# Ancient Platinum Technology in South America

## ITS USE BY THE INDIANS IN PRE-HISPANIC TIMES

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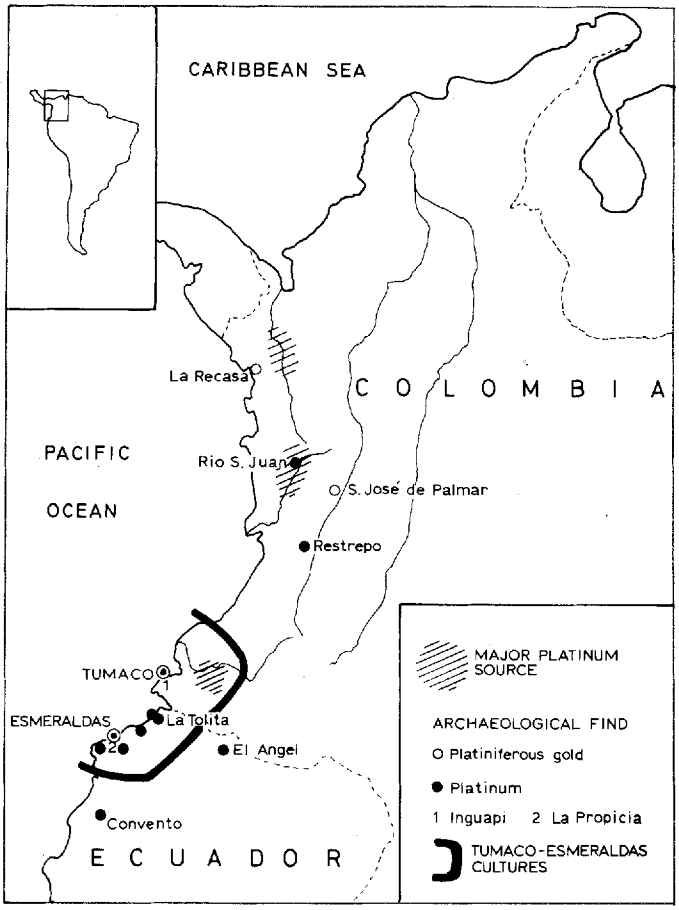
*The early inhabitants of South America had recognised platinum and had used it for making ornaments well before the Spanish Conquest. Their techniques and ability in metal working are reviewed, based upon archaeological evidence and modern metallographic examination.*

The occurrence of platinum group metals as small inclusions in the goldwork from many parts of the Ancient World is well-known. These inclusions were not deliberate alloying additions; platinum, palladium, rhodium, iridium, osmium and ruthenium are not infrequently found in alluvial deposits associated with gold. Thus the working of these placer deposits gives rise to the unintentional presence of platinoid inclusions, particularly of the iridium-osmium-ruthenium group, and to traces of platinum metals in solid solution, especially platinum, palladium and rhodium. For example, Lucas reports the presence of white specks, apparently of platinum, on the surface of several XII dynasty Egyptian gold objects (1) while Partington mentions the existence of osmiridium inclusions in another Egyptian gold piece from 1400 B.C. (2) and more recently Ogden has provided extensive reviews of Old World platinoid sources and their association with the goldworking in antiquity (3, 4). Young (5, 6) and Meeks and Tite (7) have recently reported on their investigation of some inclusions in ancient goldwork, from the Eastern Mediterranean and Near East, during which analyses were carried out to determine their compositions, and therefore possible sources for the gold used to fabricate the objects.

Berthelot described finding a strip of native platinum beaten out to form a small inlaid strip in a bronze box from Thebes, one of the few instances from the Old World in which native platinum had been utilised (8). This strip was used in much the same way as silver and was probably confused with it. The situation is rather different in the New World where, in parts of Ecuador and Colombia, platinum was used not only as a material for the fabrication of small objects, but also for sintering with gold and for the production of bimetallic and platinum-clad articles.

### Native Platinum in Colombia and Ecuador

The Andean mountains provide a rich source of many minerals and metals. Platinum is found associated with ultrabasic rocks such as pyroxenes, peridotites and dunites along the seaward flanks of the western cordillera. The erosion of these rocks and fluvial transport result in alluvial deposits of platiniferous sands and gravels. The most important area in which these deposits are exploited is that of the Chocó region of Pacific Colombia, while minor areas occur in the Tumaco district of the department of Narino, south coastal Colombia, and in the department of Esmeraldas, north coastal Ecuador. Although some of the platinum nuggets can be quite substantial—a specimen from the Chocó area in the Royal Museum of Madrid weighed nearly 700 grams (9)—the alluvial material is usually found in small grains




occurring with gold placer deposits. The sizes of both types of grain are similar (10) and they are often flattened out as a result of fluvial transport. The colour of the platinum grains is grey-white and small cavities are sometimes filled with ferruginous material such as magnetite. The specific gravity varies from 14 to 19, in much the same range as that of native gold, and consequently the two elements will be concentrated together by hand panning and would have to be sorted later.

Outside of the Chocó area, platinum group metal inclusions are uncommon in ancient Colombian goldwork. In most areas of the country, gold-workers had access to deposits that were either free from platinoids or that contained only very minor quantities of them. Chemical analysis of gold objects from Colombia, reveals that ancient goldwork from the area is usually very clean and that platinoid inclusions are quite rare; this is supported by recent electron microprobe analysis and metallurgical examination (11).

## The Composition of New World Platinum Deposits and Artefacts

When the Spanish first began to work the gold deposits of Colombia they noticed a grey-white infusible metal which was of no apparent use. Even when samples did reach Europe great difficulty was experienced in obtaining malleable platinum in bulk because of the very high melting point.

The great Swedish chemist J. J. Berzelius (12), and his co-worker L. F. Svanberg examined some platinum samples from Colombia in 1828. Their results are given in the Table along with those of Teodoro Wolf (13, 14), a geologist who was one of the first to discover small pre-Hispanic objects of platinum from the Esmeraldas district of Ecuador. A recent analysis of native platinum from the Chocó area is included (15), together with two electron microprobe analyses of small objects from Esmeraldas.

The native platinum of the area is an iron-platinum alloy, often ferromagnetic, containing up to about 12 per cent of iron and frequently occurring with small inclusions of osmium-iridium alloys or the more complex ternary alloys such as rutheniridosmine. For a guide to the nomenclature of these alloys see Harris and Cabri who carried out a number of analyses of native osmium-iridium-ruthenium alloys and named them in a systematic manner (16). Platinum deposits can be associated with metallic arsenides such as sperrylite, $As_2Pt$, and cooperite, AsPt (17), but these inclusions have not been observed in any ancient platinum work. Although native copper-iron-platinum alloys occur in Colombia they are uncommon; there is one known example from the area of a copper-platinum alloy nugget being used to make a small penannular nose-ring.

Apart from this example, other ancient platinum objects are either made from native iron-platinum nuggets or sintered alloys of gold and platinum. Intergrowths of platinum and gold may occur in nature, but these rare grains have only been reported from south-east Borneo (18); there is no evidence for their existence in New World platinum deposits.

*Fig. 1 This sheet metal mask with human features and animal fangs is fabricated from a gold alloy clad on both sides with a gold-platinum alloy. The cladding is far from homogeneous, with a platinum content varying from 2 to 30 per cent. The holes suggest that the mask, which is 7.1 cm high, was originally pinned to a wooden idol. It is believed to come from the Rio Esmeraldas, Ecuador, and was obtained in the 1870s by Adolf Bastian, first Director of the Ethnographical Museum, Berlin. (Museum für Völkerkunde, Berlin, No. Va 2152)*

## Pre-Hispanic Objects of Platinum

Predictably, most of the platinum objects in museums and private collections originate from the Pacific lowlands of Ecuador and Colombia. The greatest concentration of finds is from the Esmeraldas region of Ecuador, with a scattering of finds from the Tumaco area on the Colombian side of the frontier, both shown on the map on page 148. Documented pieces are very few, and most of these specimens were obtained by purchase from *guaqueros*, professional treasure-hunters and tomb-robbers, who possess generations of expertise in finding ancient mounds and cemeteries. Since gold and gold-rich objects are the main attractions, it may well be that most examples of platinum work—in particular small, unspectacular and broken pieces—have not found their way into collections. For the same reason, and because no workshop sites have, as yet, been excavated, metallurgical equipment such as blowpipes, crucibles and moulds may be under-represented, but a great deal of evidence for the successful casting and working of gold and platinum has been reviewed by Bray (19).

The archaeological material from Tumaco-Esmeraldas is generally found in alluvial deposits which seem to be the result of re-deposition of material from eroded and washed out sites (20). The repertoire of metal objects includes danglers, face studs, nose ornaments,

*Fig. 2 A composite gold and platinum ornament, believed to be from the Tolita region of Esmeraldas, Ecuador, illustrating a high standard of design and workmanship. (Museo del Banco Central, Quito.)*

fish hooks, needles, awls, tweezers, figurines and miniature masks, one of which is illustrated in Figure 1, while a very elaborate composite gold and platinum ornament from the area is shown in Figure 2. Most of these are made from gold or copper-gold alloys known locally as tumbaga, but there is also a fair number of platinum-alloy items. A collection of this Ecuadorian material was the subject of two excellent monographs by Bergsøe (21, 22) and a few pieces from his collection are illustrated in Figure 3. These specimens are now in the National Museum of Denmark, Copenhagen, where permission was obtained to study the collection and to take samples 1–4 milligrams in weight, mostly from fragmented material, for metallographic and chemical analysis.

Many of the gold and tumbaga objects from Esmeraldas show a minor platinum content in the range of 0.1 to 5 per cent, but the pieces illustrated in Figure 3 contain platinum in significant amounts and show the deliberate and careful workmanship employed in using sintered gold and platinum alloys.

In Colombia, the Museo del Oro at Bogotá has some nose-rings of platinum, including those shown in Figure 4, and also a fine bimetallic nose ornament from the Tumaco area with one half of the piece made in platinum and the other in gold.

For earlier publications describing some ancient platinum artefacts from South America the works by Pérez de Barradas (23), Linné (24), Orchard (25), and Rivet and Arsandaux (26) should be consulted.

## The Archaeological Evidence for Platinum Metallurgy

All items of known provenance are marked on the map. Most of the discoveries are from sites west of the Andes, in the platinum-rich areas of the Colombian Chocó and coastal Ecuador. However, a few objects were exported from the manufacturing region and made their way either southwards along the coast or inland to the Andean highlands. Among these trade pieces are nose-rings from Restrepo in the Calima region of Colombia, such as that shown in Figure 4.1 and a figurine from El Angel, Carchi, Ecuador, which has one eye of silver and the other of platinum (27). This figurine leads one to speculate that platinum was valued principally for its colour, and that the Pacific tribes may have used the locally available platinum as a substitute for imported silver.

The dating of the Tumaco-Esmeraldas tradition of metallurgy is difficult to establish with precision. Archaeological sites span the

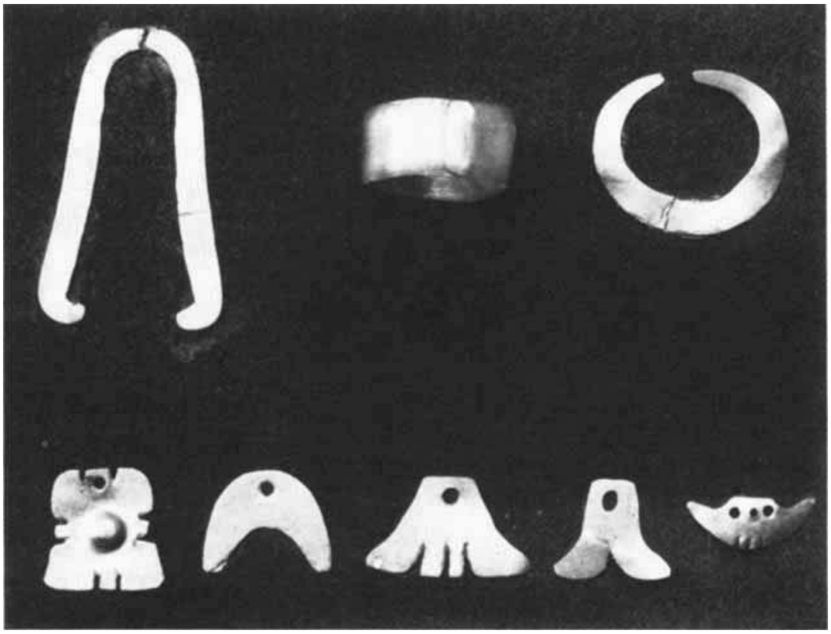


*Fig. 3 Some examples of gold platinum objects from the Bergsøe Collection obtained from coastal Ecuador, and now in the National Museum of Denmark. The piece second from the left on the bottom row is clad with platinum, the microstructure being shown in Figure 8 (National Museum of Denmark 08274)*

**Chemical Analyses of Native Platinum from Colombia and Ecuador and Electron Microprobe Analyses of Two Fabricated Objects**

| Sample | Native Platinum | | | Sintered Gold-Platinum | | | Gold-Platinum Block | |
|---|---|---|---|---|---|---|---|---|
| Location | Colombia | Chocó | Esmeraldas | Esmeraldas | | | La Tolita | |
| Reference | Berzelius 1828 (12) | Monroy 1978 (15) | Wolf 1872 (13) | Different areas of the object shown in Figure 4.5 | | | Different areas of the object in Figure 4.4 | |
| | | | | 1 | 2 | 3 | 1 | 2 |
| Platinum | 81.30 | 86.16 | 84.95 | 85.26 | 5.68 | 3.17 | 83.47 | 6.37 |
| Palladium | 1.06 | 0.35 | 4.64 | nd | nd | nd | 0.68 | nd |
| Rhodium | 3.46 | 2.16 | | 2.11 | nd | nd | 2.59 | nd |
| Iridium | 1.46 | 1.19 | nd | nd | nd | 40.23 | 0.10 | nd |
| Osmium | — | — | — | nd | nd | 43.54 | nd | nd |
| Ruthenium | — | — | — | nd | nd | 10.16 | nd | nd |
| "Ir/Os" | 1.03 | 1.19 | 1.54 | — | — | — | — | — |
| Gold | nil | nil | 1.12 | nd | 79.51 | nd | 0.24 | 70.17 |
| Silver | nil | nil | tr | nd | 8.98 | nd | 0.13 | 7.23 |
| Copper | 0.74 | 0.40 | tr | 0.87 | 7.52 | nd | 1.03 | 7.23 |
| Iron | 5.31 | 8.03 | — | 7.19 | nd | nd | 6.37 | 0.10 |
| Silicon | nil | 0.97 | 0.81 | — | — | — | — | — |
| Total | 94.36 | 100.45 | 93.06 | 95.43 | 101.69 | 97.10 | 94.61 | 91.10 |

nil = absent, nd = not detected, — = not determined, tr = trace.

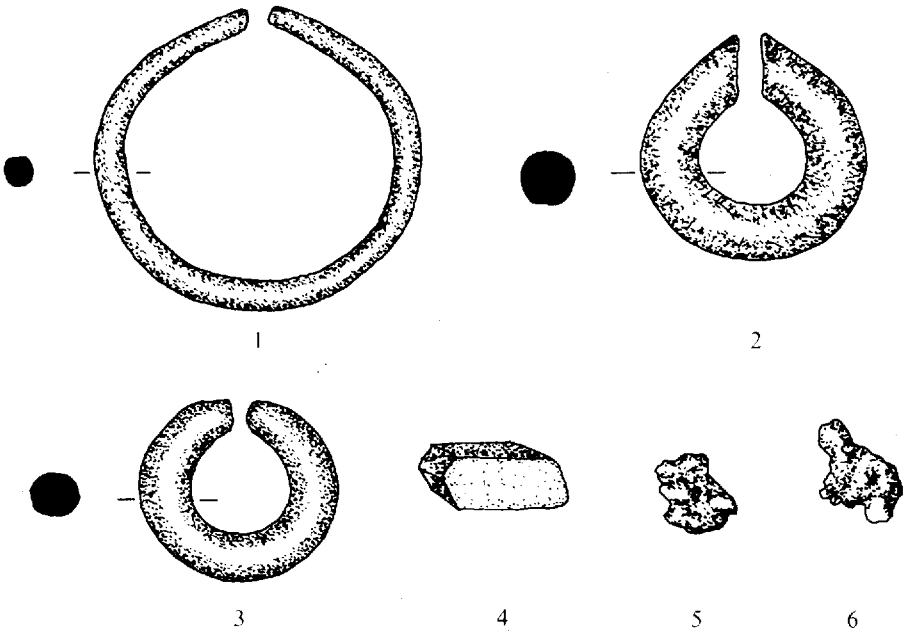



*Fig. 4 This schematic presentation of a selection of platinum alloy objects from South America depicts them here at approximately full size. 1. A gold-platinum nose-ring with grey coloured surfaces and with no large inclusions visible. (Restrepo, Valle del Cauca, Calima area; Museo del Oro 4201.) 2. A nose-ring of native iron-platinum with some small inclusions visible on the surface. The alloy is ferromagnetic. (Museo del Oro.) 3. A nose-ring of native copper-iron-platinum with small inclusions of iridosmine. The alloy is ferromagnetic. (Museo del Oro.) 4. A small ingot of gold-platinum alloy having pale silver-yellow coloured surfaces. The alloy is ferromagnetic. (National Museum of Denmark 08242.) 5 and 6. These two small lumps of sintered gold-platinum represent early stages in fabrication. (National Museum of Denmark 08267.)*

period from about 800 to 400 B.C. down to the European Conquest (28), but few scientific excavations have yielded metal objects from undisturbed contexts, and none of these items is of platinum. So far, the oldest evidence for any kind of metallurgy in this area consists of three pieces of cut and hammered gold wire found at Inguapi, near Tumaco, in a stratum dated by radiocarbon to 325 B.C. $\pm$ 85 years (29). By the third or fourth century A.D. copper objects are documented from La Propicia in Esmeraldas (28, 30) and at about the same time sophisticated metalwork in gold, silver, copper and various alloys becomes widespread in Pacific Ecuador.

The great archaeological site of La Tolita, reputedly the source of most of the platinum items in museum collections, has been dated by radiocarbon determinations which suggest that the site was occupied from A.D. 90 $\pm$ 60 to A.D. 270 $\pm$ 200 years, and had probably been abandoned by A.D. 800 at the latest (28). Unfortunately, because of re-deposition, it cannot be proved beyond doubt that the metal items washed from the earth at La Tolita are contemporary with the main occupation at the site, for gold jewellery of 'Tolita style' continued in use up to and beyond the Spanish Conquest, and is depicted in a portrait signed by Adrian Sanchez Galque and dated 1552 (31).

Further north at La Recasa, Linné found a gold nose ornament in which the platinum inclusions were clearly visible. This item came from a tomb which cannot be more recent than the 13th century A.D., and might be a few hundred years older (24, 32). Similar platinum metal inclusions can be seen in the nose-ring from San José de Palmar, part of which is shown in Figure 5.

In spite of these inadequacies, all lines of evidence suggest that platinum working has a long history in South America. The 'platinum problem' must have become apparent as soon as metalsmiths attempted to work the gold and platinum placer deposits from the gravels of the Pacific rivers, and in this context the early date from Inguapi is significant. By the early centuries of the Christian era, if not before, it seems likely that the technological problems had been solved.

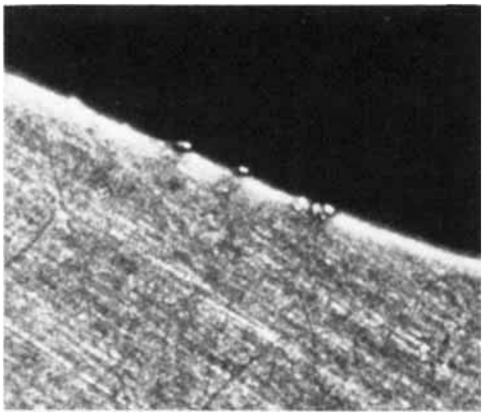


*Fig. 5 Part of a large crescent-shaped nose ornament of hammered metal found at San José de Palmar in the Andes on the edge of the Colombian Chocó. The detail shows grains of platinum in a gold alloy matrix, which is typical of objects made of unsorted material from placer deposits where platinum occurs in gold-bearing gravels. The platinum content may be high; analysis of river sands from Ecuadorian Esmeraldas gave 82.54 per cent gold and 17.46 per cent platinum. (Collection Dr. Hernán Borrero, Bogotá.)*

## The Working of Platinum

Pure platinum melts at about 1770°C which is much higher than the melting points of either gold at 1065°C or copper at 1085°C. The Indian smiths were able to melt and cast gold and copper alloys since the necessary temperatures could be obtained using a charcoal fire and blowpipe, the basic metallurgical equipment of the area. However the highest temperatures obtainable must have been in the region of 1200 to 1400°C, insufficient to melt platinum. It is also difficult to weld together small grains of native platinum to produce a compact mass, a difficulty enhanced by the presence of iron and other platinum group elements. There are two principal solutions to the problem of how to make use of this intractable material; either to use natural nuggets of sufficient size that small objects, such as nose ornaments, could be made in one piece, or to use small grains of platinum and attempt to bind them together with a fusible matrix such as gold, a process which has similarities to that of modern powder metallurgy. Pure platinum has a Vickers DPN hardness of about 50 and is quite soft and malleable; however native platinum grains were found to be appreciably harder, with DPN microhardness values ranging from 90 to 200, the reason for this being the iron content of the grains. Solid solution hardening as well as the existence of ordered phases may give rise to much higher hardness figures.

In the laboratory, a 6 weight per cent iron–94 weight per cent platinum alloy was prepared under inert conditions in an induction furnace. The hardness of the cast ingot was found to be 90 HV and by alternate cold-working in a percussion mortar and annealing at 900°C for 15 to 20 minutes it was possible to achieve a 50 per cent deformation, the small strip produced having a hardness of 130 HV. Large native iron-platinum nuggets could therefore be worked into nose-rings such as those shown in Figure 4.

Analysis by X-ray fluorescence (XRF) of the piece shown in Figure 4.2 detected the presence of palladium, rhodium, iridium, osmium, and iron besides the major platinum constituent. The surface of the nose-ring is well finished but a number of cracks appear in the surface, and the irregularities are particularly noticeable at the flattened ends where working was more severe. Another nose-ring, Figure 4.3, possesses a purple-brown patination with some

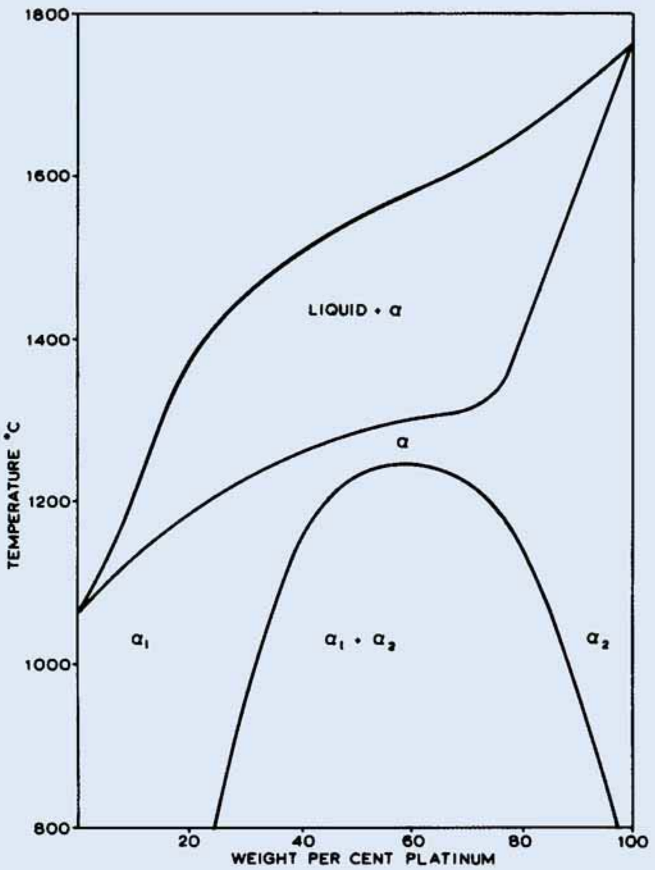



*Fig. 6 The gold-platinum equilibrium diagram shows a wide separation between the liquidus and solidus curves and the existence of a two-phase field between 25 and 97 per cent platinum, after Darling, Mintern and Chaston (33). Ancient gold-platinum alloys, made using temperatures well below the melting point of platinum, usually have solid solution compositions within the $a_1$ region and outside of the range of spinoidal decomposition ($a_1 + a_2$)*

osmiridium inclusions visible in the surface and a dark powdery interior. XRF analysis showed the presence of platinum and copper, with small quantities of palladium, iridium, osmium and iron. This piece has been fabricated from a natural cupro-platinum nugget; the purple-brown patina and powdery interior owing their origin to oxidation.

If a mixture of platinum grains and gold is heated with the blowpipe some interdiffusion will occur and the resulting sintered mixture can be worked to form small objects. The presence of platinum in solid solution, as well as the discrete platinum grains, produces a change in colour from gold to grey-yellow to grey-white as the platinum content increases.

The nature of the gold-platinum binary system has been thoroughly investigated and the diagram is shown in Figure 6 (33). Notable features include the wide separation between liquidus and solidus curves and the existence of a two-phase field between 25 per cent and 97 per cent platinum. Improved hardness values of gold-platinum alloys can be achieved by small additions of iron (34), an element already present in the native grains. Inherent alloying additions besides iron, such as copper and silver are often minor constituents of these gold-platinum alloys. Bergsøe found that such alloys possessed hardness values well over 200 HV in the cold-worked state (21).

The structural effect of sintering the grains together is to produce a gold-platinum alloy matrix containing a number of discrete platinum particles. The physical effect of fusion and working is to break down these particles into a fine dispersion of small globular remnants, the extent to which this occurs

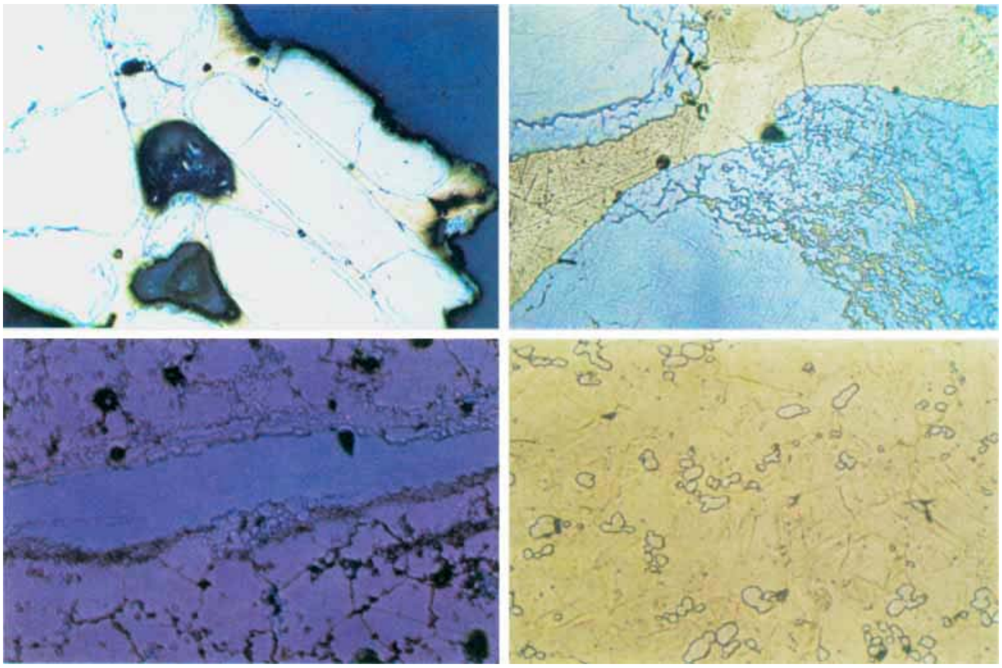


*Fig. 7 An etched sample of a sintered gold-platinum object from Esmeraldas, (illustrated top left, × 33) shows the structure to consist of native platinum laths in a gold matrix; these laths contain occasional platinoid inclusions. Examination at a higher magnification (top right, × 132) reveals the gradual dissolution of the platinum into isolated globular remnants. An etched section of a smaller sintered lump (bottom left, × 268) shows grain boundary precipitation with some larger platinum particles. The microstructure of the small gold-platinum alloy block from La Tolita (bottom right, × 132) consists of a remarkably homogeneous dispersion of small platinum globules in a gold-rich matrix; some platinoid inclusions occur in this alloy*

depends on the working history of the piece, the size of the platinum grains and the temperatures employed. The two small sintered lumps from Esmeraldas, illustrated in Figures 4.5 and 4.6, show the starting material during fabrication and the two top photomicrographs in Figure 7 show the microstructure of the larger piece. Part of the relatively large platinum nuggets in the top right photomicrograph can be seen to be breaking up gradually. A typical nugget composition, as determined by electron microprobe, was platinum 88, rhodium 2.8, copper 0.8 and iron 6.9 per cent with no iridium, osmium, gold or silver detected. Some small inclusions within the platinum were found to be of iridosmine while one inclusion was of native osmium. According to Ogden, there are no previous reports of native osmium inclusions being found in ancient platiniferous goldwork (4).

The structures of some of these alloys are by no means as straightforward as the sintered grains shown in the top pair of photomicrographs, Figure 7. For example, a section through the smaller of the sintered lumps from Esmeraldas, shown bottom left in Figure 7, reveals a much more intimate association between the two components, a small grain size, and the remnants of a large platinum mass only in the centre where it has been protected from the full effects of working. The grain boundaries are noticeably thickened by the precipitation of a very fine spheroidal phase. Electron microprobe analyses of the matrix, a gold-rich tumbaga alloy, and of the platinum globules can be found in the Table. Platinoid inclusions were again present and both iridosmine and osmiridium, as well as rutheniridosmine, were found.

The small rectangular block from La Tolita,

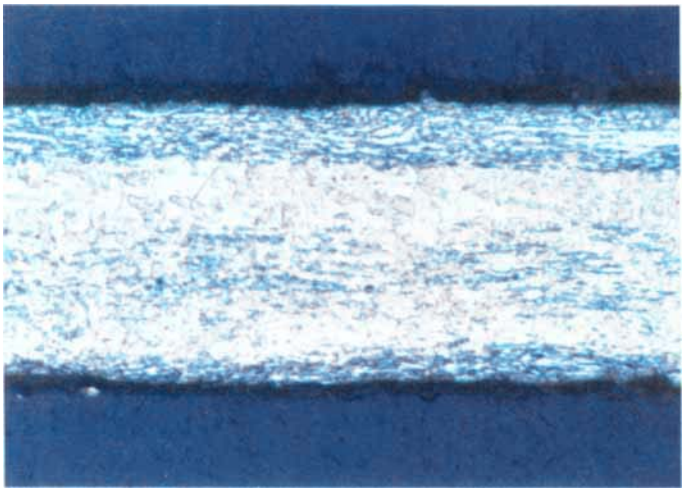


*Fig. 8 A section through part of the crescent-shaped dangler illustrated in Figure 3 shows that both surfaces are clad with platinum. Small platinum particles have been flattened out over the underlying gold and then burnished to produce a smooth, silvery appearance, etched × 230*

Figure 4.4, is made of a pale yellow gold-platinum alloy which is ferromagnetic. The block shows chisel marks at one end as if it had been cut from a longer strip. Metallographic examination of this piece showed a heavily worked gold-rich matrix of small twinned grains with a fine dispersion of evenly distributed platinum particles, some spheroidal precipitation and a few platinoid inclusions, as is illustrated in Figure 7, bottom right. This piece gave one of the highest microhardness values found during the investigations, 290 HV. The utilisation of alloys of this sort for making small needles, awls and other tools must have had practical benefits in terms of increased hardness and wear resistance.

Small ornamental pieces such as the danglers shown in Figure 3 could be produced in gold, in copper with hammered gold platings, or in gold clad with platinum on either one side or both sides of the object. One such piece is a small dangler shown in Figure 3 which is clad with platinum on both sides. The photomicrograph, Figure 8, clearly shows the nature of this platinum cladding. It is composed of a number of small particles flattened out over both sides and well burnished to produce a smooth and silvery finish. In a laboratory experiment, a crude simulation of this type of structure was accomplished using a sintered gold-platinum matrix on which was hammered some filings of a 4 per cent iron–96 per cent platinum alloy, with cycles of working and annealing at 700°C for about 20 minutes. After burnishing, this plated piece assumed a dark grey colour while the reverse remained golden, showing that this kind of simple technique could be employed.

There is no doubt, however, that to produce these small and delicate objects the ancient metalsmiths possessed craftsmanship of a very high standard, not only in the utilisation of a material which, in other areas of the World, was largely ignored, but in the control over working, annealing and cladding techniques.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