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The Early Bronze Age at Faynān/Wādī 'Arabah: A Period of New Technology in Copper Production

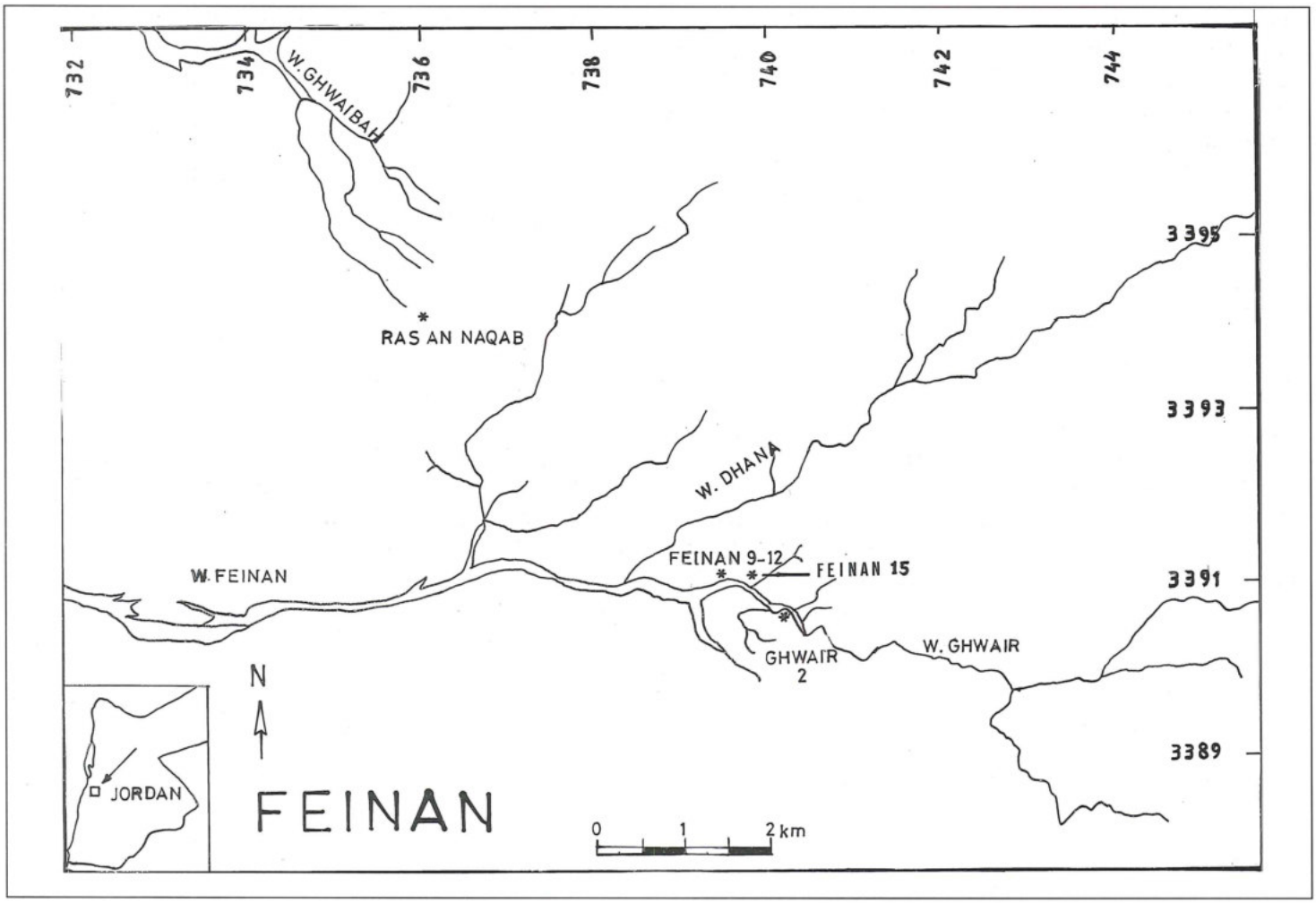
Copper production represents one of the many socioeconomic changes that characterized the history of Jordan with the beginning of the Bronze Age. The emphasis on copper production derives from the necessity for determining when and how copper was produced at Faynān on the one hand and how did copper production at Faynān fit into the general economy of the southern Levant on the other. Mining started very early in the Pre-Pottery Neolithic (Hauptmann 1991), but smelting activities began much later. The use of copper ores can be traced to the PPNB, when "greenstone" beads and green powder for cosmetics became popular all over Transjordan and Palestine. Greenstones from Pre-Pottery Neolithic levels at Jericho, 'Ayn Ghazāl and Bayḍa consist very often of copper ores from the Faynān district (unpublished results, Faynān Project).

The tradition of working metal extends back into the Chalcolithic (Hauptmann 1989; Weisgerber and Hauptmann 1988) – and maybe earlier in the Neolithic – when copper ore was followed down from where it outcropped at the surface with the help of primitive stone hammers and chisels. The distinctive marks made by the tools can be clearly seen on the walls of the galleries of the mines at Jabal Khālid and Umm al-'Amad. In this period smelting took place on a small scale within the settlements, in bowl-like crucibles (Khalil 1985) heated from above. For this kind of household-metallurgy malachite was mainly used, but it was not until the early third millennium BC and the advent of smelting, that copper production reached its highest point. Of secondary importance is the copper mineralization along veins in the Massive Brown Sandstone Unit (MBS), which was intensively mined during the Chalcolithic and later in Roman times. Here the main copper carrying minerals are malachite, with relics of chalcocite and tile ore, and paratacamite, but the main ore body in Faynān consists of a 1-2m layer of secondary copper ores in the Dolomite-Limestone-Shale Unit (DLS) which was mainly exploited during the Early Bronze and Iron Ages. Predominant copper minerals are Cu-silicates and malachite. The mineral content and the intimate inter-growth with black manganese oxides give the ores a distinctive appearance that allows to tell them apart from all other copper occurrences in the Levant.

In the history of copper smelting at Faynān, the technology which led to the production of 300-500 tons of copper during the early Bronze Ages is of particular interest and that is why the reconstruction of this technology became one of the main goals of the Faynān Project. Methods of extractive metallurgy apparently reached a first high technological level then. From that point onwards, metal smelting was not limited to the use of pure copper minerals only. The ability to smelt lower grade ores (inter-growth with host rocks) facilitated the exploitation of huge resources. These facts mark a certain revolutionary development of copper metallurgy and caused a considerable expansion of mining and smelting. Therefore, it seems that copper production at Faynān in the middle of the third millennium had far extending effects on the economy and trade relationships in the early phases of the Bronze Age for the entire region. Possibly, the importance of copper metallurgy was such that it may have served as a catalyst for the emergence of urbanism in southern Palestine and Transjordan in the Early Bronze Age (Kempinski 1989; Ilan and Sebanne 1989).

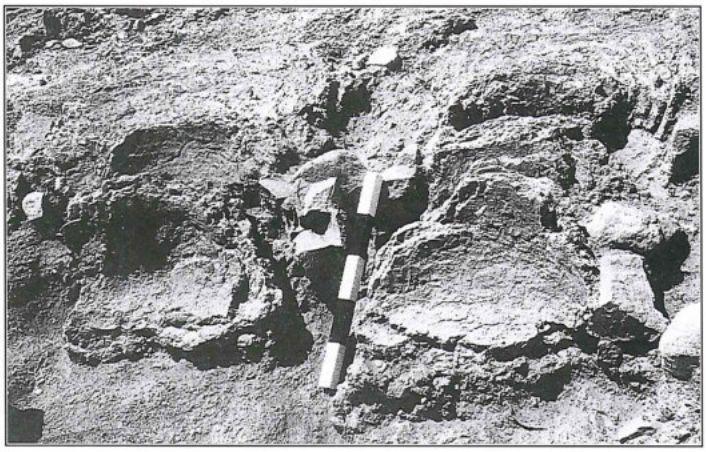
The Jordanian-German team at Faynān worked between 1986-1990 (Hauptmann and Weisgerber 1987; Najjar 1990; Najjar *et al.* 1990) at 12 smelting sites, where metal was produced leaving the earliest, and so far the largest slag heaps known in southern Levant. The amount of slag heaps found at different sites clearly demonstrates a copper production on an industrial scale.

Faynān 9 and 15 (FIG. 1) were discovered and excavated between 1986-1988, the later site is situated on a slope facing east. From there it has an open view to the East Jordanian Plateau over Wādī Ghwair. This seems to be quite a typical situation for an Early Bronze Age smelting site. The slags extend to the east of the furnaces, over an area of about 600 square metres and to a



1. Location map of Faynān (Feinan).

depth varying between 20 and 40cm. The heaps are very eroded and flattened. Fragments of furnaces were found in the slag heaps at Faynān 5, 15 and Rās an-Naqab. Our excavations had the good fortune to discover several of these furnaces almost intact, buried in the slags. More than 50 smelting furnaces were discovered. All of them were built on tops of hills facing the strong seasonal winds. The excavation revealed a unique design of furnaces compatible with operations by natural draught. The early furnaces were of clay-lined stones and there is evidence of relining up to more than 20 times. The furnaces would have been a simple cylinder open from the front and of about 20cm preserved height . The diameter can be estimated at about 50cm. The best parallel to the form of the furnaces could be the "tractor seat" (FIG. 2). Heavily tempered with straw and sometimes with tiny fragments of slag, lining fragments show a considerable degree of vitrification penetrating for several centimetres, suggesting a high temperature maintained for many hours. In almost all of the cases, the back clay walls of the furnaces were renewed many times. The unique design of the furnaces provides the possibility to reach temperatures up to 1200 degrees Celsius, and that is high enough to produce copper and slag in the liquid state. The use of mixed copper/manganese ores from the Early Bronze Age onwards was intimately connected with the development of fluxing. This made the separating of copper from the host rocks in the liquid state possible, although at the beginning the separation from the slag was



2 . Early bronze furnaces.

not carried through to completion mainly because of the not fully liquid state of the slags during the smelting process under primitive conditions. Having smelted the ore, the raw copper has to be separated from the slags. First the slags were crushed, and this was usually done in the immediate vicinity of the furnaces – around the furnaces at Faynān 15 and Rās an-Naqab the excavations revealed a series of mortars carved into the rocks – then after that the prills and lumps of copper most probably were melted into bigger pieces and finally cast into copper ingots. The copper produced at Faynān was rather pure except for a minor lead content. The chemical composition of the metal enables a clear distinction from any deliberately or unintentionally produced alloys such as As/Sb-copper or Sn-bronze, which were common in the southern Levant during the Early Bronze Age. The work on the archaeometallurgy of copper in the Faynān area sponsored by the Volkswagen Foundation/Germany began as a joint research project between the Department of Antiquities of Jordan and the German Mining Museum to investigate the remains of early copper production at Faynān/Wādī 'Arabah.

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