

# ARCHAEO-METALLURGICAL AND MINING-ARCHAEOLOGICAL STUDIES IN THE EASTERN 'ARABAH, FEINĀN AREA, 2ND SEASON

by

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The second season of the project of the German Mining Museum, Bochum, took place from February 23rd to April 26, 1986. It was carried out by grants of the Stiftung Volkswagenwerk and the permission of the Department of Antiquities of the Hashemite Kingdom of Jordan.

The project was directed by Andreas Hauptmann (mineralogy and early metallurgy). According to the complexity of problems and questions in the history of early metallurgy scientists and technicians from several faculties were involved: G. Weisgerber (mining-archaeology), Ch. Roden (archaeology, early metallurgy), G. A. Wagner (dating with scientific methods), P. Mirwald, E. Heit-kemper (ore deposits, geology), W. Frey, H. Kürschner, Ch. Jagiella, U. Baierle (botany, early fuel supply for copper smelting), G. Schneider (technical ceramics), J. Heckes (surveying, photogrammetry), S. Averbek (mining engineering), J. Kunkel (conservation, excavating technics), A. Weisgerber (drawings), A. Knauf (pottery) and Th. Henning as cook. The team was accompanied and supported by the representative of the Department of Antiquities, E. Masa' deh.

After a general survey in the Feinān area in 1984 the campaign was concentrated on a more detailed investigation of the mines, smelting sites and the problems connected with the early metal production.

The investigations conducted are at best to be explained following the way of metal production from ore via mining to the smelting and the final products.

## Geology

Geological studies were carried out in some centres of early mining in Wadi Ḍana, Wadi Khalid, Qalb Ratiye and Wadi Abiad. Ores were collected and several profiles were mapped and sampled to get information on their geochemistry - the basis

not only for the reconstruction of early smelting techniques and metal amounts were produced, but also for the presently running provenance studies of metal artifacts found in Jordan from early periods.

The field work could clearly show that there are two different ore horizons in the area. The first contains mixed manganese and copper ores, the second only copper ores (*cf.* Hauptmann and Weisgerber, in *ADAJ*, 1987, in print). Measurements of the natural radioactivity of the ores showed marked differences between the two horizons. This could give important hints for the genesis of the ore deposits at Feinān and should be further studied by geologists.

Most important for the history of early metallurgy, however, is the fact that one of these ore horizons contains partly sulphur-bearing ores, while in the other only oxidic copper ores occur.

The exploitation of these different ores during different periods is a remarkable milestone insofar as it represents the development of a single step to an at least two-step smelting process. During our last campaign it was shown that this progress probably took place during Roman times.

## Mining Archaeological Survey

Systematical surveying was carried out in the area of Qalb Ratiye, 2 km NW of Feinān, and in the Wadi Abiad at about 2.5 km distance. In Qalb Ratiye 58 mines were registered. Clearing work was carried out in mines 4, 6 and 12. Mines 6 and 12 were roughly mapped. Nearly on all the surfaces of the dumps of these mines chalcolithic mining tools together with pottery and flint could be collected. As also a lot of Roman pottery occurred on the same dumps, two periods of exploitation are indicated.

During Chalcolithic times the copper mineralization was exploited unsystemati-

cally. The mines grew irregular, so that the entrances of the mines were low and the galleries narrow. Picks or hammers of basalt stone have been used as tools. The use of these heavy stone tools made the walls and ceilings of the mines slightly rounded. Without exaggeration most of the nearly 60 mines at Qalb Ratiye started in the Chalcolithic or Early Bronze Age. They may represent the oldest large mining area for copper in the Near East so far known.

Nearly all these mines were reopened during Roman times after being abandoned for a period of about 2500-3000 years. First, the Roman miners cleaned the Chalcolithic mines from their wastes and took stone hammers and potsherds together with flint to the daylight. Mostly the Romans used the old mines again to reach the ore body and started to enlarge the mine inside. Only at mine no. 4 and 6 the old, narrow entrance was also enlarged and steps were hewn into the rock. Looking for copper ores not yet exploited by the Bronze Age miners the Romans enlarged the galleries near the floor (mine 12) and to the ceiling. Their most common method of prospecting for new mineralization zones was to sink shafts either from the surface of the mountains (mine no. 15, 30, 32, 35) in zones of tectonic fractions or even in the mines themselves (12, 51). This method was very successfully insofar as sometimes extraordinary large mines could be developed in the new level. It was also observed that from "new" mines shafts were sunk again to new levels, e.g. mine 12 had at least 3 floors and mine 51 four or even more. The miners climbed in the shafts up and down using step holes. In mine 51 a shaft with stairs along the wall was seen where the ore could be easily carried out, but normally ores and minerals were moved by winches or tripods with wheel. Unexpectedly we found indications that perhaps animals were used underground to carry loads. Beside the mouth of mine 51 three tanks (two with "tapping holes") were hewn out in the sandstone rock. A typical device to fix animals nearby may indicate that they were used to feed and to water animals. Obviously the ore was transported by animals to the central smelter at Feinān

town.

In the Wadi Abiaḍ the evidence was only slightly different from Qalb Ratiye because there also Iron Age mining activities took place. At the beginning, however, in Wadi Abiaḍ, more Chalcolithic/Bronze Age mines exploited the same low grade ore as in Qalb Ratiye. They were all reworked in Roman time, some of them on an extraordinary large scale. Prehistoric stone picks, flints, sherds and small pieces of slag lay together with Roman sherds. In Wadi Abiaḍ there is one pure Roman prospecting tunnel. It is 2 m high, 1.50 m wide and about 40 m long. This great effort was unsuccessful and did not lead to a rich mineralization. The large size of this tunnel together with devices to fix animals show that its shape obviously was planned for transport of the ore by animals. These are extraordinary wide dimensions which make clear that nearly all other mines go back to older activities and were rarely enlarged in the entrance area.

In the Wadi Abiaḍ like in Wadi Khalid a lot of Iron Age mines exist. Here, a completely different mineralization of copper in the shales between the sandstone was exploited. In Wadi Abiaḍ this orebody could be reached by shafts. In one case we discovered a double shaft, one beside the other. So far we have no explanation for this because we could not yet enter an Iron Age mine. Both shafts are 6m deep. The larger the mines at that depth are, the worse the air for the miners became. Fresh air would be the big problem. In Wadi Khalid a shaft (17/1) was discovered at about 30 m distance to mine and shaft 17. It is situated high above mine 17 on a steep slope of the mountain. This shaft has an open depth of 30m. It had no purpose other than the ventilation of mine 17. It may be the oldest ventilation shaft of this size known for the time being.

A Chalcolithic miner's village was discovered near the mines at Qalb Ratiye. The foundations of about 17 huts partly complete, partly only in reliefs were discovered. Here also fragments of grooved or bored basalt picks or hammers so typical of the old mines were collected together with a

few Chalcolithic potsherds and flints. Details of the site were not cleared because of the Roman occupation nearby.

Another settlement in the Wadi Fidān, once discovered by T. Raikes, is also clearly attached to the Chalcolithic mining. The people here produced stone tools for the work in the mines. All stages from handy, but natural rocks up to crude sized tools with drilling holes and broken final products were discovered. From these findings, a complete set was collected for an exhibition in the Archaeological Museum in Kerak.

These two miner's settlements from Chalcolithic times are completely unique in Near Eastern Archaeology.

### Other Archaeological Sites

From the many other archaeological sites discovered during the survey only the three most important are mentioned here:

- About 1 km west of Khirbet el-Feinān a low tell was remarked. It is about 1-2 m higher than the surroundings and is cut in half by the Wadi Feinān. In the profile more than 4 m of archaeological layers are visible. The level at the surface is dated to Chalcolithic times. The surface is strewn with small pieces of slag showing clear connections with the copper metallurgy. This site will probably become important for the prehistory of the Wadi 'Arabah and Southern Jordan. The Bedouins had no name for the site. Therefore it was called Tell Wadi Feinān in our records.
- On top of the 550 m high Ras Jebel Khalid, under a small abri and in a natural trench between two rocks, large amounts of ash, flint, pottery and bones from Chalcolithic, Iron Age and Roman times were discovered. We suppose a summit sanctuary, possibly of the miners working in the area around the Jebel.
- A Nabataean watch post was remarked on a rocky hill beside the pist from 'Ain el-Fidān to Feinān near the border of the two provinces of Kerak and Ma'an.

### Archaeometallurgy

The work at the smelting sites from different periods in the area of Feinān included archaeological as well as scientific investigations.

Some small-scale excavations were carried out at two places of primary copper production in the vicinity of the ruins of Feinān. Both sites were selected because of their different structure of industrial remains, especially within the slag heaps and the relict of a small number of visible furnace remains. A small square was excavated at Feinān 9, a place densely scattered with intentionally broken copper slag, a small number of slagged sandstone slabs and numerous broken conical clay sticks, the so-called ladyfingers. Archaeometallurgical and archaeological work in 1984 had proved that these typical elements belonged to an early phase of copper production, dating to Chalcolithic and Early Bronze Age times.

Archaeological work in 1984 was able to show that the slag heaps at these sites have to be connected with a unique form of furnaces, consisting of a multiple relined backfront supported by stones or in contact with the ground, small side walls made of stone and clay and a horizontal semicircular bottom. Apparently no tuyeres were used for smelting, much more the metallurgical procedures were carried out by natural draught. For this purpose the small sandstone slabs may have been used to construct a grating at the frontside of the smelter to let the air pass through, while the clay sticks were set in vertically above the bottom to hinder the slag from blocking the tuyere-like spaces between the slabs. A similar technique is known from Mesoamerica, but if analytical work proves this hypothesis, it would be the first known hint on the use of natural draught in the primary copper production in prehistoric times.

At Feinān 9, 25 furnaces of this kind were excavated, but more than a dozen sites with identical features were discovered within the Feinān area.

At Feinān 5, an Iron Age smelting site

with some 10,000 tons of slag, three furnaces of different shape could be studied by small surroundings. These furnaces consist of a flat and round pit-like furnace bottom and a low dome made of slag-tempered clay. The lenticular interior of the domed furnace shows different forms of additional linings to build up a small zone of reaction and a flat pit, where the molten slag could grow stiff. Similar furnaces are known from Timna, but the state of conservation of the furnaces of Feinān 5 will allow more detailed reconstruction of the techniques of copper production.

As slags are the most important indicators of the early smelting processes and the evaluation of the amount of metal produced, samples were collected systematically not only from Feinan 5 and 9, but also from every known smelting site in the area. Also, soundings were made to get deep-sited material of slag and furnace linings for thermoluminescence dating. The furnaces excavated offered the unique possibility to take orientated samples of ceramic furnace lining and slag from decisive points of the furnace. For the first time, there is possibility to study the kind of smelting process, e.g. temperature and gas composition and distribution in ancient smelters with chemo-physical methods in the laboratory and to connect it with the archaeological evidence.

In the context especially of the main periods of copper production, the Late Iron Age and the Roman Period, the question of the fuel supply for smelting the metal is most important. Charcoal inclusions from slags were collected to determine the kind of wood used for the smelting processes. The first preliminary results are :

- in the Late Iron Age (e.g. Khirbet en-Nahas) *Tamariscus species*, *Acacia tortillis*, *Phoenix dactylifera* (palm tree) and some *Juniperus phoenicea* were favoured as fuel.
- in Roman Times (e.g. Feinan 1) especially shrubs like *Haloxylon persicum*, *Retama raetam* and trees of *Acacia tortillis* were buried.

This means that in Khirbet en-Nahās as well as in Feinān during these periods trees and shrubs occurring in the terrasses and wadis close to the smelting sites were cut down. Apparently, the more removed but rich oaks and juniper trees which were growing abundantly on the Jordan Plateau were hardly used. Following these results samples from shrubs and trees were taken in order to determine their fuel value. Also, their weight was registered for a quantitative calculation of wood supply.

It should be mentioned that for provenance studies the first metal artifacts from EB- and MB-periods as well as several ores are under study. The metal artifacts were sampled during our last trip to Jordan in October 1985. Combined neutron activation, atomic absorption and lead isotope analyses will show, if, e.g., the copper from Bab edh-Dhra', Numeira and other sites in Jordan have connection with Feinān.

Because of the distribution of the sites from different periods, the archaeological evidence and the excellent geological and metallurgical material available for scientific investigations, the Feinān area, especially the sites Feinān 5 and Feinān 9 will play a significant role in the future discussion of the archaeology and early metallurgy of the Middle East.

### General Remarks

During the survey in the whole Feinān area marks of clandestine excavations were observed. Unprofessional diggings were carried out on top of Ras Jebel Khalid (550m), in the mines of Wadi Ratiye, in the Roman house near the Roman mines at Qalb Ratiye (house of the cisterns in our records from 1984 when the ruin was still untouched) and almost every cemetery from Prehistoric to Byzantine. The most dramatic damage was done to the Byzantine cemetery of Feinān where about 300 tombs (from about 600) were systematically looted. This is clearly the result of long time "excavation" and could not have been done during some days. Professional looting is obvious. This cemetery was un-

touched in 1984 except for the 8 tombs  
robbed in 1932 which were reported by

Frank (*ZDPV* 1934).

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