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Recreating a smelting method of the past, researcher Vanessa Workman feeds a shaft furnace, alternating layers of coal and iron ore for three hours to extract the iron metal.

Four types of experimental furnaces built for smelting trials in 2019 to explore methods, conditions and clay types that could help explain refuse found in ancient metal workshops.

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PHOTOGRAPHS BY MARIA ENUIKHINA

## FRESH INSIGHTS

# Unearthing ancient metalworking practices

Artifacts discovered at an archeological dig in modern Israel reveal the impacts of the introduction of iron

BY VANESSA WORKMAN, AS TOLD TO DAN FALK

*Vanessa Workman is a PhD researcher in archeology at Bar-Ilan University who is working at one of Israel's most important sites, Tell es-Safi/Gath. The project is led by esteemed archeologist Aren Maeir, who began the dig, located southwest of Jerusalem, 25 years ago. The team is unearthing artifacts from multiple eras, and of particular interest is the period around 1000 BCE. That is when, after centuries of working with bronze, tradespeople adopted iron, which quickly became one of the region's most valuable resources. Workman, who is an Azrieli Graduate Studies Fellow, recounts the team's revelations about this dynamic era of human history.*

**Tell es-Safi has been** identified as the biblical city of Gath, the home city of the giant Goliath, of battle-with-David fame. But people lived and worked here long before biblical times, as early as the third millennium BCE. From about 1200 BCE, the Philistines established a city there, subsisting on agro-pastoral practices and trading with people across the eastern Mediterranean.



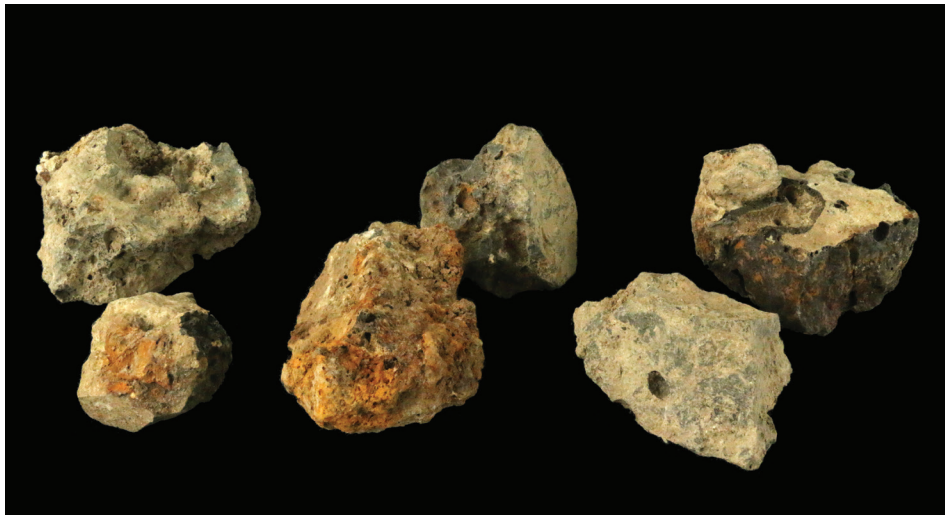
← Excavations revealed a bronze/iron workshop, dated to 10th/9th c. BCE, adjacent to a large cultic complex in the lower city.

Iron slag from the archeological site Tell es-Safi, found in a bronze/iron workshop from the early Iron Age (10th/9th c. BCE) that was in use when the large city was occupied by the Philistines.



← An archaeo-metallurgist colleague uses medieval-style bellows to supply air to a small shaft furnace for iron smelting.

A bronze bracelet dating from the Iron Age, found in the vicinity of the metal workshop at Tell es-Safi/Gath.



Iron was as prized in ancient times as oil is today. With the control of iron resources and technology, a culture could produce tools for agriculture, which increased productivity in the fields. Kingdoms could make more weapons. And the metal's trade value brought wealth and prestige to the elite. We are trying to connect the dots between the era's raw materials, technology, craft and societal structure.

Iron is sometimes called a "democratic metal," because the ores that contain it are widely found. The catch: it takes much know-how to extract and work with it. Once smiths learned how to control the amount of carbon mixed in with the iron (creating steel), they could make more sophisticated and effective tools and weapons.

We've uncovered evidence of workshops where these early metalworkers plied their

craft. By early 12 BCE, iron jewelry—typically rings and bracelets—begin appearing in the archaeological record. By the ninth century BCE, knives, sickles and arrowheads turn up, even the occasional sword. It seems knowledge of working with iron passed down through generations of smiths, causing production of this new metal to evolve.

We've tried to reconstruct the entire iron production process, from the source of iron ore to the clay furnaces that were used. By examining the chemical makeup and microstructure of the waste products of the metalworkers' activities, we can learn even more about the technologies behind the iron artifacts. We use several techniques to analyze the elements present in the artifacts, and different types of microscopes to study the minerals and compounds that formed at high temperatures inside the

Earth. From this data, we can interpret the technologies used and look for similarities between workshops to see cultural-technological connections.

The approach is much like putting together a big jigsaw puzzle. You take all of these pieces—bits of their material culture—and try to put it all together. We want to come as close as we can to assembling a complete picture of these people and their technologies in this time of great change. ■