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Monte Romero September 1986 — the discovery of a unique Phoenician silver smelting workshop in south-west Spain

Monte Romero is a modern mine, now abandoned, located in the Sierra de Aracena, c. 100km. north of the town of Huelva. From the late nineteenth century until several years ago different ore bodies were mined here for copper, lead, zinc and silver, but many grooved mining picks found by mining engineers as far back as 1879 provided evidence for the exploration of these lodes in prehistoric times (I. Pinedo Vara, *Piritas de Huelva*, 1963, 403-9).

Several lodes of rather different mineralisation were recorded at Monte Romero belonging to two major types; one, mainly chalcocite, carbonates and chalcopyrites containing 6-20% copper, some native copper and only low Zn and Pb, the other mainly blende and galena. A typical sample of the latter contained (according to Pinedo): 16.2% Pb, 31.4% Zn, 2.1% Cu, 26.7% S, 9.0% SiO₂, 0.4% As, 0.6% Sb, 0.01% Sn, 0.09% Cl, 0.1% Fe, 500gms/t Ag, 1.5gms/t Au.

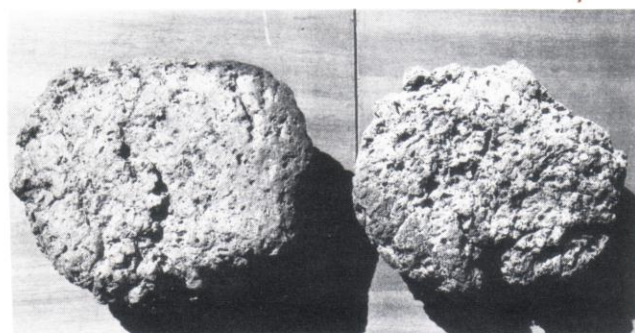
In view of the complexity of the latter ore lode, which is rather difficult to smelt, it must be assumed that the prehistoric grooved stone mining tools were originally used for the mining of copper ore, probably from outcrops on the upper slopes of the hills of Monte Romero, traces of which can still be seen.

IAMS's Huelva Survey 1974-75

In 1975 the IAMS research group to south-west Spain (The Huelva Archaeo-Metallurgical Project directed by Beno Rothenberg), located on top of a low hillock within the boundaries of Monte Romero, a small barren area, c. 30 × 20m., with different types of slag, clay tuyères, stone tools and potsherds (Site 56 on the Survey Map in B. Rothenberg and A. Blanco Freijeiro, *Studies in Ancient Mining and Metallurgy in South-west Spain*, London, 1981, 84-90). The pottery found at this site could be dated to the eighth-seventh centuries B.C. and appeared to be related to the Phoenicians. Our special attention was drawn to Monte Romero, not only by this apparently early date for the extraction and smelting of complex ores, hitherto considered unworkable by the ancient metallurgists, but also by the peculiar nature of the metallurgical debris indicating very sophisticated metallurgical processes.

The most outstanding find was a pile of complete slag balls - some globe-shaped, others like a rugby ball or bun-shaped, but all with a flattish surface, which gave the impression that they reflected the shape of the small furnace (c. 20-25cm. diameter) from which they originated. All of these slag

balls were extremely viscous and porous, showing many inclusions of free, unmolten quartz pieces (c. 1-2cm.) and could not have been tapped out of a furnace at the end of the smelting operation. Most of the slag was extremely dense (heavy) but some was of very low density (very light) and the chemical analyses (Samples HP146 and HP148, in Rothenberg-Blanco, *ibid*, 87) showed both to be silver slag. However, next to the ball slag we also found a handful of lumps of



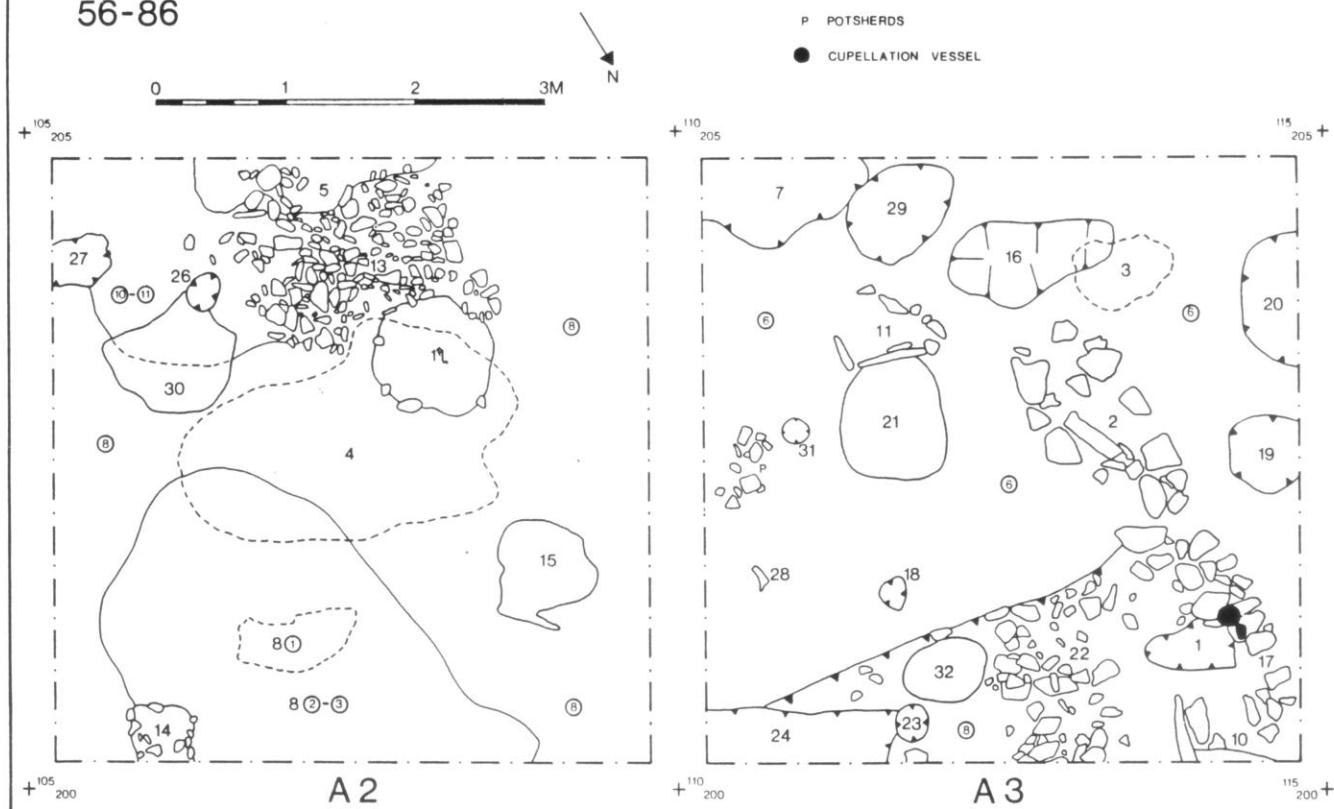
Typical ball-shaped silver slag.

Site 56, Monte Romero. The group of people stand in the area where the smelting remains were found in the survey and later excavated. In the background, recent mining dumps.



MONTE ROMERO

56-86



Preliminary plan of the excavation in September 1986, showing the installations in Squares A2 and A3.

solid platey tap slag with 'ripples' on the upper surface which, when analyzed (Samples HP147 and HP145A, in Rothenberg-Blanco, *ibid*, 86-7) proved to be copper smelting slag, some containing a considerable quantity of matte. Considering the sulphidic ores of Monte Romero, the presence of matte and fayalite slag was to be expected, but the free-silica containing ball slag, and the process which produced it, remained unexplained. Similarly unexplained was the fact that both types of slag – tapped copper slag and highly viscous non-tapped silver slag – appeared mixed together at one and the same spot on a 'Phoenician' site.

Monte Romero, as seen by the IAMS survey team, was clearly an enigma: prehistoric stone tools for mining at a complex ore deposit, together with several different, and not well-understood, slag types of copper and silver smelting and mainly handmade pottery of 'Phoenician' type. Only systematic excavation and very detailed archaeo-metallurgical research might solve these problems, which seemed to indicate a hitherto unknown chapter of the history of metallurgy.

Excavations at Monte Romero, September 1986

Excavations at Monte Romero were carried out in September 1986 as part of IAMS's Southern Iberia Archaeo-Metallurgical Project (*IAMS Newsletter* No. 5, 1983), sponsored by the Volkswagen Foundation, Hannover; Rio Tinto Minera A. S. Madrid, and Rio Tinto Zinc plc, London. Fieldwork and the archaeological processing of finds and findings were directed by Beno Rothenberg and Phil Andrews, and the scientific investigation of the metallurgical finds by I. Keesmann of Mainz University. The pottery will be studied by A. Perez-Macias, Rio Tinto Mining Museum.

Two adjacent squares of 5 × 5m. each (A2 and A3), containing the previous find spot were selected for excavation. Due to the shallowness of the soil cover above bedrock (20–40cm.), no complete metallurgical installations were preserved. However, enough debris and fragments were left, many *in situ*, to enable us to form a coherent archaeo-

metallurgical picture of two distinct but closely interlinked extractive processes which produced silver as well as copper from the same complex ore deposit.

Square A2: On roughly circular, hearth-like installations (as at Locus 12), where there was no slagging discernible, the sulphidic ore was apparently first 'roasted' in preparation for the smelting operation. It was then smelted in adjacent small furnaces, many fragments of which, consisting of slagged slate plates, were found in a heap (at Locus 13). A dark, charcoaly working floor spread over most of Square A2 and on it a heap of fine clay (Locus 5) was obviously raw material for furnace linings and tuyères.

The slagged furnace fragments were unusually heavy and did not show the porous slag build-up commonly met with in

Locus 12, an ore roasting installation.





A3 – Locus 1 in foreground, next to Wall Locus 2. In the background, slate-built installation, probably the hearth of a silver-producing workshop.

copper smelting furnaces (as in the Late Bronze Age furnaces at Timna, *IAMS Newsletter* No. 5, 1983) and it seemed that these fragments were heavily impregnated with lead. A well-preserved tuyère was found with the furnace parts and its slagging indicated its protrusion into the smelting hearth at an angle of c. 35° to the horizontal. A pile of slag next to the furnace spot consisted exclusively of lumps of solid tap slag. The density of many of these slag pieces indicated that matte was produced here as a phase of the production of copper and silver (see sample HP145A for matte and HP147 for copper, in Rothenberg-Blanco, *ibid*). Locus 30, which consisted mainly of a thin but rather hard layer of crushed slag (and most probably matte), could well have served as a 'roasting floor' of the matte, as part of its subsequent processing to metallic 'black copper'.

Square A3: At the north side of A2 and all over Square A3 a totally different picture was met with which was dominated by the free-silica rich ball-shaped slag and a peculiar kind of fired or charred yellowish soil, which was found next to and underneath some installations built of slate plates on edge (Loci 10, 11, 14). One of these installations (Locus 11) was relatively well-preserved and at its narrow end showed an opening with clay packing, perhaps the location of bellows. There was no slagging on any of the stone structures in Square A3, not even on Loci 11 and 10, which appeared to be some kind of furnace structures. The tuyères found in this area were also quite different. Although clearly fired and obviously used in a metallurgical process, they were not at all slagged and very brittle. The explanation for this fact may well be their shape, these tuyères were curved, i.e. used to blow air across the top of a crucible or cupel and not into a smelting hearth.

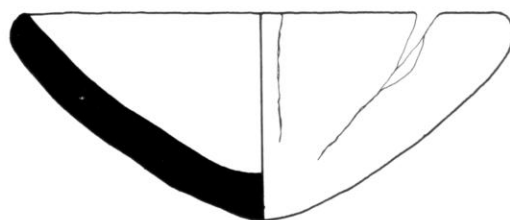
The most exciting part of the multi-phased extraction process found here spread from the south-east end of Square A2 to the north-west end of Square A3 and was found at Locus 1 in Square A3. Somehow related to Wall Locus 2 and stone 'platform', Locus 22, was a 'storage area' for used cupels, a number of which were found stacked on top of each other in a shallow depression in the bedrock. No such cupels had ever been found previously at a mining site and here were about a dozen complete ones. There was also a large quantity of heavy litharge spills and lumps, dispersed over this part of A3. Somewhere nearby must have been the cupellation centre where, at the end of the smelting process, lead was oxidized in a cupel to free the silver.



Curved tuyère in situ.



One of the cupels found in Locus 1 (scale in cm.).



A typical cupel for silver extraction – the first time such vessels have been found in excavation.

The tentative metallurgical process model

A metallurgical process model, albeit still tentative in detail, can already be proposed, based on the nature and locational sequence of the findings at Monte Romero and their preliminary metallurgical inspection:

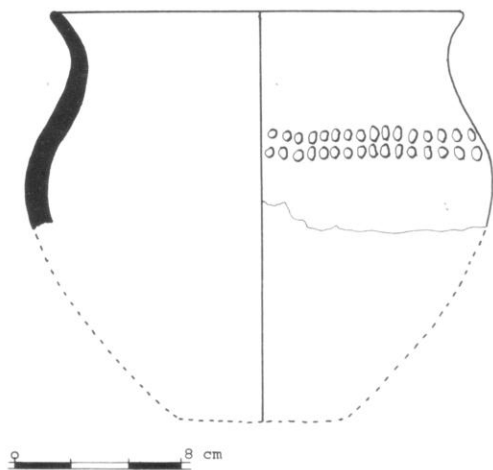
1 After some roasting of the complex ores of Monte Romero these were smelted in Square A2, or nearby, to a matte-like copper, lead and silver rich metallic compound. This was the first intermediate product of a complex chain of operations which ultimately produced silver and copper.

2 Subsequent liquation of this metallic compound together with additional lead, dissolved and collected most of the silver into the lead, which could then be separated from the copper matte by gentle heating.

3 The silver could then be separated from its lead collector by cupellation in the special vessel ('cupel') whereby the litharge (lead oxide) would be run out, leaving the metallic silver behind in the conical bottom of the cupel.

4 The litharge could be recycled by reduction to metallic lead to be used again in a further leading process of matte.

5 The desilvered matte was further (partially) roasted and then smelted (probably with silica flux) to metallic raw copper ('black copper'), a process which would produce the kind of copper slag found at the site.



Handmade decorated vessel, 'Phoenician' period, seventh–sixth century B.C.

The metallurgical principles underlying this extractive model are quite well known from much later historical and recent periods and were still expounded in early twentieth-century text books of metallurgy, but this is the first time that almost all of its components were actually found, and in a locational sequence, in an early smelting site.

We are, however, still left with one major problem: the much discussed 'Phoenician free-silica slag', i.e. the ball-shaped slag with large unmolten rock inclusions as found in Square A3, does not appear to fit into this process model. A further surprise awaited us here.

The investigation of the cupels and ball slag, although still in a preliminary stage, showed that very little remained of the original ceramic material of the cupels, which was replaced during the cupellation process by lead oxide containing many crystals of metallic silver as well as silver-rich metallic copper. We now have to recognise the free-silica ball-shaped slag as being a product of the melting down of the used cupels, and possibly also of heavily leaded furnace wall fragments (as found in a heap at Locus 13). The rock inclusions would have acted as a 'sieve' to facilitate the separation by gravity of the metal components, i.e. allowing the metal to drip through the porous conglomerate of unmolten rock fragments at a low temperature.

Although the pottery from the excavation has not yet been processed, it all seems to belong to the same 'Phoenician' horizon previously indicated by the survey findings.

Monte Romero is a unique site with its complete sequence from the complex ore deposit to the final cupellation and beyond. The study of the various products of Monte Romero will also provide essential new information for the understanding of many other ancient mining and metal working sites, where only partial and fragmentary evidence of metal production is available.

The historical implications of the appearance of such sophisticated extractive metallurgy at the time of the Phoenician cultural domination of southern Spain will be far-reaching, but more work must be done at the site and on the finds by archaeologists, scientists and historians, before major conclusions can be drawn from the surprising discoveries at Monte Romero.

Beno Rothenberg, Phil Andrews and Ingo Keesmann

Metal from the Depths of the Sea

In the wake of the discovery in the sea near Haifa, Israel, of ancient tin and copper ingots IAMS announced (*Newsletter* No. 1, 1980) a new archaeo-metallurgical research programme to study ancient metal trade routes as represented by metal hoards found in the sea. Preliminary investigation of the ingot finds strongly suggested the need for further, more intensive exploration in the sea in search of reliably located and better dated metal finds, before the commencement of a full-scale archaeo-metallurgical research programme. E. Galili of the Centre for Maritime Studies, Haifa University (CMSH), reports here on the finds made by recent underwater explorations (surveys and excavations). IAMS, in collaboration with Dr N. H. Gale of the Department of Earth Sciences, Oxford University, has now begun the systematic archaeo-metallurgical investigation of these important and, mostly, unique finds. The extractive-metallurgical aspects and the manufacturing processes of the different types of tin and copper ingots, together with their dating and provenance, will be investigated. This work is expected to contribute important information towards a better understanding of the trade routes of metal in the Ancient World.

The almost straight 2000km. long coastline of Israel did not provide any natural shelters from storms for the ships which sailed along this ancient shipping lane for thousands of years. Once caught in a storm, ships sailing close to the coast, as was normal in antiquity, found themselves trapped and had little chance of survival. Of the numerous ships that sank along Israel's coast in ancient times, about 9% have been found in the 200m.-wide breaker zone close to the shore.

The wooden parts of the wrecked and foundered ships, and the lighter items of their cargo, were washed away by the sea whilst the heavy items sank down to the sand-covered, hard clayey sea bottom. Here, for several thousand years, they have been protected by the sand cover from salvage and re-use by man.

In the last 30–40 years, huge quantities of sand have been quarried away by building contractors and others from many parts of Israel's coast. These activities disturbed the sedimentary equilibrium and thereby created a considerable shortage of sand on the shallow coastal shelf. Consequently, many areas which had been covered by a thick sand layer for thousands of years became uncovered and numerous archaeological sites and objects were exposed. Besides prehistoric settlements which had been swallowed up by the sea, many

