The Innovation of Steel in Transjordan

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INTRODUCTION

In this modern "Age of Steel," we are apt to overlook the fact that steel was first made more than 3,000 years ago in areas bordering the eastern Mediterranean Sea. Dating to the transitional period between the Late Bronze Age and the Iron Age I (1300-1100 B.C.), iron artifacts, including jewelry, weapons, and tools, have been excavated at sites in present-day Cyprus, Israel, and Jordan. Thus far, the largest discoveries have been made in Cyprus, Israel, and Jordan. Because of the vagaries of archaeological research and since many artifacts currently lie buried and unexamined in museum storerooms, the relative quantities of iron artifacts from various countries can easily change.

INNOVATION OR ACCIDENT?

Definitive evidence for solid-state carburization of steel was the presence of a carbon gradient at or near the surface of an artefact (i.e., a pattern of carbon diffusion into the iron that would have proceeded from the exterior surface inward). The metallography of the Balqash artfact, however, revealed no surface gradient; instead, this type of cross-sections was present in part because the microstructure of the metal is such common and much of the surface region is oxidized. Thus, it is not possible to state definitively that surface carburization occurred. Apparent diffusion gradients, however, were observed in 19th century B.C. steel artifacts from Transjordan, a site approximately 40 km (25 miles) northwest of the Balqash. An alternative possibility may be that some form of carburization had taken place after the Balqash artifact had been exercised in local communities. Further in-situ testing of the surface characteristics of the Balqash find is under way to determine the nature of the iron. This work is expected to help reduce the amount of material needed for testing. Although the findings are preliminary, they do indicate that the metal was not as soft or ductile as previously thought. This suggests that the hardness of the metal was more important to the smith than its aesthetic qualities. Additionally, it is speculated that the iron was used for weapon making, although further research is needed to confirm this hypothesis.

The iron artifacts from the Balqash area were made using a technique called "wrought iron." This method involved heating the iron to a high temperature and then hammering it into the desired shape. This process is still used today, and the term "wrought iron" comes from the Latin word "wurtz." The iron was then cooled slowly to allow the carbon to form a solid solution with the iron, creating a strong and durable material. The iron was then hammered into the desired shape, and the process was repeated until the desired shape was achieved.

The metallographic analysis of the Balqash artifact revealed a unique microstructure. The iron was found to be in the ferrite-pearlite region, which is characterized by a combination of ferrite (a solid solution of carbon in iron) and pearlite (a mixture of ferrite and cementite). This microstructure is typical of wrought iron, which is known for its strength and durability.

The iron artifacts from the Balqash area were found in association with other artifacts, such as bronze objects and pottery. This suggests that the iron was being used in a variety of contexts, including weapon making, tool making, and possibly even jewelry making. The presence of iron artifacts in such contexts indicates that iron was becoming more widely available and was being used more frequently.

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ermed medieval Islamic smelting operations, but preliminary surveys at a site only 10 km (6 miles) north of the Baqah, Dhahar Abu Thawab, have yielded early Iron-Age sherds. The chemical composition of one well-fused piece of slag from the latter site, as determined by proton-induced x-ray emission spectroscopy, is close to that of one of the Baqah iron/steel artifacts, particularly in its elevated cobalt content. This is even more noteworthy because a few red glass beads, found in association with the iron/steel artifacts in the Baqah burial cave, also show elevated cobalt. Since the glass has a very high iron-oxide content (48%), it is quite possibly a reworked slag, perhaps a spin-off product of the primary metals industry.11

Dhahar Abu Thawab is in the midst of a fertile area at a higher elevation than the Baqah along the watershed, and probably received more rainfall in antiquity than it does today. In a period of climatic deterioration such as the late Bronze and early Iron Ages are projected to have been, it would have been a preferred direction of migration. The area also includes extensive tracts of oak foresting, which could have met building and, especially, fuel needs.

It may be suggested that native metalsmiths only began to exploit an ore deposit in the Abu Thawab area on a large scale when the Late Bronze culture began to disintegrate and decentralize. It is also possible that metalsmiths from farther south, who were associated with the copper industry in the Wadi Arabah, may have contributed to the development of the new technology (the prevalence of Red Sea molasses in the Baqah burial cave is evidence of such contact).

Figure 3. Cross-section of anklet/bracelet from Baqah burial cave, showing extensive inhomogeneous carburization with Widmanstätten pattern.

Similarly, it can be seen from this study that the early ironwork of the Late Bronze Age was not only a continuation of the earlier tradition but also a development of it. This is evident in the fact that the earliest iron artefacts, such as the anklets and bracelets from the Baqah burial cave, show a high degree of carburization, which is characteristic of the technology of the late Bronze Age.

References
5. This interpretation is based on the work of N.R. Napi and H. Chan, using electron energy loss spectroscopy to identify carbide precipitates.
12. Personal communication, S.J. Boucek, excavator of tomb and member of University of Sydney (Australia expedition) under the direction of J.B. Hennessy (May 19, 1980).

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