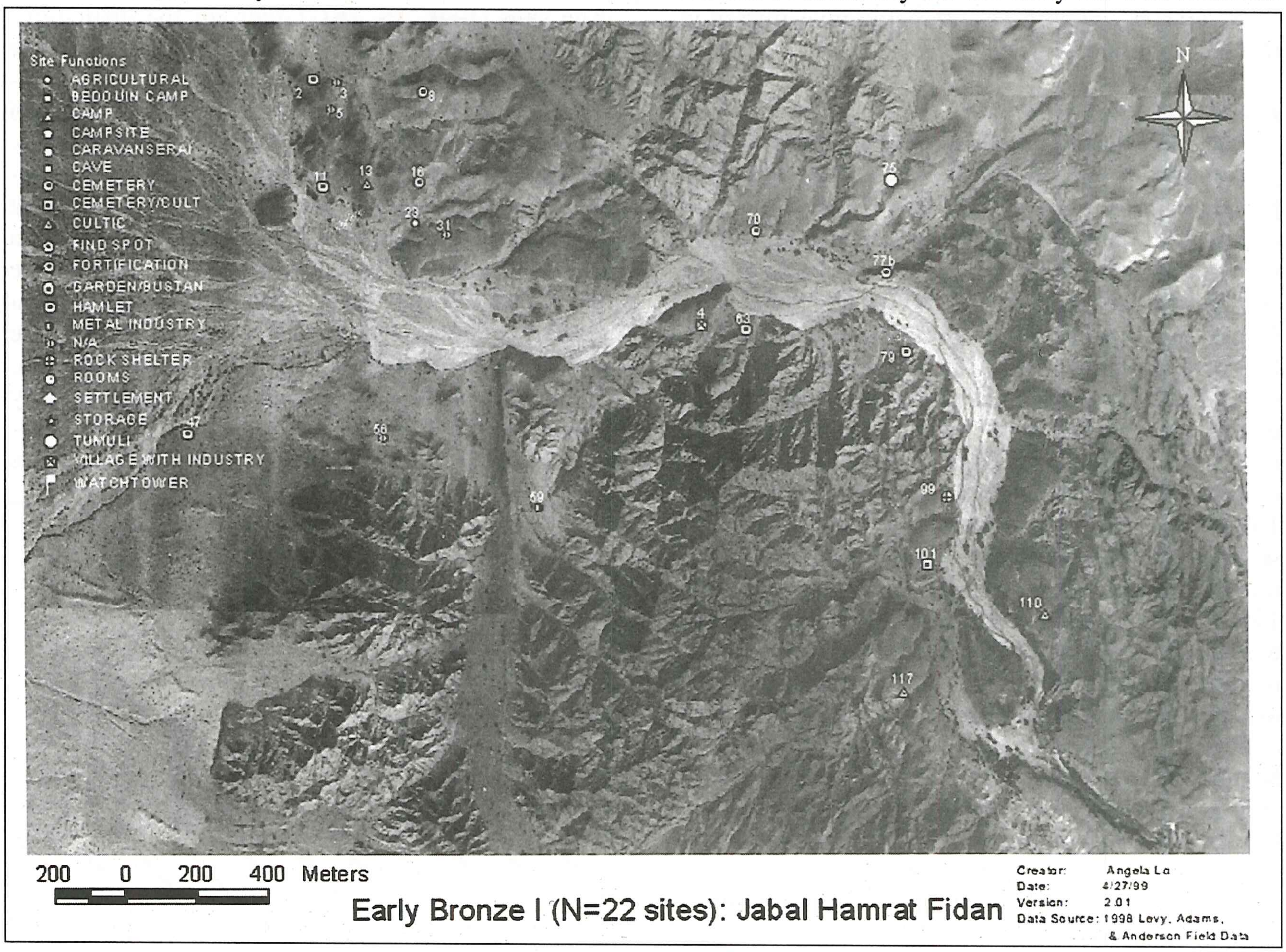


12. Histogram illustrating EB I site distribution by function.

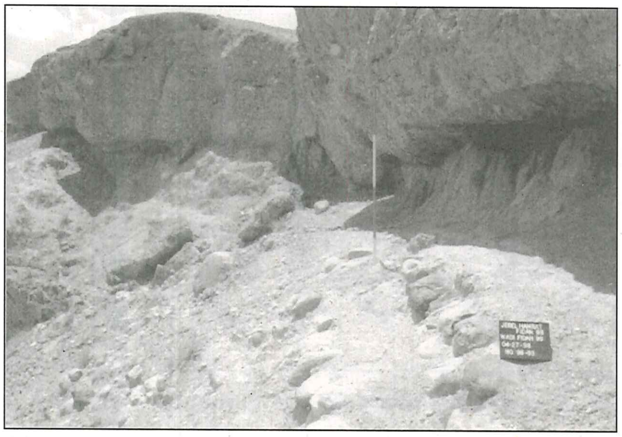
Bronze and Iron Age periods. In this paper, we discuss regional settlement patterns for only two of the periods represented in the study area: Early Bronze I and Iron Age I-II. A monograph length report is planned that will present all of the survey data and settlement pattern models.

Early Bronze I Settlement Pattern

Prior to the 1998 survey, the only Early Bronze I site reported in the Jabal Ḥamrat Fīdān was the village and metallurgical site of Wadi Fidan 4 (Adams 1999; Adams and Genz 1995; Raikes 1980). As noted above, WF 4 'floated' in the Faynān district as an isolated, but import, major EB I settlement. By the end of the 1998 survey, a total of 22 EB I sites were identified (**Fig. 12**). Prior to the survey, issues concerning local subsistence and social networks at the "Gateway to Faynān" were lacking. It is now possible to document a two-tier settlement hierarchy in the JHF during the early EB I that focused on WF 4 that was surrounded by five small hamlets. This type of settlement organization is often linked with the emergence of Chiefdoms (cf. Levy 1998; Johnson and Earle 1987). Imbedded in this EB I landscape were a series of cemeteries (n = 3), a special metal smelting site located some 600m southwest of WF 4, a rock shelter with well-built wall and *in situ* early EB I juglet, agricultural installations, and other features (**Fig. 13**). The rock shelter (WF 99) may have functioned as a "watch tower" helping to monitor access to the Faynān valley and associated mines upstream (**Fig. 14**). The identification of a two-tier settlement hierarchy for the early EB I in southern



13. GIS plot of EB I sites by function, Jabal Ḥamrat Fīdān, Jordan.



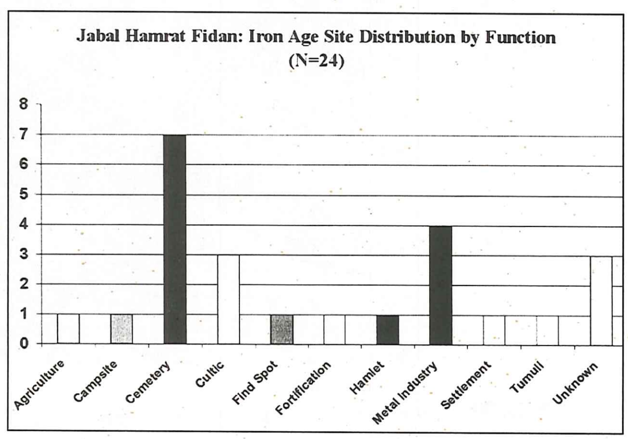
14. *Photograph of WFD 99, and EB I rockshelter with stone walls where an in situ juglet was found.*

Jordan is of great interest when compared to contemporary developments in southern Palestine where post-Chalcolithic settlement is usually characterized by pit houses and more ephemeral settlements (Levy *et al.* 1997). Does the new JHF settlement pattern data reflect a more complex social organization in the copper ore resource zone than in traditional research areas in western Palestine? This and other hypotheses are being investigated in the JHF regional project.

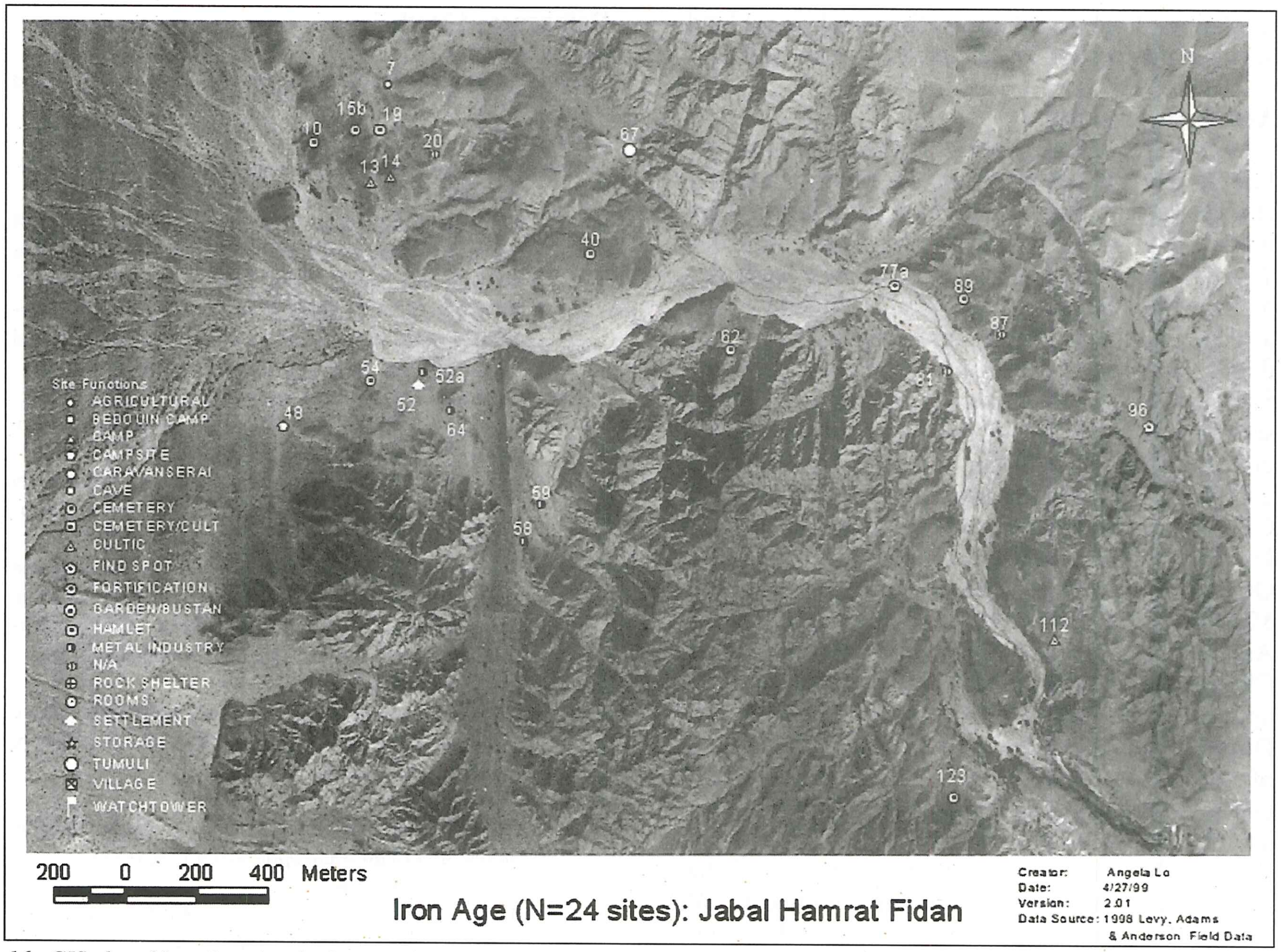
Iron Age Settlement Pattern

The JHF Project excavations at the Iron Age cemetery site of WF 40 provides important new data for assessing the nature of the early Iron Age occupation of southern Jordan in general and Edom in particular. Calibrated radiometric dating of the site shows that it is used between 1015–845 BC, suggesting that it falls roughly between the Iron I–II periods. Until very recently evidence for a pre-seventh century Iron Age occupation on the Jordanian plateau south of Wādī al-Ḥasā has been both very sparse and highly debated in the literature (Finkelstein 1992a; 1992b; Bienkowski 1992a; 1992b). Notwithstanding Finkelstein's assertions that early Iron Age ceramics are present in most 'Edomite' sites excavated to date (Finkelstein 1992a; 1992b), there is a lack of stratified evidence to support this hypothesis. Moreover, the absence of these early Iron Age sequences should be seen as part of a larger problem concerning the almost complete absence of archaeological evidence for Middle Bronze Age, Late Bronze Age and Iron Age I occupation in Transjordan in general. Although this 'gap' in occupation of southern Transjordan is now a well-known phenomenon, it has yet to be satisfactorily explained. Recent attempts to account for this situation have taken two approaches, the first of which has been to suggest that the lack of sites reflects the 'nomadic' nature of populations in the region at this time, which have been suggested to exist largely as groups reliant upon a pastoral economy. The second approach has been to attempt to rectify the lack of sites through more intensive survey of the region over the last two decades, to address this perceived 'gap' in occupation of southern Jordan. These surveys, both north (Karak Plateau Survey, [Miller 1991]) and south of Wādī al-Ḥasā (Wadi al-Hasa Archaeological Survey, [MacDonald 1988]; Southern Ghors and Northeast Arabah Survey [MacDonald 1992]; Edom Survey Project [Hart 1989, 1992]; Aqaba-Ma'an Survey [Jobling 1981]), have all met with relatively limited success. Thus, new Iron Age data from the WF 40 cemetery (Levy, Adams and Shafiq 1999) and the 1998 survey data for the Iron Age are a welcome addition to the study of culture change during this period.

Prior to the 1998 survey, the primary Iron Age sites known in the study area were Khirbat an-Naḥās, Glueck's Khirbat Ḥamrat Ifdān (KHI; Adams 1992), and the WF 40 Cemetery (Levy *et al.* 1999). The JHF survey shows a total of 24 Iron Age sites (**Figs. 15, 16**). Given all the difficulties in clarifying the temporal nature of the Iron Age occupation in Edom outlined above, without stratified material, the generic 'Iron Age I–II' was used to date pottery from these sites. While Glueck's KHI (Adams 1992) is interpreted as a possible fortification/watchtower, and one small settlement and hamlet site were recorded (**Table 2**), there is a lack of developed Iron Age settlement sites in the Wādī Fīdān survey area. This is of great interest given the newly discovered widespread evidence of Iron Age smelting in the survey area (**Fig. 16**). Along the banks of a secondary drainage (locally known as the "Wādī al-Min-Batah") in the western sector of the research area (**Fig. 3**), four sites

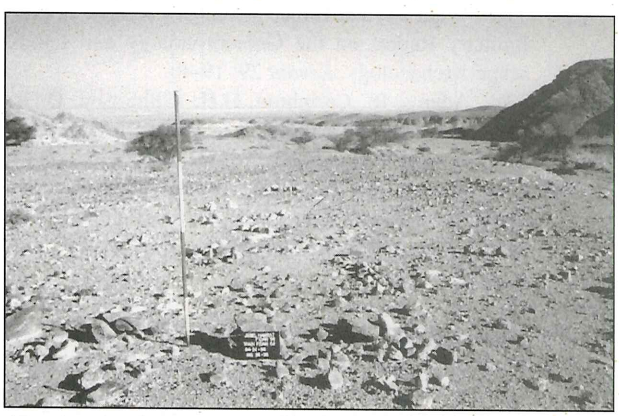


15. *Histogram illustrating Iron Age site distribution by function.*



16. GIS plot of Iron Age sites by function in the Jabal Ḥamrat Fīdān survey area.

(WF 52a, 58, 59, and 64) were found with hundreds of small smelting furnaces (**Fig. 17**). In the same area a small settlement site (WF 52) and large campsite area (WF 48) were also located. The dating of this constellation of Iron Age sites will be of great importance for identifying the developmental sequence in this period and its relation to historical texts dealing with sedentary and nomadic settlement in this part of Edom.



17. Overview of WFD 59 dating from the Iron Age. The numerous stone piles represent the remains of smelting furnaces.

Conclusion

This paper has outlined the general research design of the Jabal Ḥamrat Fīdān (Jordan) Regional Archaeology Project and the preliminary results of the 1998 reconnaissance survey in the Wādī Fīdān portion of the study area. Our project has established the necessary protocols to link reconnaissance survey observations, EDM digital survey data, and GIS analyses for two-dimensional settlement pattern study. In this brief overview of the project, notes on the settlement patterns for only two periods, the EB I and Iron Age, were presented. To help develop excavation strategies for the sites discovered in the study area, non-intrusive geophysical surveys play a central role in the decision making process of where to excavate and identifying what the layout of these ancient communities looked like. The Phase I fieldwork took place from 1999–2000 and we were able to fully integrate all of the methods described here for 3-D modeling of the actual excavations and social landscape in this part of Jordan (cf. Levy *et al.* 2001).

Acknowledgments

A version of this paper was presented at the 7th International Conference on the History and Archaeology of Jordan held in Copenhagen, Denmark. The spring 1998 survey team included: Thomas Levy, Russell Adams, James Anderson, Yoav Arbel, John Moreno, Craig Bardsley, Richard Lee, Solomon Kuah, and Alison Dingle. We thank our cooks from Egypt, Ramadan Salem and Sa'id Sa'id Ahmed Abdu, for providing a "Thousand and One Nights" of wonderful cuisine. A special thanks to Angela Lo who participated in the UCSD Faculty–Mentor program and produced the GIS plots included here. We would like to thank Dr. Pierre Bikai, Director, American Center for Oriental Research (ACOR) in 'Ammān and Alison McQuitty, then Director of the British Institute in Amman for Archaeology and History (now CBRL), for their help and support. We sincerely appreciate the guidance and support of the former Director General of the Department of Antiquities of Jordan, Dr. Ghazi Bisheh, and the new Director General of the Department of Antiquities of Jordan, Dr. Fawwaz al-Khraysheh, for the JHF project. Khalil Hamdan our DOA representative has been especially helpful with our fieldwork. We would also like to acknowledge the kindness and hospitality shown to our team by the Bedouin villagers at Qurayqra where our JHF base camp is located. Finally, many thanks to Mr. Adolfo Muniz (UCSD) for his help with this publication.

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