Recent excavations at the Neolithic site of Cerro Virtud (Almeria, southeast Spain) have produced new information about the development of metallurgy that may change ongoing research not only in the Iberian Peninsula but also in the rest of western Europe. The discovery of metallurgy in this region in the first half of the 5th millennium BC poses serious challenges to the interpretation of how this industry developed and spread, given that the nearest European region with similar evidence is the Balkans. This study presents the archaeological context of the discovery and the various analytical techniques (XRF, SEM, \(^{14}\)C) that have been applied to it.

Key-words: Neolithic, metallurgy, Spain, Cerro Virtud, \(^{14}\)C dating, XRF, SEM

Introduction
Rescue excavations in 1994 at Cerro Virtud (Almería, Spain), a site dated to the first half of the 5th millennium BC, have provided the oldest evidence for metallurgy in western Europe. This date is more than a millennium older than had previously been attested. The sole evidence consists of a sherd of an ordinary open-mouthed ceramic vessel that was used to smelt copper. The sherd has a layer of slag on its inner surface.

This discovery is not only important because of its date but also because of its cultural context. The study of the site and the surrounding region shows that the beginning of metallurgy is associated with the consolidation of mixed farming. Thus, metallurgical production begins during the process of Neolithicization in Iberia in an egalitarian social context showing no traces of hierarchical differences. Cerro Virtud revitalizes the traditional debate about metallurgy as a factor in social change and strengthens the hypothesis that it developed independently and autonomously in the Iberian Peninsula.

Diffusionism vs autonomous development of metallurgy
For years scholars believed that the most significant technological developments (such as metallurgy) had spread into Europe from the Near East (Wertime 1973; Savory 1968). Today, scholars no longer think in these terms; they generally consider that the development of these new technologies could have occurred in several parts of the world more or less simultaneously. Colin Renfrew was the first to propose the autonomous development of metallurgy in the Balkans (Renfrew 1969) and the Iberian Peninsula (Renfrew 1967; 1970). For the lat-
Renfrew based his hypothesis on the relative antiquity of metallurgy in Iberia and the absence of findings between this region and the Balkans. This absence has progressively been filled by a variety of metallurgical discoveries in the intermediate regions (Camps 1991; Guilaine 1991; Strahm 1994).

Systematic fieldwork to investigate the role of metallurgy in the development of prehistoric societies in southeast Spain began in the late 1970s, but it was not until the late 1980s that such research made a significant interpretative impact (Chapman 1990). These studies did not find any evidence of metallurgy older than the mid 4th millennium BC date proposed by Renfrew. In support of an autonomous development, Montero (1993; 1994) pointed out that prehistoric metallurgy was much more archaic in Spain than in the rest of Europe. This archaism is seen as the result partly of a distinct metallurgical tradition and partly of the slight importance of metal in the development of social complexity in the region (Gilman 1996). This tradition has three main features that should be emphasized:

1. The use of vase-ovens, a special kind of smelting crucible, for reducing ores, a system not as yet documented outside the Iberian Peninsula. The discovery of several fragments from the Bauma del Serrat del Pont (Girona) (Alcalde et al. 1998), close to the French boundary, also suggests its possible knowledge in the south of France.

2. The absence in the Iberian Peninsula of the characteristic crucibles with handles, found from the mid 4th millennium cal BC in almost all western Europe (France, Switzerland, Italy, Corsica, etc.) (Fasnacht 1991; Camps 1991).

3. The absence in southern Iberia of the clay tuyères frequent in metallurgical contexts in the rest of Europe (Gatiglia & Rossi 1995). These only appear in the late Chalcolithic in northern Iberian regions linked to the Atlantic and central European metallurgical spheres (Alcalde et al. 1998).

The discovery of metallurgical activity at Cerro Virtud changes the chronological aspect of this panorama.

**The Neolithic at Cerro Virtud and the origins of metallurgy**

The site is located (FIGURE 1) in the natural depressions found near the top of a hill that stands 35–40 m above the cultivated alluvium of the river Almanzora (Almería), 3 km from its mouth. It has a long sequence with various phases of Neolithic occupation, including the presence of a contemporary collective burial. As a result of the site's topography, there is no stratigraphic connection between some of the excavated areas. Other details about the site may be found in previous publications (Montero & Ruiz-Taboada 1996; Montero et al. 1999).

The material recovered has the typical characteristics of other sites of the so-called Impressed Ware Complex (Bernabeu 1989). The predominant decorative motifs of the pottery are parallel-line incisions, punctuations, impressions, digitations and appliqué cordons. There
are also comb-decorations, characteristic of the Spanish Levant, and red-burnished pottery, characteristic of Andalusian cave sites. The presence of decorative elements typical of these Neolithic traditions is hardly surprising since the site is located between the two regions, although the absence of cardial impressions should be noted.

The proportions of decorative motifs of the pottery from these levels places the occupations in the first half of the 5th millennium cal BC (phase IB2 of the Neolithic sequence defined by Bernabeu (1989)). The radiocarbon evidence from Cerro Virtud confirms this chronology, the dates falling between 6160±180 BP (5440–4690 cal BC at 95% probability, Beta-101424) and 5660±80 BP (4700–4350 cal BC at 95% probability, Beta-90884). Table 1 summarizes the proportion of decorative motifs from phase 1, square B2 (where the vase-oven was found), and phase 2 of Cerro Virtud and from other published sites in Andalusia and the Spanish Levant.

The metallurgical remains were recovered from square B2. (Three other fragments of different vase-ovens were also recovered from the trench (TR). This modern trench was filled up with prehistoric layers removed from closer
The stratigraphy of this sector consists of various modern mixed layers, a thin Chalcolithic layer, and below this a Neolithic deposit about 60 cm thick, resting on the clayey marl of the base (FIGURE 2). The fragment appeared in the lower part of the Neolithic level about 9 to 15 cm above the marl. This undisturbed layer corresponds to phase 2 of the site’s occupation. The chronology obtained on the basis of ceramic comparisons is confirmed by a radiocarbon date obtained from organic sediments in the layer, 5830±90 BP (4915–4475 cal BC at 95% probability, Beta-118936).

The vase-oven fragment (FIGURE 3) is 9 mm thick and barely 3 cm long. Remains of slag adhere to its inner face. Metallography permits the identification of small metallic globules within the siliceous matrix. These indicate its function as a container for the reduction of ore. The outer face reveals no trace of having been submitted to thermic action. The slaggy inner surface is the result of copper-ore reduction with charcoal. These features are commonplace in these types of objects and have been described elsewhere (Montero 1994: 227–30; Craddock 1995: 133–4).

XRF-EDS analyses were carried out in the Instituto de Patrimonio Histórico Español. Because the metallic globules formed a very small proportion of the matrix only a qualitative analy-
FIGURE 5. Copper mapping from a slaggy area of B2/10 fragment.

sis was possible. A minimal amount of copper was identified, as well as lead, antimony and barium in somewhat larger proportions. A scanning electron microscope (SEM) was used for a more detailed study of the distribution of these elements. The slag texture is not very homogeneous, but its basic composition was similar in the two analyses carried out with broad windows: Si, Ca, Al, K, Mg, Fe, N, S, and Cl were detected (FIGURE 4). Zone 2 was richer than zone 1 in Ca and Al and had also Ti.

Given the difficulty of aiming the microprobe at a point with copper, plus the low sensitivity of the method when it is not applied to a point, we opted for graphic mapping of the elements. As a result we detected copper (FIGURE 5), lead and antimony broadly dispersed in various microscopic fields. Although the slag is very leached, we deduce from these analyses that the vase-oven fragment was used to smelt copper ores that contained lead and antimony, among other impurities.

Other very light and porous fragments of slag were found beside the vase-oven fragment, and the same kind of slag was also found in the bottom levels of square B3 (phases 1 and 2). Several samples, all of them complex silicates, were studied. Various semiquantitative analyses were conducted on sample B3/30-5 from phase 2 using the SEM of the Universidad Autónoma de Madrid (TABLE 2). Some analyses detected the presence of barite (barium sulphate) and celestite (strontium sulphate) (TABLE 2: no. 3), types of minerals present paragenetically in the geological formations of the Vera Basin (in particular Herrerías and Sierra

<table>
<thead>
<tr>
<th>sample</th>
<th>Fe</th>
<th>Cu</th>
<th>As</th>
<th>Ag</th>
<th>Sb</th>
<th>Pb</th>
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<td>1-63</td>
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<td>0-93</td>
<td>4-67</td>
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<td>28-64</td>
<td>68-1</td>
<td>-</td>
<td>0-07</td>
<td>2-02</td>
<td>1-15</td>
</tr>
<tr>
<td>PA6354C</td>
<td>22-80</td>
<td>68-6</td>
<td>-</td>
<td>0-24</td>
<td>8-29</td>
<td>-</td>
</tr>
</tbody>
</table>

TABLE 3. Analysis by XRF of mineral samples from Mina Guadalupe, near Cerro Virtud. Only metallic fraction (% weight) considered.

Almagrera) and transferred into sedimentary deposits as a result of erosion.

None of the measurements detected copper, which probably means the sample was not a metallurgical slag. It seems to be a foamy glass produced by an intense fire, the sort of 'fuel ash slag' (Biek & Bayley 1979) that can be formed as a result of accidental fires in clayey settings or even in wooden structures. They appear frequently in Neolithic sites in southeast Europe as the result of long-used hearths or the destruction by fire of houses built of wood and clay (Glumac &
Todd 1991). Their external appearance is similar to copper slags, but the latter can be distinguished by their greater specific gravity.

The slags formed under these conditions share a low percentage of iron and calcium, according to Biek's (1977) analysis of specimens from a fire in a Roman granary. Their composition, however, largely depends on the characteristics of the medium that produces them. At Cerro Virtud, clayey marl composition is not like that described so far in the scientific literature. Marl is sedimentary and contains 40–60% calcium carbonate, the rest being clay. It might respond to intense heat or produce reactions in a manner similar to clay, since at Cerro Virtud the marl's texture is quite clay-like, and this would explain the high proportion of calcium and barium in the slags analysed from our site, indicating that a material with these characteristics was part of their formation process. The slags only appear in the lower levels of squares B2 and B3 of the site, where they were in contact with the clayey marl.

The metallic elements detected in the vase-oven correspond to the characteristics of the copper ore at Herrerias, located at the foot of the hill. Louis Siret's early 1900s analyses of samples from that locality showed a high proportion of Pb (Montero 1994: 101). New samples obtained in 1994 near the Guadalupe mine confirm the presence of lead.

Most of the metallic materials recovered from Cerro Virtud and from Bronze Age sites in the immediate vicinity of Herrerías contain lead, a circumstance that is rare at Almizaraque and other prehistoric sites in the region (Montero 1993; 1994). Thus, from the Neolithic onwards there seems to exist a direct relationship between the type of impurities found in copper ores and the metal found at particular sites. This suggests the inhabitants of sites exploited ores in their immediate vicinity.

Conclusion

The evidence indicates a very early start to metallurgy, with a date in the first half of the 5th millennium cal BC. This age is only exceeded in the Balkans and is similar to data drawn from northern Italy, a region closely linked geographically and culturally with the Balkans (Barfield 1996). There is no chronological and geographical continuity in the first appearance of metallurgy between the Orient and the western Mediterranean, suggesting an autonomous and independent development in Iberia.

The early evidence shows a full development of metallurgy involving the transformation and reduction of copper ores. The vase-oven method of ore reduction is present from the very beginning and continued in use throughout later Iberian prehistory. There are many examples, some of which even involved the use of decorated pottery (Alcalde et al. 1998). The probable use of local resources, at short distances from settlements, undoubtedly encouraged metallurgical experimentation.

Knowledge of metallurgy at Neolithic Cerro Virtud cannot have been an isolated phenomenon. This discovery warrants a contextual review of material recovered from earlier excavations. Many metal objects from collective megalithic burials associated with both Neolithic and Chalcolithic materials have been assigned to the latter period because of the assumption that metallurgy was absent in the Neolithic. Clear proof that the metal belongs to the older period will be difficult. We have a clear case, however, in the copper awl from the cave of La Cocina (Valencia): it was recovered from a secure stratigraphic context, a level that because of its lithic industry cannot, according to Bernabeu (1989: 136), be younger than phase IB of the Neolithic, an age comparable to that of Cerro Virtud. This find has always been interpreted as a proof, not of an early start of metallurgy, but as persistence of geometric microliths into the Chalcolithic. In the future we no doubt will obtain other finds in reliable archaeological contexts that will confirm the evidence from Cerro Virtud.

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References

Re-assessing the logboat from Lurgan Townland,
Co. Galway, Ireland

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Recent study of the prehistoric Lurgan logboat reveals many details of its construction and date. Speculation on how the boat was used and why it was incomplete offer an insight into Irish prehistory.

Key-words: logboat, Ireland, prehistory, peat bog, sea craft

Logboats have been found in northwestern Europe in large numbers and it is clear that they were in use from the Neolithic to late medieval times (Lanting & Brindley 1996). Because they are relatively robust, their survival rate compares favourably with other primitive craft such as log- and bundle-rafts and hide-covered vessels of the kind depicted in the Broighter gold model (McGrail 1996). The role played by logboats in the social economy of prehistoric Europe, however, has probably been underestimated, particularly in lowland areas

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