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Cover
Gold jewelry of the Bronze Age. *Centennial gift, 1968. 68.115–139.*
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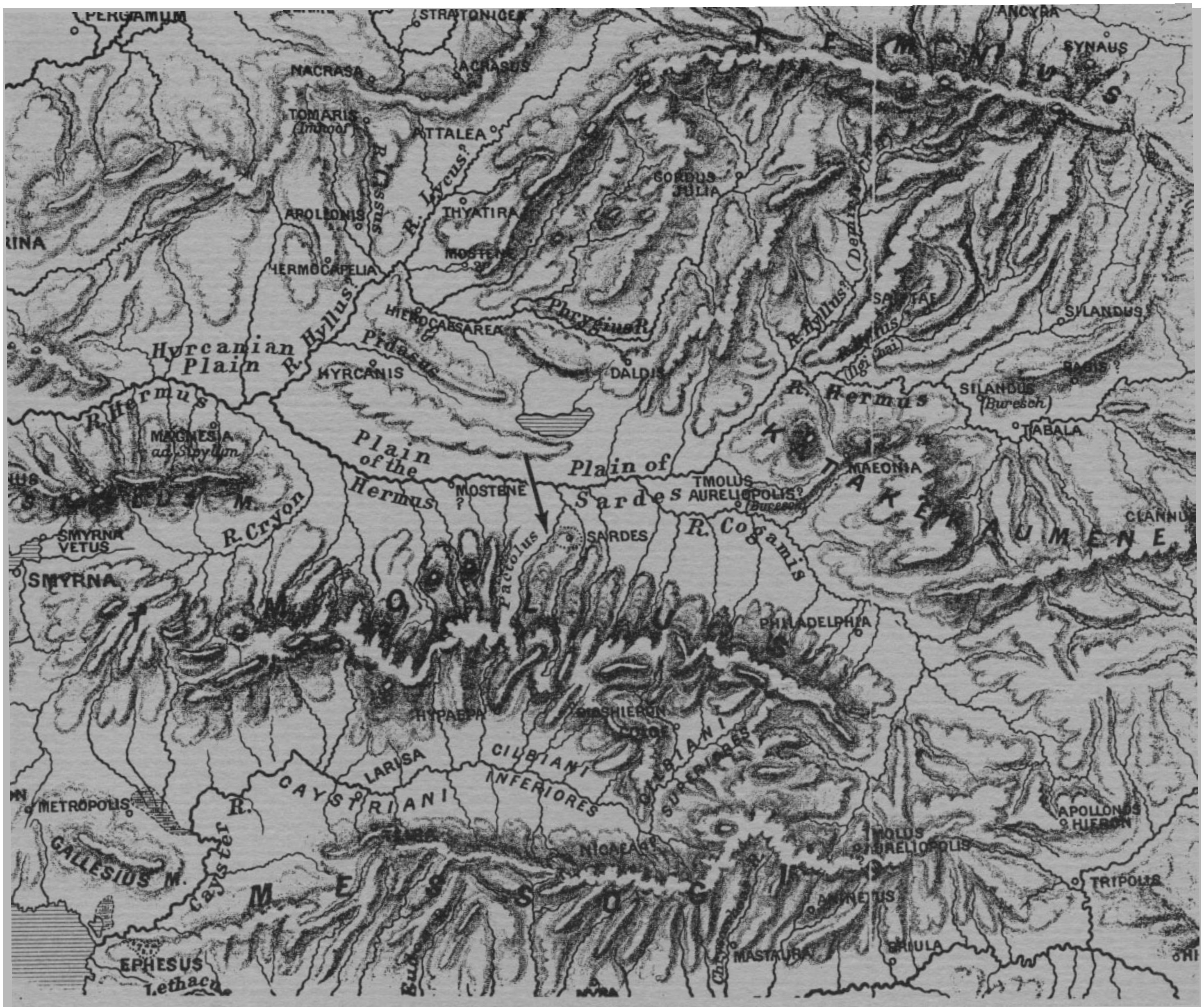


1. Lydia showing Sardis and the Pactolus River Valley (see arrow).

The Fabulous Gold of the Pactolus Valley

WILLIAM J. YOUNG

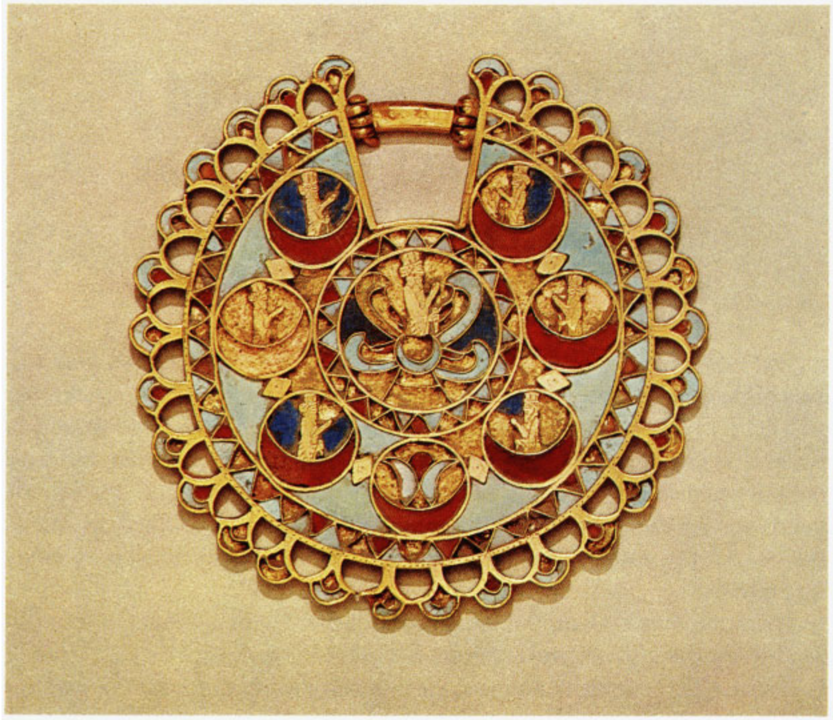
The rugged Aegean coast of Asia Minor, anciently called the Anatolian Plateau, constitutes a high, quite barren, irregular tableland. In the center of the western part of this tableland, at the northern foot of Mount Tmolus is a great plain watered by the Hermus and its southern tributary, the Pactolus (fig. 1). The ruggedness and harsh climate of this region might have discouraged any civilization that would have naturally evolved there had its river valleys not been amazingly rich in gold and its mountains rich in ores of silver, copper, and iron. This part of Anatolia was, in all probability, the cradle of metallurgy.

As early as the Bronze Age, the inhabitants of the Anatolian Plateau found riches prospecting for gold, silver, and other metals and ultimately opened up trade routes for their materials. Eventually itinerant metalworkers ventured farther afield to more populous areas. One route for the movement of these early peoples might well have been eastward to Mesopotamia and Iran through the Iranian Plateau.

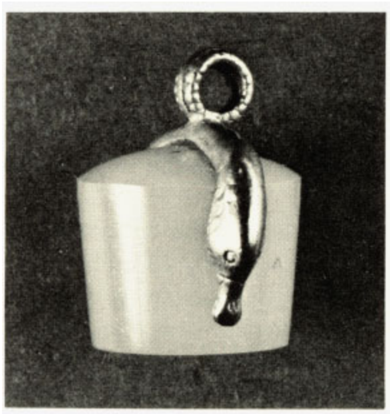
The gold of the river valleys in ancient Anatolia might not have aroused the interest of the museum scientist were it not that the gold from the Pactolus Valley contains very rare inclusions.

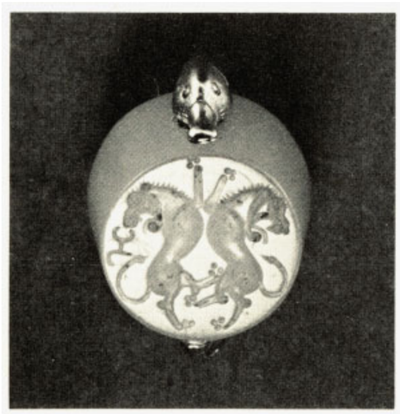
The Museum of Fine Arts recently purchased a gold earring of the Achaemenian period, circa fifth century B.C. (fig. 2). Of superb workmanship, the earring was undoubtedly made for a person of the royal court. The design was created by inlaying precious stones (red carnelian, blue turquoise, and lapis lazuli) on each side of a gold disk in forms outlined by gold cloisons. This technique is known as cloisonné inlay. The earring was made for pierced ears, with the lobe of the ear fitting into a V-shaped slot.

It would be interesting at this point to trace the steps in the craftsman's procedure. He first started with a circular gold disk approximately 48 millimeters (1⅞ inches) in diameter and 0.2 millimeters in thickness (comparable to the thickness of a file card). The circular piece of thin gold was overlaid with thin strips of flat ribbon gold, approximately 0.12 millimeters thick, soldered at right angles to the surface. The craftsman then formed seven circles within which the cut-out figure of the king, or Ahura Mazda,[1] was set upon a crescent. He then incised these small profiles with delicate circles and crescents. The outer edge of the earring was formed into palmettes by soldering small arched pieces of gold of a thickness of 2.6 milli-



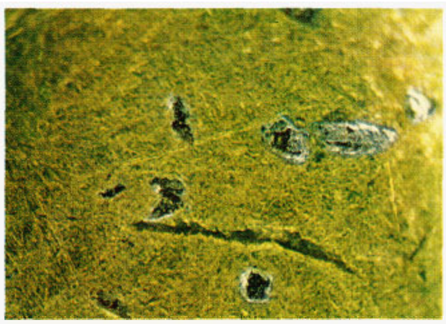
2. Achaemenian earring. 5th century B.C. Gold with inlays of lapis lazuli, turquoise, and carnelian; diam. 5 cm. *1971.256.*



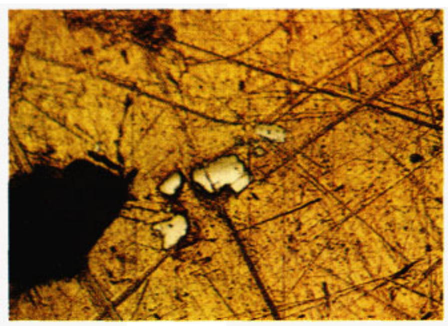


3. Persian stamp seal. Achaemenian, 5th century B.C., chalcedony with gold mount; diam. 1.5 cm. *66.1077.*

4. Lydian coins.



5. Platiniridium inclusions in Achaemenian earring.



6. Platiniridium inclusions in Lydian coins.

meters, with no fewer than 168 solder joins. Into the design was fitted lapis lazuli, turquoise, and carnelian. The color of the carnelian was enhanced by underlying the natural thin stone with red cinnabar, a practice still in use today.

When the earring was critically examined in the museum's Research Laboratory under a binocular microscope, using a power of 40x, minute silver white particles embedded in the gold matrix were discerned (fig. 5). The diameter of these particles is approximately less than that of a human hair. The problem for the laboratory was how to determine the composition of such small particles chemically and nondestructively. Using the laser microprobe (a fairly recent purchase) it was possible to focus a laser beam on the center of a particle and obtain a full spectrochemical analysis of the inclusion.

The laser beam is created with a neodymium-doped glass rod, which, when activated by light photons, produces coherent radiation in contrast to ordinary radiation, which is incoherent. The laser light can be brought down to a dimension of approximately 20 microns. (A human hair is approximately 80 microns in diameter.)

At a given point, the laser was permitted to be focused upon the inclusion under analysis, and a burst of laser light having a temperature of 15,000 degrees centigrade was allowed to vaporize a minute sample creating a small crater approximately 20 microns in diameter. At such a point the burst of laser light, lasting no more than a millionth of a second, was looked upon by the emission spectrograph, which fingerprinted the various elements present in the sample vapor.[2] The crater formed from the removal of such a small sample is not discernible to the human eye.

The silvery inclusions with a bluish tinge proved on analysis to have a composition of 65 percent platinum, 30 percent iridium, and a low percentage of osmium. These proportions indicated a platiniridium-osmium alloy that is found in gold placer deposits in only a few parts of the world: the Ural Mountains, Brazil, and the Ava River near Mandalay in Burma.[3] It is interesting to note that the disk of the earring, with which the craftsman began his composition, is of a different gold than the decorated areas. The disk is a redder gold, having a higher percentage of copper than the overlaid design, and was found to be lacking platiniridium inclusions.

That the ancient craftsman was aware of the presence of small, shiny, white particles in the gold, one can only offer a hypothesis. Careful study of the earring indeed showed that the white particles are situated in certain areas of the king's figure, such as the face, the tip of the knee or elbow, which could have created a variety of reflections when the earring was being worn.

Because of the important implication of these small white inclusions of platiniridium and because of the rarity of this alloy, it was felt that it would be fruitful to trace the gold to its source. Most of the gold in antiquity was obtained from auriferous rocks derived from the action of erosion of the matrix by water. The ancient prospector may perhaps be visualized using a sheepskin to filter the gold from the quartz sand in the placer deposits of a stream; the small hairs of the sheepskin would hold the heavier gold behind while allowing the lighter sandy material to be carried downstream. Hence the legend of the "Golden Fleece."

Another fine Achaemenian piece in the museum's collection is a small stamp seal made of bluish white chalcedony. The design is composed of two rearing affronted lions with heads turned backward (fig. 3). Two ducks' heads in gold form the clasp. Examination of the clasp under magnification revealed that the gold contained platiniridium inclusions, indicating that in all probability it was from the same source as the gold of the Achaemenian earring. This theory is supported by stylistic evidence that relates the seal to those of the Persian satrapy at Sardis.[4]

Once again we return to the history of Asia Minor several hundred years B.C. According to Herodotus, a development of great importance took place at Sardis in Lydia.[5] Considerable quantities of gold were extracted from the alluvial sands of the

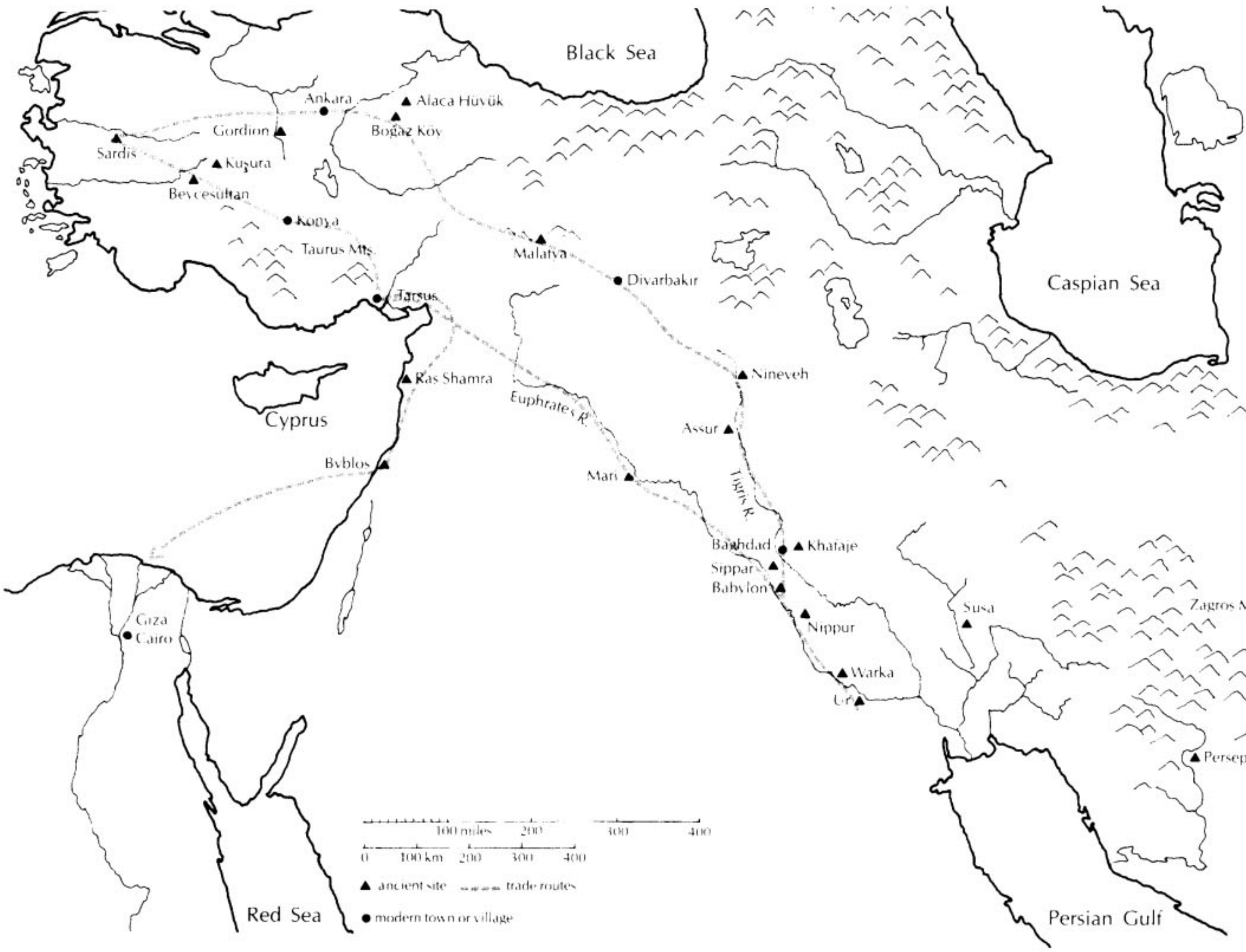
Pactolus in about 700 B.C. and were collected by the founder of the Lydian Empire, Gyges. By means of his gold and his successful trading ventures, he gained in wealth and power, and he became the first despotic ruler over the Lydians. Most significant from the point of view of this study, Gyges realized the importance of establishing a sound currency. During his rule the first stamped, authenticated gold coinage of the western world was produced (fig. 4). The last of Gyges' successors is thought to have been Croesus, whose wealth was vast enough to justify a legend, and who is credited with the introduction of silver and electrum (a natural alloy of gold and silver) coinage as well as gold coinage. At a very early date, the Greeks adapted this form of currency. Strabo recorded that the gold in the Pactolus Valley had been virtually exhausted by 500 B.C.[6]

Close examination of a number of Lydian gold coins has revealed small rounded or angular silver white inclusions of platiniridium in the gold matrix (fig. 6). These inclusions were also submitted to analysis by the laser microprobe and proved to be of the same platiniridium-osmium alloy that was found in the Achaemenian earring and stamp seal.

The Hermus and the Pactolus valleys were an important source of native gold not only in the Persian period but also in the early Bronze Age. A southern route followed by the peoples of that time might well have been from Sardis to Beycesultan, then to Karahuyuk, and through the Taurus Mountains to Tarsus. There the route divided. One branch may have skirted the Mediterranean coast, leading to Ras Shamra and Byblos, and then perhaps across the sea to Giza on the Nile. The other branch may have continued inland from Tarsus to Tell Jedeideh, thence to the fertile valleys of the Euphrates and Tigris, and on to Sumer and the larger cities, Kish, Ur, and Eridu (fig. 7).

In approximately 3000 B.C., the beginning of the Early Dynastic Sumerian period, a system of city-states developed, one of the most prominent of which was Ur. The fine workmanship of the gold in the Early Dynastic royal tombs at Ur (ca. 2600 B.C.) would suggest a long history and experience in goldsmith's art and an early contact with gold-producing areas.

The Museum of the University of Pennsylvania granted us permission to examine microscopically various gold objects from the Royal Cemetery at Ur. These consisted of a fluted gold beaker, large saucer earrings, a necklace with pendant leaves with the veined design produced by tracing with a tool or stick, a necklace of lapis lazuli and rounded gold beads, spiral rings and a gold bracelet from the grave of Queen Shub-ad, ca. 2600–2500 B.C. (fig. 9). The microscopic examination proved that all these objects from Ur contain platiniridium inclusions in the gold matrix.[7] The inclusions vary from approximately 50 microns to 150 microns in diameter. From this one may infer that native gold was used and that the Sumerian goldsmith did not practice gold refining in the Early Dynastic period. The presence of the platiniridium inclusions strongly suggests that the gold of the various objects from the Royal Cemetery at Ur originated and was transported from the Pactolus Valley.



7. Trade routes of the ancient Near East.

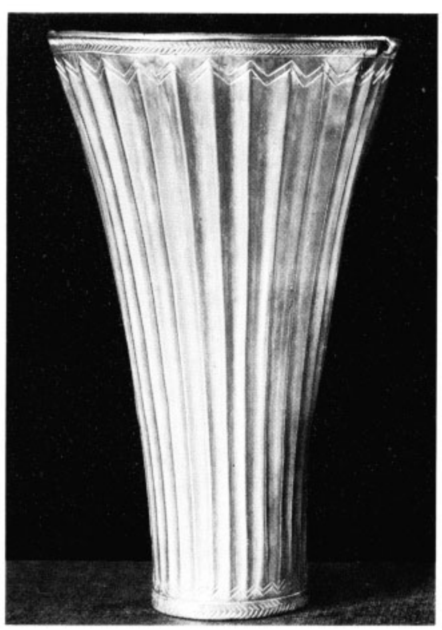
Another important ancient source of gold was Astyra in the Troad. According to Strabo, it was from this gold that the legendary King Priam of Troy derived his immense riches.[8] A small hoard of jewelry in the University of Pennsylvania Museum is said to have come from this region.[9] The collection consists of an ornamented pin, basket earrings, bracelets, pendants, necklace, diadem, and a number of shell earrings. There is similarity between these pieces and the gold objects from Troy published by Heinrich Schliemann in *Ilios: The City and Country of the Trojans* (1881).[10] The University Museum also permitted us to examine their collection of gold from Troy, and we found that in comparison with the reddish gold from Ur, the Troy gold is of paler color, as it is electrum. Moreover, it was found to be lacking in the characteristic inclusions of platiniridium, indicating that it did not originate from the Pactolus area.

8. Egyptian gold cylinder seal, Dynasty 5.
Centennial gift, 1968. 68.115.

As a centennial gift, the Boston Museum received an early Bronze Age funerary hoard of 125 pieces, which include 69 gold roundels in two sizes (each with five concentric circles with a raised center boss), 35 lunettes, as well as hair rings, a diadem, 3 gold bracelets, and an Egyptian seal (cover illus.). The hollow gold cylinder seal is incised with Egyptian hieroglyphs (fig. 8), precisely indicating two Egyptian pharaohs, Menkawhor and Djedkare, who reigned successively in Dynasty 5 (ca. 2490–2450 B.C.).[11]

A microscopic examination was made of the 125 pieces, and platiniridium was observed in most of the gold matrixes. These inclusions were particularly evident in the gold hair rings, the roundels, and a gold bracelet with lion finials. It was found that the gold from which the cylinder seal was made was lacking in platiniridium inclusions, and analysis showed it to be a gold-silver alloy. It is evident that the seal was first incised in the flat and then made into a cylindrical form by soldering. What appeared to be a core inside the hollow gold seal was dated by thermoluminescence.[12] If the cylinder seal had been formed over a clay core, the thermoluminescence time clock would have been turned back to zero at the time the cylinder was heated during the soldering. But the thermoluminescence date indicated an approximate geologic age of 250,000 years for the "core" material, which strongly suggests that what appeared to be a "core" was in fact silt that filtered into the cylinder during burial. X-ray diffraction analysis indicated this deposit to be mainly calcite with some quartz.

The gold funerary hoard must have originated from the tomb of a person of high rank, perhaps a princess, who was buried in her royal finery. In all probability, the



9. Gold objects from Ur from the University of Pennsylvania Museum.

roundels were fastened across the princess' chest in a pectoral design.

It is likely that the Egyptian gold seal was carried by a courier from Egypt. Although the name of the bearer is not recorded on the cylinder, it is quite evident from the inscription what his duties were. Under Menkawhor he was "Inspector of Tenant Farmers of the Pyramid called Netjer." He also served Menkawhor's successor, Djedkare, as "Master of Secrets and House Official of the Palace."[13]

Since the location of the tomb from which the hoard originates is not known, it is impossible to indicate how great a distance the gold from the Pactolus Valley was transported. We do know from the characteristic inclusions of platiniridium that the gold must have come from the same source as the Lydian coins, although, as has been mentioned, Strabo wrote that the gold in the Pactolus River had run out by 500 B.C. The identification of platiniridium in the early Bronze Age jewelry and in the material from Ur clearly indicates that the Pactolus was an extremely important source and that this gold was available in the Pactolus Valley as early as 2600 B.C.

NOTES

1. William Kelly Simpson, "Acquisitions in Egyptian and Ancient Near Eastern Art in the Boston Museum of Fine Arts, 1970–71," *Connoisseur* 179 (February 1972), 120; John F. X. McKeon, "Achaemenian Cloisonné-Inlay Jewelry," *Alter Orient und Altes Testament* 22 (in press). Mr. McKeon made many helpful suggestions concerning the historical sections of this article.

2. I am indebted to Miss Florence E. Whitmore for interpreting the spectrographic analysis.

3. Charles Palache, Harry Berman, and Clifford Frondel, *Dana's System of Mineralogy*, 7th ed. (New York: Wiley, 1944), vol. I, p. 110.

4. Further evidence for the use of the gold supply at Sardis by the Persians is the inscription of Darius I at Susa, which states that the gold used by the craftsmen at Susa came from Sardis and Bactria. See McKeon, "Achaemenian Cloisonné-Inlay Jewelry."

5. Herodotus 1.93, v. 101, v. 49.

6. Pliny, Naturalis Historia 33.66; Strabo 13.4.5 and 13.1.23.

7. The gold fluted beaker was examined with the aid of a magnifier through the glass of its exhibition case, and platiniridium was thought to be seen. Professor Cyril Stanley Smith of Massachusetts Institute of Technology had the opportunity to examine this piece more closely and concurs that platiniridium exists on the side and bottom of the beaker.

8. Strabo 12. 2. 323.

9. George F. Bass, "Troy and Ur: Gold Links between Two Ancient Capitals," *Expedition* 8, no. 4 (Summer 1966), 26–39; idem, "A Hoard of Trojan and Sumerian Jewelry," *American Journal of Archaeology* 74, no. 4 (October 1970), 335–341.

10. Bass, "Troy and Ur," p. 28.

11. Emily T. Vermeule, "Golden Links to the Bronze Age," *Horizon* 13, no. 1 (Winter 1971), 51.

12. Thermoluminescent dating can be achieved on most ceramics, cores, and lava materials that have been heated in the recent past. Thermoluminescence results from the fact that radiation, by alpha, beta, or gamma rays, may displace certain electrons in some of the crystal lattice, such as quartz or felspar, which is found in most clay fabrics. Once pottery has been heated to a temperature greater than 400 degrees centigrade, and its electrons have emitted their thermoluminescent light, the thermoluminescent time clock will be turned back to zero. All ceramic material from archaeological sites shows thermoluminescent glow. This energy is proportional to the total radiation dose that has been absorbed by the material during use or burial. Consequently, recently fired ceramic wares show little thermoluminescent glow, and it is therefore possible by measuring the amount of this glow to indicate the approximate age of the material.

13. Vermeule, "Golden Links," p. 52.