THE PHARAOHS' GOLD: ANCIENT EGYPTIAN METALLURGY

In an age when mining is conducted on an industrial scale through the use of explosives, huge draglines, and enormous ore-carriers, there is a tendency to forget that mining was, and is, an activity involving the concerted efforts of human beings. In his depiction of mining activities in California's nineteenth-century gold fields, William S. Greever in *The Bonanza West: The Story of the Western Mining Frontier, 1848-1900* calls to mind the human factor involved in the extraction of ore from beneath the earth's surface:

> [T]he deepest shafts in California quartz mining went down . . . about three hundred feet; often a deposit was worked by a tunnel into a hillside or even an open cut. The men used hand drills, sledges, and a little black powder to extract the ore.[1]

Mining ore was, however, only an initial step in the process of extracting metals from nature's tenacious grip. As Greever concedes "to separate gold from . . . ore was a difficult process.[2] There is, then, a second factor inherent to the mining industry. This second step involves milling or processing the ore to recover its metallic content.

As mining operations in California's mother lode country increased in size and scale, the clamor for more efficient means of processing ores grew ever more strident and in response to this demand milling processes grew increasingly sophisticated. Greever notes that California's hardrock miners first relied on arrastras and Chilean mills to reduce their ores. When these devices failed to provide satisfactory returns California's argonauts then began to employ stamp mills to process their gold ores.[3]

The processes underlying the operation of a stamp mill had changed little in the centuries leading up to the California gold rush.[4] Greever compares the basic function of a stamp to that of a pharmacist's mortar and pestle. In its simplest application, a stamp was dropped repeatedly on a piece of metallic ore until the ore was reduced to powder. The sand or finely crushed material that emerged from the stamp was then subjected to a variety of concentration and refining processes to separate the metal from the waste.[5]

Just as today's miners owe a debt to the practical miners and engineers of California's gold fields, early miners depended on technology first developed thousands of years ago. The evolution of this technology merits examination.

The exact time or even rough estimates as to when humanity began to make use of metals remains hidden in the dim mists of prehistory. We can only presume that many thousands of years ago ancient artisans discovered nuggets of placer gold or lumps of native copper and hammered and polished the raw metal into shapes and designs that suited their needs.

Historical and archaeological records indicate that the peoples of Egypt and Mesopotamia by 4,000 B.C. had made great advances in metal-working and were familiar with metallurgical processes.[6] In the centuries prior to 3,000 B.C. metallurgical technology had advanced beyond just mining, milling, and smelting to the production of alloys.[7] One such alloy, bronze, revolutionized the manufacturing of tools and weapons and forever changed humanity's perception of the physical elements that comprised the world. With the discovery of the basic principles of mining and metallurgy, humanity could now improve upon nature—alter the basic composition of the elements—to meet its needs.

Any attempt to portray fully the early history of the mining and milling of ores in a brief article is simply not feasible. Likewise any attempt to recount the mining and metallurgical history of a single nation is just as difficult. What can be presented, however, is a brief account of a single civilization's fascination with gold and its epic endeavors to acquire that most ancient and precious of metals.

One such ancient people evolved in North Africa along the banks of the Nile River in Egypt. Egyptian civilization—birthplace of pharaohs and pyramids—was from its inception a culture and society driven by an insatiable appetite for gold.

Beginning about 5,000 B.C. various Hamtic peoples began to settle along the Nile, hunting, fishing, and raising crops to sustain their small villages. Within a few centuries, the neolithic peoples of the Nile, these proto-Egyptians, left the stone age behind and embarked upon the transition from village life to that of city dwellers, and builders of a great civilization.[8]

Archaeological and historical sources suggest that Egyptian metal-workers as early as 4,000 B.C. had developed remarkably sophisticated gold-smithing skills.[9] In the millennia prior to the beginning of the Christian era, Egypt was in all likelihood both the largest consumer and producer of gold in the Eastern Hemisphere. During this period, estimates show that Egypt consumed four-fifths of the gold production of the ancient world. By 1,500 B.C. Egypt's production of gold reached an estimated 1.4 million pounds.[10]

Gold became an essential element or Egyptian material and spiritual culture. From jewelry to religious statuary, from currency to the trappings of state, the people of Egypt found a multitude of uses for gold.

Gold, for example, was a medium of exchange in ancient Egypt and as such long predated the coining of silver.[11] By the end of the fourth millennium B.C., during the reign of the Pharaoh Menes, small 14-gram gold bars stamped with the pharaoh's name were produced by the royal treasury.[12] It is believed that Egypt's earliest gold currency was in the form of rings. In circulation by around 2,700 B.C., these rings bore a stamp which indicated their weight.[13] Although archaeologists have yet to discover specimens of this ring-money, J. Gardner Wilkinson, a noted nineteenth-century Egyptologist, found that this form of currency was commonly represented in Egyptian art work.[14]

To the Egyptians, gold served more than as a medium of exchange, it was also a substance of great religious significance. By the time the pharaohs ruled, gold was believed to be the substance of the body of the sun-god, *Amon-Re.* Consequently, the pharaohs, descendants of *Amon-Re,* lived a golden life, surrounded by the "sun's metal." Their furniture, clothing, dining utensils, ornaments and symbols of office, all were fabricated from this sacred metal.[15]

One indication of the importance of the sun's metal to Egyptian culture is found in its written symbol for gold. Wilkinson suggests that the hieroglyphic character that signified gold was comprised of three separate characters describing the process of refining gold: a symbol for the bowl or pan in which the gold was washed, a symbol representing the cloth through which the gold was strained, and a symbol depicting flowing water.[16] Modern scholars, most notably C. H. V. Sutherland, suggest a linkage between the Egyptian word for gold, *nub,* and Nubia, one ancient gold producing region which lay just to the south of Egypt proper.[17]

An old adage states, *"gold is where your find it."* The Egyptians understood this concept and became quite proficient at finding the precious metal. So important was the search for gold that one of the oldest known maps, dating to around 1350 B.C., illustrates an Egyptian goldfield.[18]

The Nile River—source of life and civilization for ancient Egypt—probably provided Egypt's metalsmiths with their earliest supplies of gold. For untold thousands of years the Nile meandered between the Libyan desert to the east and the coastal high lands flanking the Red Sea to the west. For millennia, the mighty Nile washed away any obstacles that stood in its path, yet it always left behind vast alluvial deposits in its wake. In addition to the deposits left by the river's ancient meanders, the Nile's annual floods, which swept down from the highlands of interior Africa, supplied, with almost clockwork regularity, the fertile silt of Egypt's farmlands.

Whether caused by the river's ancient meandering or from its annual floods, one region of ancient Egypt, which lay between the first and sixth cataracts of the Nile, was especially rich with gold.[19] The vast alluvial deposits of this region, located roughly from modern-day Aswan, Egypt, to Khartoum, Sudan, provided Egypt's earliest goldsmiths with their raw material. Modern scholars estimate that these placer deposits yielded some 40,000 pounds of gold.[20]

Two major fields supplied Egypt with its free milling gold quartz. The first, the Coptos-Berenice district, a plateau region in Upper Egypt, consisted of a broad quartz zone approximately 60 miles wide, stretching east to west from the Red Sea littoral to the Nile valley, and extending south from the 26th parallel for some 200 miles. The ores of the Coptos-Berenice district were readily mined by shallow surface works.[21]

The site of ancient Egypt's second major source of free milling ore lay to the south and west of the Coptos-Berenice district in what was then known as Nubia, a region encompassing much of the northeastern quarter of modern Sudan. The Nubian fields, which extended east to west between the Nile and the Red Sea and lay just north of the 22nd parallel, consisted of auriferous deposits. The Nubian mines, like those of the Coptos-Berenice district, were easily worked from the surface.[22] Many of the major Nubian quartz mines were located in the Bisharee desert.[23]

Wilkinson notes that from the days of the pharaohs to as late as the tenth-century A.D., the Bisharee district had been extensively explored and prospected. In an account of his travels through Bisharee in the nineteenth-century, he found ample evidence of this activity: "so diligent a search did the Egyptians establish . . . that I never remember to have seen a vein of quartz . . . which had not been carefully examined by their miners."[24]

Diodorus Siculus, a historian from the Greek colony on Sicily, writing at the close of the second-century B.C., provides us with a brief description of the quartz zones in what was possibly the Coptos-Berenice district-

> The soil, naturally black, is traversed with veins of marble of excessive whiteness, surpassing in brilliancy the most shinning substances; out of which the overseers cause the gold to be dug.[25]

That Diodorus was speaking of quartz when he referred to "marble" seems a reasonable assumption. Pliny the Elder, a Roman student of natural history writing in the first-century A.D., also describes gold as "found sticking to the grit of marble."[26] He further notes that gold was found "sparkling in the folds of the marble."[27]

Not all of the gold that adorned the pharaohs and filled their royal coffers came from mines and placers under Egypt's direct control. Beginning around 2,000 B.C. Egypt sent trading fleets south from ports on the Red Sea to seek out new sources of gold along the coast of Africa. One trade center, known to the Egyptians as Punt, was opened on the East African littoral, near the mouth of the Zambezi River in modern Mozambique. From Punt shiploads of gold, ebony, and slaves flowed north to enrich the pharaohs and their subjects. [28]

Leslie Aitchison, metallurgist and historian, logically suggests that ancient civilizations relied on alluvial deposits for their supplies of gold long before developing the technology necessary to mine and mill quartz ores.[29] His description of early placer operations demonstrates the high degree of technology employed by ancient prospectors and miners. According to Aitchison, the use of animal skins—sheep pelts in particular—as filters to trap gold in the washing process became the inspiration for great myths:

> The washings were passed over the fleeces and the particles of gold adhered to the wool. Almost certainly, the legend of the Golden Fleeces that was sought by Jason in the Colchis region of northern Anatolia had its factual basis in this practice.[30]

Once the "Golden Fleece" was thoroughly impregnated with gold dust, the miners burned it to recover the gold trapped within its wooly fibers. Aitchison notes that placer miners in Egypt used cattle and goat skins as filters, while bundles of cloth were similarly employed in the Nubian goldfields.[31] Not surprisingly, "modern" placer miners of the nineteenth century adopted this same technique, tacking a piece of old carpet to the bottom of their rockers to trap gold dust.

Historian C. H. V. Sutherland also argues that placer mining long predated hardrock mining. The Egyptians, he theorizes, worked the alluvial deposits by panning, a process employed by "prospectors throughout history".[32] Sutherland's description of panning clearly reveals the enduring nature of certain processes and technology:

> A shallow circular dish . . . is filled about two-thirds full with the pay-dirt to be washed. . . . The prospector . . . both rotates and twists the pan so as to keep its contents suspended in the water. . . . The movement thus given to the water results in the lighter particles being carried away, leaving a residue either of pure gold or heavier gold-bearing ore or both.[33]

J. Gardner Wilkinson's explanation of the symbolism underlying the Egyptian hieroglyphic for gold certainly lends credence to Sutherland's contention that Egyptian prospectors were familiar with gold panning.[34]

Although the exact time when the Egyptians began to mine and mill quartz ores is not known, scholars agree that by 3,000 B.C. the art of milling ores was an established facet of Egyptian metallurgy.[35] The Greek historian Diodorus provides us with a compelling description of mining operations in what was probably the Coptos-Berenice district. As was the case with many ancient civilizations, the Egyptians relied on slaves to work their mines. "The Pharaohs," Diodorus writes, "consign to the mines those who have been condemned for crime and who have been made captive in war."[36] Those unfortunates who were sentenced to hard labor in the gold mines toiled at their tasks in chains, "getting no rest and jealously kept from all escape."[37] Diodorus further notes that:

> [N]o attention is paid to their persons; they have not even a piece of rag to cover themselves; and so wretched is their condition that everyone who witnesses it deplores the excessive misery they endure.[38]

The mine superintendents assigned tasks to the mine laborers based on their skills, strength, and age. The conscript laborers who were "skilled in distinguishing the stone," acted as the slaves' overseers, relying on the whip and lash to achieve production quotas.[39]

Lacking explosives or power drills, Egyptian miners employed fire to aid in the sinking of shafts: "the hardest of the earth . . . they burn with a good deal of fire, and make soft."[40] On other occasions cadres of slaves used crude tools to drive the shafts ever deeper into the depths of the earth: "[T]he soft rock and that which easily yields to stone chisels or iron is broken down by thousands of unfortunate souls."[41]

The strongest among the miners, men in the prime of their lives, worked with iron pickaxes and "sheer brute force" to follow drifts among the quartz laden country rock.[42] "They hew out galleries," Diodorus observes, "not following a straight line but according to the vein of the glittering rock."[43] Interestingly the miners made use of a miner's lamp to provide illumination in the shafts: "living in darkness . . . they carry lamps fitted to their foreheads."[44] According to Diodorus, the miners labored at the ore face, hacking away at the quartz and country rock until "the stone falls in masses on the floor."[45] The muckers, "the boys who have not yet reached manhood," transported the gold-bearing ores to the mine head where it was sorted for milling by "men who are more than thirty years old."[46]

Little is known of the actual tools used by Egypt's hardrock miners.[47] While Diodorus does mention iron pickaxes, his narrative contains no mention of additional mining implements. Egyptian quarrymen commonly worked with granite, basalt, and occasionally, quartzite. Two of the most common methods employed in the quarries were wedging and "pounding with balls of dolerite."[48]

The composition of the chisels used to cut wedge slots has been subject to great debate, with some students of the subject asserting that Egyptian metallurgists "possessed the now lost art of giving copper a very high temper."[49] Three forms of hammers are known to have been used by Egyptian laborers. The first resembled nothing more than a sculptor's mallet; the second, a simple club-shaped piece of wood, was apparently the equivalent of a single-jack; and the third was a heavy two-handle maul, similar to the modern double jack. Clarke and Engelback, scholars who have studied Egyptian construction methods, assert that the club-shaped hammer was used with chisels and perhaps to drive wedges.[50]

A second method of quarrying granite was known as "pounding." Pounding involved, "the systematic bruising away of the rock by means of balls of a . . . stone called dolerite.[51] These balls, some of which weighed twelve pounds, were held in the hand or sometimes mounted on a shaft.[52] Whether constructed of stone, copper, iron, or steel, one can only assume that the tools and technology employed by ancient Egyptian quarrymen to carve the vast blocks of basalt used to construct the Great Pyramid at Giza, were used in the mines of the Coptos-Berenice and Bisharee districts.

Because of the abundance of labor and their knowledge of mining techniques, Egypt's mining engineers successfully developed extensive underground operations. One ancient mining complex in the northern region of the Coptos-Berenice district, near modern Fatiri, contained an estimated three to four miles of tunnels, shafts, and drifts. Modern scholars estimate that more than one million tons of ores were hoisted from the Wadi Hamish mine near modern Aswan.[53] The main shaft of a mine at Eshuranib consisted of a "narrow oblique chasm," which extended down to perhaps the 180-foot level.[54] Again, as was the case at Fatiri, the miners at Eshuranib proved adept at driving drifts in pursuit of gold veins.[55]

Once the ore had been sorted at the mine head, the matrix was conveyed to a nearby millsite. As in the mines, slaves operated the Egyptian quartz mills. Men too old to labor at the mines and women slaves worked to concentrate and refine the quartz ores.[56]

At the millsite, ores were crushed and sized and then transported to the stamps. According to Diodorus, the stamp batteries consisted of a series of stone mortars and iron pestles which crushed the quartz "to the size of a lentil."[57] Translators disagree in their interpretation of Diodorus's terminology. Alex Del Mar, Mining Commissioner to the U.S. Monetary Commission and historian, interprets the passage to read that the ore was reduced to the size of a "bean."[58] Sutherland, on the other hand, maintains that the stamps crushed the ore "as fine as wheat flour."[59]

Perhaps the oldest machinery employed in the Egyptian quartz mills was the mortar and pestle. As early as 30,000 years ago, Cro-Magnon artists employed the mortar and pestle to prepare the pigments used to create their magnificent "cave-art."[60] In its basic design and function, this ancient machine has changed little. Prehistoric artists, Egyptian millworkers, and modern assayers all have used the mortar and pestle.

After the stamps had crushed the gold-bearing ore, the resulting aggregate, a mixture of quartz gangue and gold, was finely ground. The grinding department consisted of a series of hand-operated mills arranged in rows where the material was "ground until reduced into a fine powder."[61] The hand-operated mills, fashioned from granite, were very similar to the grind stones used to mill grain.[62] Based on archaeological finds and surviving illustrations, it is clear that these mills consisted of nothing more than a flat, hard surface upon which the grain or, in this instance, aggregate was pulverized with a hand-held grindstone.[63]

After being milled, the sand was run through washers and further concentrated. The concentrator consisted of a broad inclined table where the sand was washed "until all the earthy matter . . . [was] separated . . . [leaving] the heavier particles behind."[64] This process, in which the fines were doused with water and rubbed by hand, was repeated frequently. In the final phase of concentration millworkers used sponges to absorb the remaining impurities, "until pure gold dust [was] left."[65]

To further refine their gold, Egypt's metallurgists implemented the process of cupellation. The concentrates were weighed, measured, and mixed with a "fixed proportion of lead, salt, a little tin, and barley bran." This mixture was poured into sealed "earthen crucibles" and roasted in a furnace "for five successive days and nights."[66] "The crucibles," Diodorus recounts, "are then opened, and nothing is found in them, but the pure gold, a little diminished in quantity."[67]

Tests of gold artifacts made throughout Egypt's dynastic periods reveal that these milling and refining processes produced 72.1 to 96.4 percent pure gold.[68] Analysis of one sample of Egyptian gold, dating from about 500 B.C., indicates that the artifact was fabricated from 99.8 percent pure gold.[69] While these analyses prove that Egyptian gold varied greatly in purity, the reasons for this disparity are not clear. Inefficiencies in the milling and refining process, deliberate debasement of the bullion, or alloying by goldsmiths as part of the fabrication process are possible explanations.

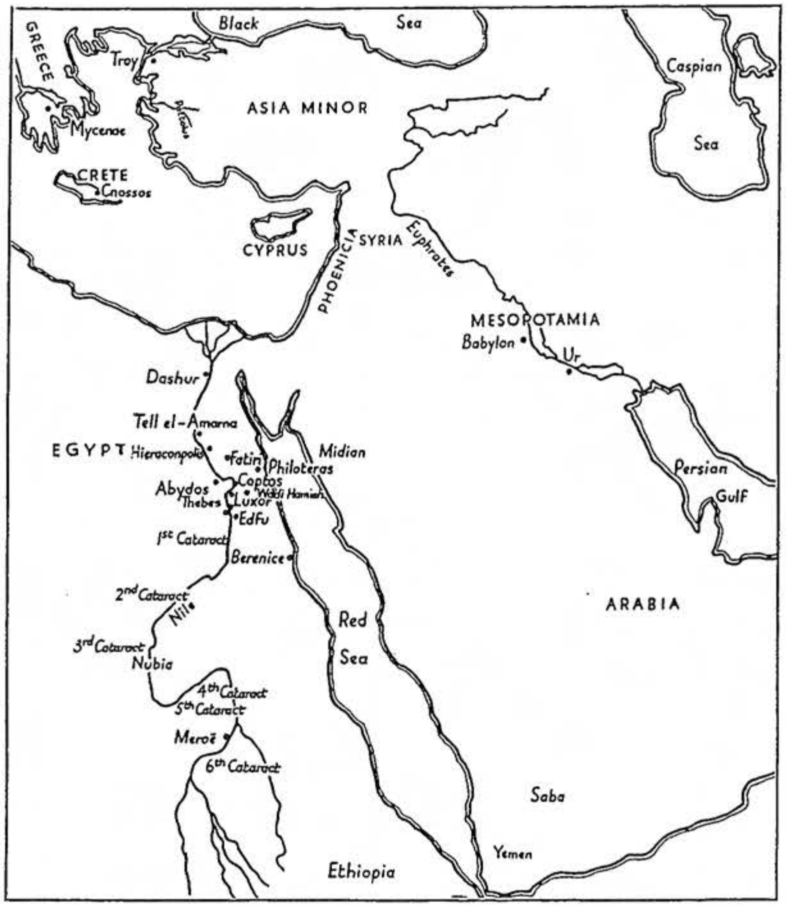
Several ancient murals portray the smelting processes employed by the Egyptian metallurgists. The basic design of the primitive smelters was that of the forge-type furnaces on which sat the clay crucibles in which raw gold was reduced to bullion.[70] One illustration depicts the smelterman squatting near the furnace, using a blow pipe to fan the coals of the furnace.[71] This method of gold smelting was commonly used in Egypt as early as 4,000 B.C.[72]

Undoubtedly, the Egyptians employed sophisticated technology to mine, mill, and refine gold. Without the use of explosives or mechanized equipment these miners capably conducted extensive underground mining operations. Indeed, with the exception of slave labor, the descriptions of metallurgic processes in the ancient Egyptian district of Coptos-Berenice varied little from the accounts of hardrock mining on the Comstock lode or at Witwatersrand thousands of years later in the nineteenth century.

Modern students of milling technology readily recognize the importance of the basic processes employed in the Egyptian quartz mill as described above. The technological evolution from manually operated mortars and pestles to the implementation of batteries of stamps in a modern quartz mill seems quite logical. Egyptian washing tables were the predecessors to the Wilfley tables, jigs, settlers, separators, and other components employed in modern concentrators. The major difference between an ancient Egyptian quartz mill and a present-day stamp mill is the absence of such modern innovations as power stamps, roasters, and amalgamation pans.

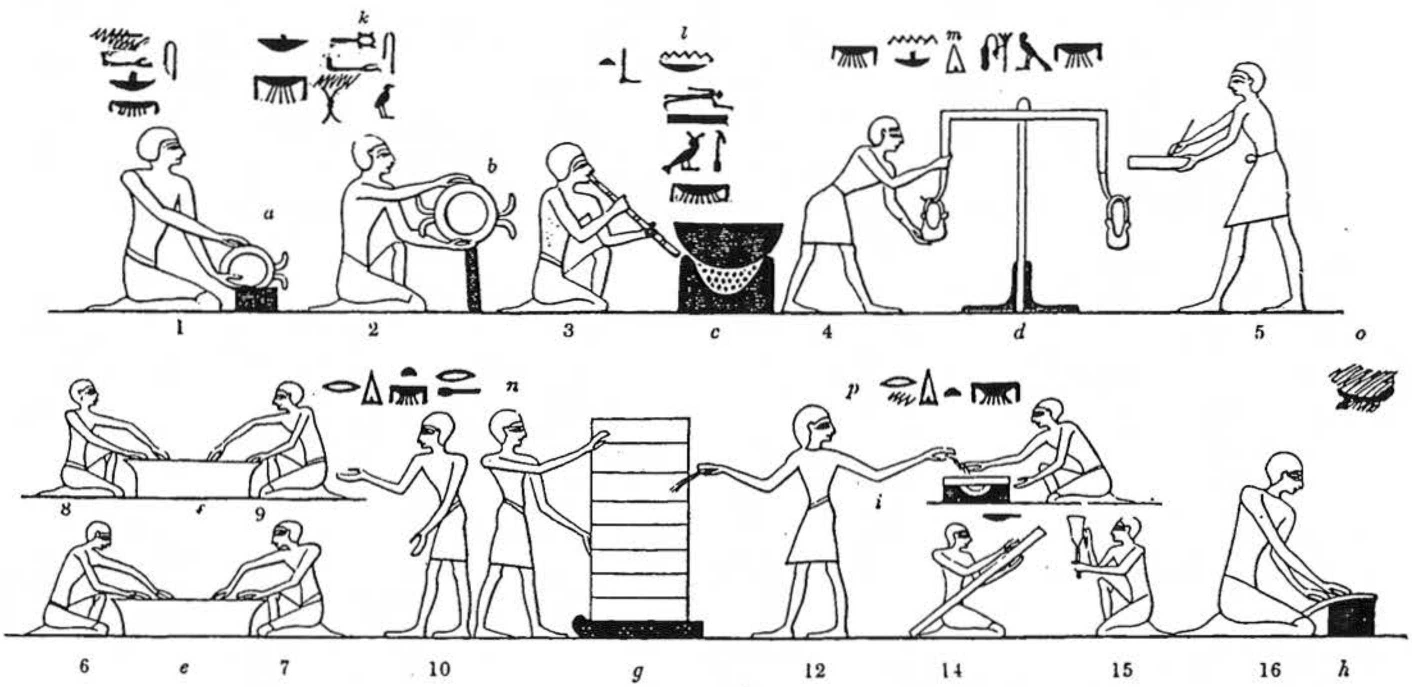
From Coptos-Berenice to California, from Bisharee to the Transvaal, the struggle of gold miners and millworkers to wrest from the earth its golden bounty is as old, or older, than civilization itself. Each generation of miners and millworkers owes a debt to their predecessors, and throughout history miners have used inherited technologies, technologies firmly rooted in humanity's ancient past.

Hal Neumann is currently employed at Heritage Research Center, Ltd., a public history firm headquartered in Missoula. Montana. His academic and professional studies have included examinations of the relationships between society, government, and natural resources development.



Egypt and the Middle East

Source: C. H. V. Sutherland, Gold: Its Beauty, Power, and Allure *(New York: McGraw-Hill Book Company, Inc., 1959).*



Egyptian Goldsmiths.

Figures 1 and 2: *fabrication of gold ornaments.* ***Figure 3:*** *use of blow pipe to melt gold bullion.* ***Figures 4 and 5:*** *weighing and record keeping of gold ornaments.* ***Figures 6, 7, 8, and 9:*** *washing gold.* ***Figure 10:*** *concentrator overseer.* ***Figures 12, 14, and 15:*** *may represent operation of a washing table.* ***Figure 16:*** *operation of hand-operated grind stone.*

Source: J. Gardner. Wilkinson, A Popular Account of the Ancient Egyptians, *vol. 2, revised (New York: Crescent Books, 1988/1853/1836).*

Egyptian smelterman using blow pipe.

Source: J. Gardner. Wilkinson, A Popular Account of the Ancient Egyptians, *vol. 2, revised (New York: Crescent Books, 1988/1853/1836).*

ENDNOTES

[1]William S. Greever, *The Bonanza West: The Story of the Western Mining Frontier, 1848-1900* (Norman: University of Oklahoma Press, 1963), 53.
[2]Ibid.
[3]Ibid.
[4]Perhaps one of the most illustrative accounts of the operations of the origins of modern stamp mills is found in Hoover's translation of Agricola's sixteenth century primer on mining, milling, and metallurgy. Agricola's treatise, first published in 1556, examines in detail the overall evolution of the mining sciences. Georgius Agricola, *De Re Metallica, Translated from the First Latin Edition of 1556, with Biographical Introduction, Annotations and Appendices upon the Development of Mining Methods, Metallurgical Processes, Geology, Mineralogy & Mining Law from the Earliest Times to the 16th Century*, trans. Herbert Clark Hoover and Lou Henry Hoover (New York: Dover Publications, Inc., 1950). Smith and Gnudi's translation of Biringuccio's work on metallurgy also merits the reader's attention. *The Priontechnia of Vannoccio Biringuccio: The Classic Sixteenth-Century Treatise on Metals and Metallurgy*, revised, trans. Cyril Stanley Smith and Martha Teach Gnudi (New York: Dover Publications, Inc., 1990/1959/1943). For a comprehensive review of early milling practices in North America see Otis E. Young, Jr., *Western Mining: An Informal Account of Precious-Metals Prospecting, Placering, Lode Mining, and Milling on the American Frontier from Spanish Times to 1893* (Norman: University of Oklahoma Press, 1970).
[5]Greever, 53-54.
[6]J. Gardner Wilkinson, *A Popular Account of the Ancient Egyptians*, vol. 2, revised (New York: Crescent Books, 1988/1853/1836), 136-149; Henry Hodges, *Technology in the Ancient World* (New York: Barnes & Noble Books, 1992), 19, 61-62; Leslie Aitchison, *A History of Metals*, vol. 1 (London: MacDonald & Evans. Ltd.. 1960), 165.
[7]Hodges, 91-92.
[8]J. M. Roberts, *The Pelican History of the World*, revised (New York: Viking Penguin, Inc., 1980), 81-83.
[9]Wilkinson, vol. 2, 139.
[10]Jennifer Marx, *The Magic of Gold* (Garden City, New York: Doubleday & Company, Inc., 1978), 49; C. H. V. Sutherland, *Gold: Its Beauty, Power, and Allure* (New York: McGraw-Hill Book Company, Inc., 1959), 26, 33.
[11]Wilkinson, vol. 2, 147.
[12]Sutherland, 31.
[13]Wilkinson, vol. 2, 149; Sutherland, 31.
[14]Wilkinson, vol. 2, 149.
[15]Marx, 49
[16]Wilkinson, vol. 2, 139.
[17]Sutherland, 26; Alexander Del Mar, *A History of the Precious Metals: From the Earliest Times to the Present*, revised (New York: Cambridge Encyclopedia Company, 1902), 33.
[18]Aitchison. vol. 1, 168; Sutherland, 41.
[19]Sutherland, 27.
[20]Marx, 49.
[21]Sutherland, 26.
[22]Sutherland, 26; Del Mar, 37.
[23]Wilkinson, vol. 2, 141.
[24]Ibid., 2, 141-142.
[25]Wilkinson, vol. 2, 143; Del Mar, 42.
[26]*Pliny: Natural History: Volume IX, Libri XXXIII-XXXV*, revised, trans. H. Rackham (Cambridge, Massachusetts: Harvard University Press, 1952), 53-54.
[27]Ibid.
[28]Sutherland, 32.
[29]Aitchison, vol. 1, 168.
[30]Ibid.
[31]Ibid.
[32]Sutherland, 27.
[33]Ibid.
[34]Wilkinson, vol. 2, 139.
[35]Aitchison, vol. 1, 168; Wilkinson, vol. 2, 136-149; Hodges, 61-62.
[36]Sutherland, 29-30; Wilkinson, vol. 2, 143.
[37]Ibid.
[38]Wilkinson, vol. 2, 144.
[39]Sutherland, 30.
[40]Ibid.
[41]Ibid.
[42]Ibid.
[43]Ibid.
[44]Ibid.
[45]Wilkinson, 144.
[46]Sutherland, 30.
[47]For a discussion of Egyptian quarrying methods and general engineering technology see: Somers Clarke and R. Engelback, Ancient Egyptian Construction and Architecture (New York: Dover Publications, Inc., 1930/1990) and L. Sprague de Camp, The Ancient Engineers (New York: Doubleday & Company, 1960; reprint, Ballentine Books, 1974).
[48]Clarke and Engelback, 23-25.
[49]Ibid.
[50]Ibid.
[51]Clark and Engelback, 26-27; de Camp, 34.
[52]Ibid.
[53]Sutherland, 30-31.
[54]Wilkinson, vol. 2, 142.
[55]Ibid.
[56]Ibid., 144.
[57]Ibid.
[58]Del Mar, 42.
[59]Sutherland, 30.
[60]Hodges, 26; John E. Pfeiffer, *The Emergence of Man* (New York: Harper & Row, Publishers, 1969), 220-229.
[61]Wilkinson, vol. 2, 144; Sutherland, 30.
[62]Wilkinson, vol. 2, 142; Sutherland, 30; Del Mar, 42
[63]Wilkinson, vol. 2, 142; Hodges, 34-35.
[64]Wilkinson, vol. 2, 144; Sutherland, 30.
[65]Ibid.
[66]Wilkinson, vol. 2, 145; Sutherland, 30, 32-33.
[67]Ibid.
[68]Aitchison, vol. 1, 166-167.
[69]Ibid.
[70]Wilkinson, vol. 2. 137. 139.
[71]Ibid.
[72]Hodges, 62-63.

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