THE SWISS ALPS AS A COPPER SUPPLY FOR EARLY BRONZE AGE METALLURGY? A LEAD ISOTOPE ANALYSIS

Florence Cattin – University of Geneva, Switzerland
Igor M. Villa – University of Bern, Switzerland, and University of Milan - Bicocca, Italy
Marie Besse – University of Geneva, Switzerland

ABSTRACT

In this article, eleven copper archaeological artifacts from central Valais and attributed to the Early Bronze Age (BzA1), are studied on the basis of lead isotope analyses and the elementary chemical composition. They are compared with new data on the copper ore deposits of Valais and published analyses covering Europe. This study does not exclude the Valais copper ores sampled as raw material and demonstrates a multiplicity of provenances for the metal and cultural influences in the alpine environment of the Rhone Valley at the beginning of the Early Bronze Age.

Dans cet article, onze objets archéologiques à base de cuivre, provenant du Valais central et attribués au Bronze ancien (BzA1), sont étudiés sur la base d’analyses des rapports isotopiques du plomb et de la composition chimique élémentaire. Ils sont comparés avec des données nouvelles sur les minéralisations de cuivre valaisannes et avec des analyses publiées couvrant l’Europe. Cette étude n’exclut pas les minerais de cuivre du Valais échantillonnés comme matière première et elle montre une multiplicité des provenances du métal et des influences culturelles dans l’environnement alpin de la Vallée du Rhône au début du Bronze ancien.

KEYWORDS

Early Bronze Age, Valais, Switzerland, Copper finds, Copper minerals, Lead isotope analysis, Provenance

INTRODUCTION

This paper presents part of the data studied for a doctoral thesis in progress [6] entitled “Copper Metallurgy in the Alps during the 3rd millennium BC”¹. This research is integrated with a larger project², that seeks to better understand the populations of the 3rd mill. BC, in particular the Bell Beakers, by combining several approaches, including analysis of common ware, the chronology of ceramic types, territorial analysis and anthropological analysis using non-metric dental traits [2, 3].

1. COPPER DEPOSITS AND MINING ACTIVITIES

Copper deposits in the canton of Valais in the Swiss Alps, and in particular those of the Val d’Anniviers, have been suggested by several researchers as a possible procurement source for copper during the Late Neolithic and Early Bronze Age [18, 12, 21]. In this region, evidence of mining activities exists, but is primarily related to activity during the 18th and 19th centuries, or undated. Evidence of copper production is rare and little studied. Furnaces and slags have been found at Zeneggen/Kasteltschuggen (canton of Valais) [9], but have not yet been attributed to a specific period. At the same time, Valais is an early and rich region for the appearance of metal in
the context of the beginning of the Early Bronze Age in western Switzerland. The question raised addressed the link between the presence of such archaeological artifacts and the copper mineralizations. Proposing a hypothesis of a local origin, we consider whether the exploitation of copper-bearing deposits had an influence on the rapid development of the Rhone civilization in western Switzerland.

2. COPPER DEPOSITS IN VALAIS

Valais is part of the alpine system, for which the highly complex orogenesis is well-known. Its relief results from the collision of the European and Apulo-African plates, which involved two oceans (Valais and Piemonte) and a micro-continent (Briançonnais). The continents involved had already had, in their turn, a complex history dating around two billion years. The intense folding that occurred led to the thrust and superposition of sediments and crystalline bedrock sometimes over hundreds of kilometers. At the same time, deep strata underwent significant metamorphosis, gradually weakening from the internal to the external Alps. This turbulent genesis is naturally reflected in the multiple characteristics of copper mineralizations, when we consider their morphology, the nature of the host rock, their mineralogic and chemical composition and their geological history.

Lead (Pb) is always present in trace amounts in metal ores (copper, iron, tin, etc). Its isotopic composition is controlled by the geological evolution of the ore-bodies, and therefore potentially provides a characteristic fingerprint of each individual mining district [16]. As our data show, the Valais ore-bodies contain Pb with an isotopic composition that can be reliably distinguished from that of most other Mediterranean and Central European mining districts. The analysis of Pb traces provides the rationale for the present investigation.

![Map showing the principal copper mineralizations in Valais (dots) and the archaeological sites studied (stars). Source: DEM: SRTM 90, v3.](image_url)
For the canton of Valais, the Swiss Geotechnical Commission has inventoried 87 mineralizations containing copper in highly variable concentrations. Its exploitation is indicated for only 33 of these. At this stage of research, we have results from isotopic analysis of 30 Valaisian mineralizations, complemented by three other deposits that are in geographic proximity and analyzed as points of comparison: Roche Rouge at Leysin/Le Sepey in the canton of Vaud, Ollomont in the Val d’Aoste (Italy) and Alagna Valsesia in the Italian Piedmont (fig. 1).

Copper mineralizations studied to date are found primarily in the penninic domain (Grand-Saint-Bernard and Tsaté nappes) and, for one case, in the helvetic nappes (Roche Rouge at Leysin/Le Seppey, Vaud). The copper-bearing minerals are essentially chalcopyrite, CuFeS₂, tetrahedrite-tennantite or « fahlore » (Cu,Fe,Ag,Zn)₁₂(Sb,As)₄S₁₃, bornite, Cu₃FeS₄, and native copper, Cu. In many mineralizations, the copper minerals are associated with lead, zinc, iron, etc.

3. CULTURAL CONTEXT

During the initial phase of the Early Bronze Age, several cultural groups occupied well-defined regions on the periphery of the Alps [11]: the Leithaprodorsdorf group at the northeast end of the alpine arc, the Unterwölbling, Salzburg and Singen groups (the latter in the Lake Constance region), and the Polada culture on the southern edge of Lake Garda. The alpine valleys also show a human presence, with remains attributed to the “interalpine groups”, autochthonous (like the Bronze Ages of the Grisons) or under the influence of groups better represented on the edges of the Alps (Austrian Tyrol group, linked to the Straubing culture). Connections that affected central Valais at the beginning of the Early Bronze Age remain, for their part, unclear [10].

In western Switzerland, the work of David-Elbiali [10, 11] has demonstrated that archaeological discoveries linked to the first phase of the Early Bronze Age can be attributed to the preliminary phase of the Rhone culture (BzA1). Dated between 2200 and 2000 BC on the basis of a new chrono-typological classification, the material corresponding to this phase is limited to central Valais, outside of which can be added two other sites, one in the commune of Etrembières (Haute-Savoie, France), with a decorated paddle-shaped pin, and the other with an inhumation tomb at Thun-Wiler (canton of Berne, Switzerland), the latter lacking metal artifacts. The typology of copper artifacts, notably the paddle-shaped headed pins, closely resembles the discoveries in southern Germany (Straubing and Singen groups).

For this study, a collection of eleven archaeological objects belonging to BzA1 was defined in order to observe if the isotopic and chemical characteristics could be associated with local ore exploitation (fig. 2 and 3). The objects are from sepulchral contexts, all in central Valais (Switzerland): Ayent/Les Places, Conthey/Sensine (tombs 1 and 2) and Sion/Petit-Chasseur I (dolmen M XI, deposit 1). Although recovered during excavations at the end of the 19th century, the material from the inhumations at Ayent/Les Places and Conthey/Sensine can be attributed to the BzA1 phase on the basis of chrono-typological considerations. The cultural attribution of the elements from Sion/Petit-Chasseur has been confirmed by C14 dates (B2593, 3700 ± 100 BP, 2300-1900 BC) [19]. The typological range includes only ornaments: five lunulae, five pins and one small ring of rolled metal.

4. ANALYTICAL METHODS

For this study, two types of analyses were applied to the sample: determination of the lead isotope ratios and the elementary chemical composition.
Fig. 2: Archaeological material studied. 1-7, Ayent/Les Places (n° 740 d-h, 733, 735), 8-9, Conthey/Sensine (n° 11561, 11603), 10-11, Sion/Petit-Chasseur (n° 40249, 40250). After [4](1-7), [30](8-9), [20](10-11).

<table>
<thead>
<tr>
<th>Conservation location</th>
<th>N°</th>
<th>Site</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCAVS</td>
<td>733</td>
<td>Ayent/Les Places</td>
<td>elongated oval flat-headed pin</td>
</tr>
<tr>
<td>MCAVS</td>
<td>735</td>
<td>Ayent/Les Places</td>
<td>paddle-shaped pin, convex edges, small form</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740e</td>
<td>Ayent/Les Places</td>
<td>pendant, lunula</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740f</td>
<td>Ayent/Les Places</td>
<td>pendant, lunula</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740g</td>
<td>Ayent/Les Places</td>
<td>pendant, lunula</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740h</td>
<td>Ayent/Les Places</td>
<td>pendant, lunula</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740d</td>
<td>Ayent/Les Places</td>
<td>pendant, lunula</td>
</tr>
<tr>
<td>MNSZH</td>
<td>11603</td>
<td>Conthey/Sensine T.2</td>
<td>decorated paddle-shaped pin</td>
</tr>
<tr>
<td>MNSZH</td>
<td>11561</td>
<td>Conthey/Sensine T.1</td>
<td>paddle-shaped pin</td>
</tr>
<tr>
<td>MCAVS</td>
<td>40249</td>
<td>Sion/Petit-Chasseur, dolmen M XI, deposit 1</td>
<td>paddle-shaped pin, small form</td>
</tr>
<tr>
<td>MCAVS</td>
<td>40250</td>
<td>Sion/Petit-Chasseur, dolmen M XI, deposit 1</td>
<td>small ring of rolled metal</td>
</tr>
</tbody>
</table>

Fig. 3: Corpus of archaeological objects studied.
Identification of the lead isotope ratios was made for 30 copper ore bodies (58 measurements) and 11 archaeological objects (11 measurements) (fig. 4). These analyses were carried out by the authors at the Laboratory of Isotope Geology at the University of Bern using a Nu Instruments™ multicollector inductively coupled plasma mass spectrometer (MC-ICP-MS).

The corpus was sampled beforehand from the mineralogy collection at the Cantonal Museum of Geology in Lausanne for the minerals and in the collection of the Cantonal Museum of Archaeology in Sion and the Swiss National Museum in Zurich for the archaeological objects. Samples were obtained by scraping, after having initially removed the altered outer surface, or by drilling (for material from the Swiss National Museum). These then underwent a procedure to collect the lead on cation exchange resins before the analysis itself. In order to estimate the precision provided by spectrometry, several measurements of the NIST SRM 981 standard were taken. The 31 measurements of the standard taken to date give weighted averages of 16.9466 ±0.0057 for the \(^{206}\text{Pb}/^{204}\text{Pb}\) ratio, 15.4942 ±0.0057 for the \(^{207}\text{Pb}/^{204}\text{Pb}\) ratio, 0.91430 ±0.00007 for the \(^{207}\text{Pb}/^{206}\text{Pb}\) ratio and 2.1667 ±0.0002 for the \(^{208}\text{Pb}/^{206}\text{Pb}\) ratio. These values compare favorably with those reported in the literature (e.g. [17]). Therefore, we present here our measured values without any further bias correction.

**Analysis of elementary chemical composition**

To date, we have obtained results of analysis of the elementary chemical composition for ten archaeological objects (fig. 7). Two previous measurements (MNSZH 11561 and 11603) resulted from analyses carried out by Mr Voute (Swiss National Museum) in 1978-80 by XRF, on metal sampled by coring (S. Van Willigen and E. Hildbrand, Swiss National Museum, pers. comm.). Six objects (740 e, f, g, h, 733, 735) were analyzed by the Stuttgart group [23], of which four were remeasured by modern techniques. Six new analyses were thus carried out. The method used employed a laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS). Advantages of this method include its minor degree of invasiveness and the absence of sampling and preparation before measurements - the analysis is carried out directly on the object, which was placed inside the measurement chamber, and the potential to simultaneously measure more than 70 different chemical elements [7].

**5. RESULTS AND DISCUSSION**

The principal aim of the study was to examine lead isotopes in archaeological objects and their relationship to the signature of potentially exploited minerals. In the first phase, the issue of homogeneity/heterogeneity of the archaeological sample was addressed. Next, the data were compared with the different signatures of the copper mineralizations, including analyses carried out on the Valaisian ores. Chemical analyses were considered as a supplementary discriminating element and not as a study in itself. Given this, questions concerning the types of metal are not addressed here.

**Analysis of the sample**

Excluding the measurement for object 11561 (paddle-shaped pin), which has an error 16 times greater than the mean, the isotopic measurements have an average standard deviation (2\(\sigma\)) of 0.12% for the \(^{206}\text{Pb}/^{204}\text{Pb}\) ratio, 0.11% for the \(^{207}\text{Pb}/^{204}\text{Pb}\) ratio and 0.01% for the \(^{207}\text{Pb}/^{206}\text{Pb}\) and \(^{208}\text{Pb}/^{206}\text{Pb}\) ratios.
<table>
<thead>
<tr>
<th>Conservation location</th>
<th>N°</th>
<th>$^{208}\text{Pb}/^{204}\text{Pb}$</th>
<th>$^{207}\text{Pb}/^{204}\text{Pb}$</th>
<th>$^{206}\text{Pb}/^{204}\text{Pb}$</th>
<th>$^{208}\text{Pb}/^{206}\text{Pb}$</th>
<th>$^{207}\text{Pb}/^{206}\text{Pb}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCAVS</td>
<td>733</td>
<td>38.487±0.017</td>
<td>15.666±0.006</td>
<td>18.373±0.032</td>
<td>2.09535±0.00042</td>
<td>0.85290±0.00010</td>
</tr>
<tr>
<td>MCAVS</td>
<td>735</td>
<td>38.516±0.174</td>
<td>15.671±0.069</td>
<td>18.396±0.081</td>
<td>2.09385±0.00066</td>
<td>0.85183±0.00027</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740d</td>
<td>39.057±0.012</td>
<td>15.701±0.004</td>
<td>18.755±0.003</td>
<td>2.08241±0.00026</td>
<td>0.83717±0.00007</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740e</td>
<td>38.591±0.012</td>
<td>15.652±0.004</td>
<td>18.731±0.003</td>
<td>2.06024±0.00033</td>
<td>0.83559±0.00007</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740f</td>
<td>38.994±0.013</td>
<td>15.697±0.004</td>
<td>18.741±0.003</td>
<td>2.08069±0.00031</td>
<td>0.83757±0.00009</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740g</td>
<td>38.707±0.014</td>
<td>15.649±0.005</td>
<td>18.770±0.004</td>
<td>2.06235±0.00027</td>
<td>0.83375±0.00010</td>
</tr>
<tr>
<td>MCAVS</td>
<td>740h</td>
<td>39.055±0.020</td>
<td>15.702±0.007</td>
<td>18.759±0.004</td>
<td>2.08180±0.00045</td>
<td>0.83703±0.00014</td>
</tr>
<tr>
<td>MNSZH</td>
<td>11603</td>
<td>38.473±0.028</td>
<td>15.608±0.011</td>
<td>18.417±0.013</td>
<td>2.08896±0.00018</td>
<td>0.84747±0.00007</td>
</tr>
<tr>
<td>MNSZH</td>
<td>11561</td>
<td>37.395±0.710</td>
<td>15.346±0.272</td>
<td>18.051±0.344</td>
<td>2.07158±0.00194</td>
<td>0.84610±0.00126</td>
</tr>
<tr>
<td>MCAVS</td>
<td>40249</td>
<td>38.556±0.077</td>
<td>15.708±0.031</td>
<td>18.422±0.038</td>
<td>2.09285±0.00017</td>
<td>0.85269±0.00008</td>
</tr>
<tr>
<td>MCAVS</td>
<td>40250</td>
<td>38.490±0.004</td>
<td>15.680±0.001</td>
<td>18.241±0.001</td>
<td>2.11000±0.00012</td>
<td>0.85961±0.00002</td>
</tr>
</tbody>
</table>

Fig. 4: Lead isotope ratios for the objects studied (analytical uncertainties are shown as 2σ).

Figures 5 and 6 represent the analyses on the 11 archaeological objects from central Valais. At first view, a relevant segregation criterion seems to be the type considered: the lunulae, the pins and the small ring being in distinct zones. A more detailed examination shows that the archaeological measurements form three clusters (group 1: 740 d, f, h; group 2: 733, 735, 40249; group 3: 740 e, g). Three objects remain isolated (11561, 11603, 40250). Elements of group 1 are sufficiently close to attribute them to the same mining district. Objects 740 d and h are so similar that we can suggest the hypothesis that they were made from the same raw material, confirmed by the chemical composition as well as the near-identical decoration. The three lunulae were made of very pure copper.

Group 2 includes three pins for which the isotopic signature, corroborated by chemical analysis (known for two of the three) and typology, demonstrate a clear link. Distinguished on the basis of lead isotopes from the three isolated elements, these objects however share a similar elevation in trace element rates.

In contrast, results for group 3 are more distant and examination of the chemical composition, notably the elevated rates of Ni and Ag for lunula 740 g, definitively excludes a common origin for the two lunulae. It is of interest to note their proportions of tin, 3.9 and 2.2%. They are thus alloys.

**Provenance of the metal**

At this stage of the study, the question of exploitation of the 30 copper mineralizations in Valais and adjacent regions analyzed can be resolved by their relationship to the archaeological objects of central Valais attributed to the BzA1. Based on data obtained to date, it is not possible to exclude with certainty a Valaisian origin for the decorated paddle-shaped pin 11603 (Gosan, Fusette and Termino copper deposits). For the rest of the sample, isotopic analyses indicate, in detail, an incompatibility with the copper ores analysed [6], even if some of the objects (733, 735, 40249) plot globally in an alpine field, but not in a special mine. In this case, we must search elsewhere for the sources(s) of metal used for their fabrication.

To attempt to identify a provenance, comparative data were collected from different literature sources [7]. The Pb isotope ratios from the literature, unless indicated otherwise, are assumed to have an analytical uncertainty of 0.1%.
Comparison of the lead isotope ratios from lunulae 740 d and 740 h coincide perfectly with the mines of Capanna Vecchie and La Pesta at Massa Marittima (Tuscany, Italy). Object 740 f is also quite similar. These three objects have very low values for As, Ag, Sb, Au and Bi. In figure 5 ($^{208}\text{Pb}/^{206}\text{Pb}$ versus $^{207}\text{Pb}/^{206}\text{Pb}$), lunulae 740 e and 740 g are at the limits of one of the analyses (outside the main field) for the Viarli Briag (Burgarski) mine in Bulgaria, which does not permit a solid attribution. The presence of tin in these two objects indicates an intentional mixing of two sources of metal.

The two pins from Ayent/Les Places (733 and 735) are difficult to characterize. In effect, several isotopic fields coincide. Nevertheless, the chemical composition demonstrates that these two pins are made of fahlore, which limits the possible sources to either Innsbruck or Brixlegg in Austria. It is surprising to observe on all three graphs ($^{207}\text{Pb}/^{204}\text{Pb}$ versus $^{206}\text{Pb}/^{204}\text{Pb}$, $^{208}\text{Pb}/^{206}\text{Pb}$ versus $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{208}\text{Pb}/^{204}\text{Pb}$ versus $^{206}\text{Pb}/^{204}\text{Pb}$) that the data from pin 733 is systematically superimposed on that from the Welsh mine of Sygun (Gwynedd, Snowdonia). The chalcopyrite found at this source did not, however, reach the elementary chemical values measured. Pin 40249 is not incompatible with certain Cretan (Miamou) and German (Mansfeld, Harz and Ludwigsdorf, Oberlausitz) data. In addition to Valaisian sources, the paddle-shaped pin 11603 is compatible with some data from Anatolia (Black Sea region).
Fig. 6: Graph of $^{207}\text{Pb} / {204}\text{Pb}$ versus $^{206}\text{Pb} / {204}\text{Pb}$ for the BzA1 archaeological samples from Ayent/Les Places, Conthey/Sensine and Sion/Petit-Chasseur (central Valais, Switzerland). (When absent, the error bar is less than the point.)

Ring 40250 could correspond to German sources in Freiberg (Erzgebirge) and Kamsdorf (Thüringer Wald, Harz). Its chemical composition, comparable to fahlores but with a low Ag and Sb content, could be due to a mixture of two types of metal.

Pin 11561 could not be linked to any mineral data from the literature.

**Archaeological analysis**

The dispersion of isotopic data for BzA1 indicates widespread and quite diversified trading activity. The metal used for our objects obviously derived from at least four different mining districts. This lack of characterization is doubled by a relatively important scattering for certain isotopic fields of ores in the frame considered.

The single univocal element concerns the three lunulae (740 d, f, h), for which the metal indicates a Tuscan origin, precisely in an isotopic field clearly distinct from the others. The two other objects of this type (740 e, g), considered elsewhere as “Valaisian”, resist any attribution. So, the lunulae from Ayent/Les Places included in this study come from three different metal sources, as is demonstrated by both lead isotope analysis and elementary chemical composition.

In central Valais, we have inventoried ten lunulae (9 at Ayent/Les Places, 1 at Conthey/Sensine T.2). Some very similar pieces were recovered at Saint-Martin de Corléans (Aoste, Italy), in the Singen necropolis (Germany), in two tombs in Upper Bavaria (Munich and Raisting, Germany), and on the edge of Lake Ledro (Italy) [11, 24]. Their low number, however, excludes defining the
origin zone of this type with precision.

Oval and paddle-shaped pins, decorated or not, are found in majority on the Middle and Upper Danube, as well as on the Middle Rhine [11]. The isotopic signatures we have obtained for this type of object can be linked with the most conviction, although less specifically, to the Austrian ores of Brixlegg and Innsbruck, and to the German sources at Mansfeld (Harz) and Ludwigsdorf (Oberlausitz). The Cretan source seems less probable for pin 40249. Pin 11603 has a good coherence with some data from the Black Sea, but its elementary chemical composition, for which impurities show an elevated rate in Sb, As, Ag and Ni, would better correspond to the galena and fahlores deposits at Fusette, Termino and Gosan, in Valais (Switzerland).

<table>
<thead>
<tr>
<th>Conservation Location</th>
<th>N°</th>
<th>Analyzing Laboratory</th>
<th>Fe</th>
<th>Co</th>
<th>Ni</th>
<th>Sn</th>
<th>Pb</th>
<th>Se</th>
<th>Zn</th>
<th>As</th>
<th>Ag</th>
<th>Sb</th>
<th>Te</th>
<th>Au</th>
<th>Bi</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNSZH 11561</td>
<td>1</td>
<td>60</td>
<td>1100</td>
<td>15'000</td>
<td>n.d.</td>
<td>1000</td>
<td>n.m.</td>
<td>2500</td>
<td>6500</td>
<td>12'000</td>
<td>16'000</td>
<td>n.m.</td>
<td>n.m.</td>
<td>n.m.</td>
<td></td>
</tr>
<tr>
<td>MNSZH 11603</td>
<td>1</td>
<td>600</td>
<td>2800</td>
<td>20'000</td>
<td>n.d.</td>
<td>600</td>
<td>n.m.</td>
<td>19'000</td>
<td>9500</td>
<td>20'000</td>
<td>n.m.</td>
<td>n.m.</td>
<td>n.m.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCAVS 40250</td>
<td>2</td>
<td>44</td>
<td>5</td>
<td>1670</td>
<td>68</td>
<td>7033</td>
<td>23</td>
<td>7</td>
<td>15'900</td>
<td>1482</td>
<td>1485</td>
<td>8</td>
<td>5</td>
<td>590</td>
<td></td>
</tr>
<tr>
<td>MCAVS 40250 d</td>
<td>2</td>
<td>56</td>
<td>0.3</td>
<td>244</td>
<td>3135</td>
<td>5</td>
<td>35</td>
<td>75</td>
<td>66</td>
<td>159</td>
<td>6</td>
<td>0.3</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCAVS 740 e</td>
<td>3</td>
<td>Traces</td>
<td>0</td>
<td>Traces</td>
<td>39'000</td>
<td>4100</td>
<td>n.m.</td>
<td>0</td>
<td>0</td>
<td>&lt;100</td>
<td>0</td>
<td>n.m.</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCAVS 740 g</td>
<td>3</td>
<td>Traces</td>
<td>0</td>
<td>1100</td>
<td>22'000</td>
<td>920</td>
<td>0</td>
<td>0</td>
<td>1200</td>
<td>Traces</td>
<td>n.m.</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCAVS 740 h</td>
<td>2</td>
<td>37</td>
<td>0.6</td>
<td>29</td>
<td>31</td>
<td>221</td>
<td>2.1</td>
<td>28</td>
<td>13</td>
<td>61</td>
<td>54</td>
<td>6</td>
<td>0.2</td>
<td>13.6</td>
<td></td>
</tr>
<tr>
<td>MCAVS 740 h f</td>
<td>2</td>
<td>31</td>
<td>0.8</td>
<td>54</td>
<td>533</td>
<td>36</td>
<td>0</td>
<td>282</td>
<td>32</td>
<td>110</td>
<td>66</td>
<td>9</td>
<td>0.5</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>MCAVS 733</td>
<td>2</td>
<td>38</td>
<td>940</td>
<td>21'300</td>
<td>361</td>
<td>24</td>
<td>0</td>
<td>34</td>
<td>7980</td>
<td>12'100</td>
<td>14'920</td>
<td>0</td>
<td>8</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>MCAVS 735</td>
<td>2</td>
<td>240</td>
<td>347</td>
<td>10'800</td>
<td>346</td>
<td>39</td>
<td>0</td>
<td>68</td>
<td>6279</td>
<td>16'400</td>
<td>12'200</td>
<td>0</td>
<td>7</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7: Elementary chemical composition for the objects analyzed (in ppm). Analyzing laboratories: 1: Swiss National Museum in Zurich, Mr Voute (S. Van Willigen and E. Hildbrand, pers. comm.); 2: Swiss National Museum in Zurich, Cattin, Wörle, Besse. 3: Project SAM, Studien zu den Anfängen der Metallurgie [23], where 0 is equivalent to <100. N.m.: not measured. N.d.: not detected.

6. CONCLUSION

The eleven objects from central Valais attributed to the beginning of the Early Bronze Age (BzA1) were made from copper from several provenances, of which the most significant if the Tuscan origin (3 lunulae). For these objects, it is difficult to conclude whether this was diffusion of raw metal or finished pieces, given that the style, although considered “Valaisian”, cannot be linked to one region in particular.

On the other hand, the other analyzed objects have Pb isotopic compositions that can be ascribed to mixing between any of a very large number of possible ore deposits across Central Europe and the Mediterranean. A similar history of underconstrained signatures due to mixing was described for Imperial Roman Pb [5]. The most striking feature of these data is the existence of clearly distinguishable clusters that require intensive trade with very diverse mining districts, one of which was likely to be Tuscany, and the others could be in Central Europe or even (at least to a small extent) in the Valais itself.

In the next phase of this doctoral research [6], it would be useful to consider if these privileged links
resulted from previously existing networks or not, and if they were maintained with the development of bronze metallurgy.

ACKNOWLEDGMENTS

This research in progress is founded by the Swiss National Science Foundation under the project "Le Chalcolithique européen : céramique, cuivre et histoire du peuplement" (proposal PP001-102710)[6]. This work is also made possible thanks to the Action COST G-8 n° 05.0082 (Marie Wörle, Swiss National Museum in Zurich, and Marie Besse, University of Geneva), the Fondation Ernst & Lucie Schmidheiny, the Cantonal Museum of Geology in Lausanne (Nicolas Meisser, Stefan Ansermet), the Natural History Museum Bern (Beda Hofmann), the Archaeology Museum in Sion (Philippe Curdy), the Cantonal Museum of Archaeology of Neuchâtel in Hauterive (Beat Arnold), the Swiss National Museum in Zurich (Samuel Van Willigen), the Cantonal Museum of Archaeology and History in Lausanne (Gilbert Kaenel, Ariane Winiger) and the Laboratory of Isotope Geology, University of Bern (Igor M. Villa).

NOTES

1. Doctoral thesis under the direction of Professor Marie Besse in the Laboratory of Prehistoric Archaeology and Human Peopling History, Department of Anthropology and Ecology, University of Geneva.
2. Project « Le Chalcolithique européen : céramique, cuivre et histoire du peuplement » (PP001-102710), financed by the Swiss National Science Foundation (FNS) and begun in 2004, for a duration of four years.
4. MCAVS: Musée cantonal d’archéologie du Valais in Sion (Philippe Curdy).
5. MNSZH: Musée national suisse in Zurich (Samuel Van Willigen).
6. Analyses carried out at the Eidgenössische Technische Hochschule (ETH) in Zurich, in the framework of a project of European cooperation in the domain of scientific and technical research (Action COST G-8 n° 05.0082), under the direction of Marie Wörle of the Swiss National Museum in Zurich and Marie Besse of the University of Geneva.
7. [34], [8], [13], [14], [26], [32], [33], [15], [28], [16], [1], [31], [35], [25], [29], [22], [27].

REFERENCES

6) F. CATTIN, La métallurgie du cuivre au 3e millénaire avant notre ère dans les Alpes. (PhD thesis in progress: Fac. des sci. ; Anthrop.).