Natural resources, technology and manufacture processes
Archeometric analyses on the material assemblages and architectural components of Mature Early Syrian Ebla

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A wide project of multidisciplinary archaeometric analyses on material assemblages (pottery and clay objects, base and precious metals, stone and bone items) dating from the Early Bronze Age IVA (c. 2400-2300 BC) has been planned as a part of the Ebla Chora Project, funded by the European Research Council (FP7–IDEAS 249394), in order to investigate the manufacture processes, the technological degree of specialization and the intersections between crafts and exchange systems at local and interregional levels. In particular the relationships between the urban town and its environment and the strategies of procurement, exploitation and consumption of natural resources and raw material in the region of Ebla is primarily the focus of the pottery and architectural components analyses, whereas precious and base metals have been studies in order to recognize alloys, metalworking technique and operational processes, which can be usefully compared with information coming from the cuneiform texts of the Royal Palace G. The identification and mineralogical characterization of common stones (limestone and basalt stones) and stones not locally available (steatite, chlorite, lapis lazuli, carnelian, iron oxides, jasper, etc.) used to manufacture EB IV objects, is intend to arrange thematic geo-archaeological maps in order to distinguish local vs. foreign resources.

Metal Analysis

Seven gold objects from Royal Palace G (L.2982) have been analyzed using a portable Energy Dispersive X-Ray Fluorescence (ED-XRF) spectrometer operating in air. In **Fig. 1a** is shown the ED-XRF spectrum obtained on one point of the gold arm of a composite statuette. All the analyzed objects never consist of pure gold but they are constituted of a binary alloy of gold and silver with a small amount of copper. In **Fig. 1b** is shown the concentration of these three elements together with the concentration obtained for the TM.89.G.0267a-d gold sheets analyzed with SEM-EDS by Palmieri and Hauptmann. The silver concentration ranges from 4 wt. % to about 30 wt. % and therefore partly reaches the composition of the natural alloy of gold and silver, the electrum (30-45 wt. %). Several objects show an amount of copper greater than 1 wt. %, above the level found in natural gold and gold-silver alloys. This result suggests that these objects were probably manufactured, not by using 'primary' gold-silver alloys, but re-melting gold based materials containing intentionally added copper.
The dagger (TM.83.G.0378) was analyzed by means of ED-XRF spectrometry to obtain information on the alloy composition and the results were compared to data obtained by Palmieri and Hauptmann on others bronze objects by using Inductively Coupled Plasma Spectroscopy (ICP-OES). The analyses show that all the objects are constituted of a copper-tin alloy (**Fig. 2**) and thus they can be classified as tin bronzes. For three bronzes (TM.79.G.0143, TM.78.G.0344, TM.79.G.0144) the tin amount correspond to the 'ideal' bronze composition with nine parts of copper and one of tin, as mentioned in the cuneiform tablets.

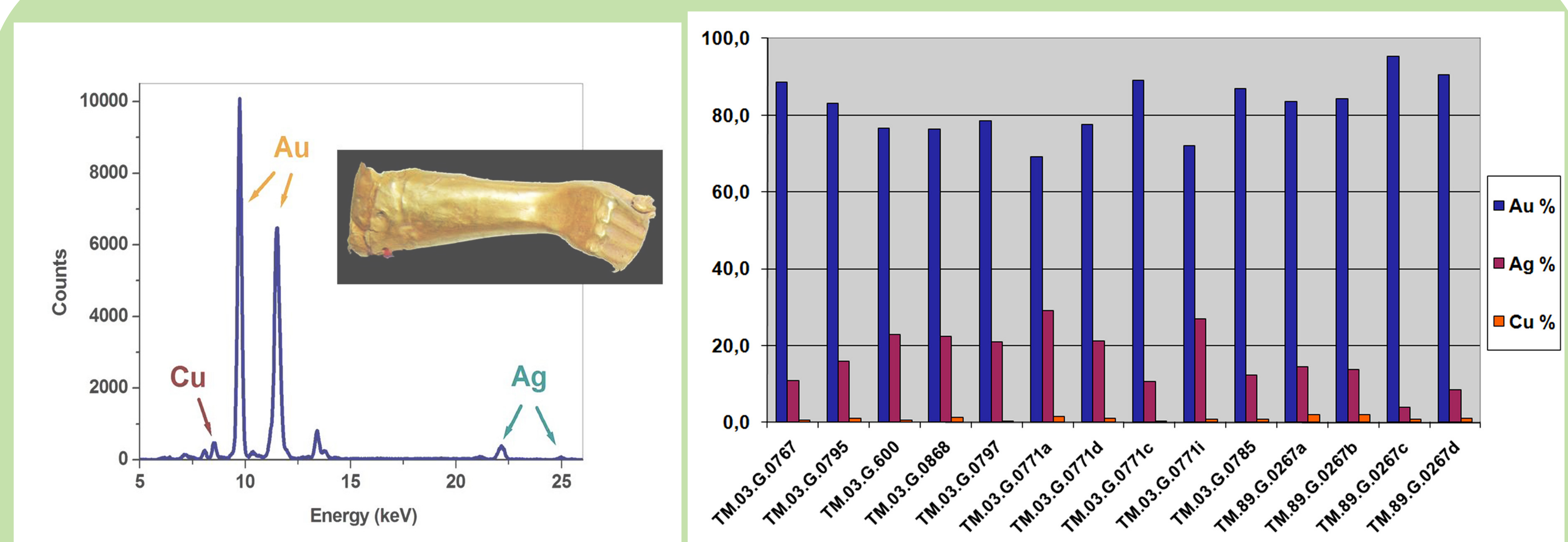

Fig. 1. – **1a.** Energy Dispersive X-Ray Fluorescence spectrum (TM.03.G.600).
1b. Gold (Au), silver (Ag) and copper (Cu) concentrations (wt. %) obtained by ED-XRF analysis and SEM-EDS microanalysis (TM.89.G.267a-d).

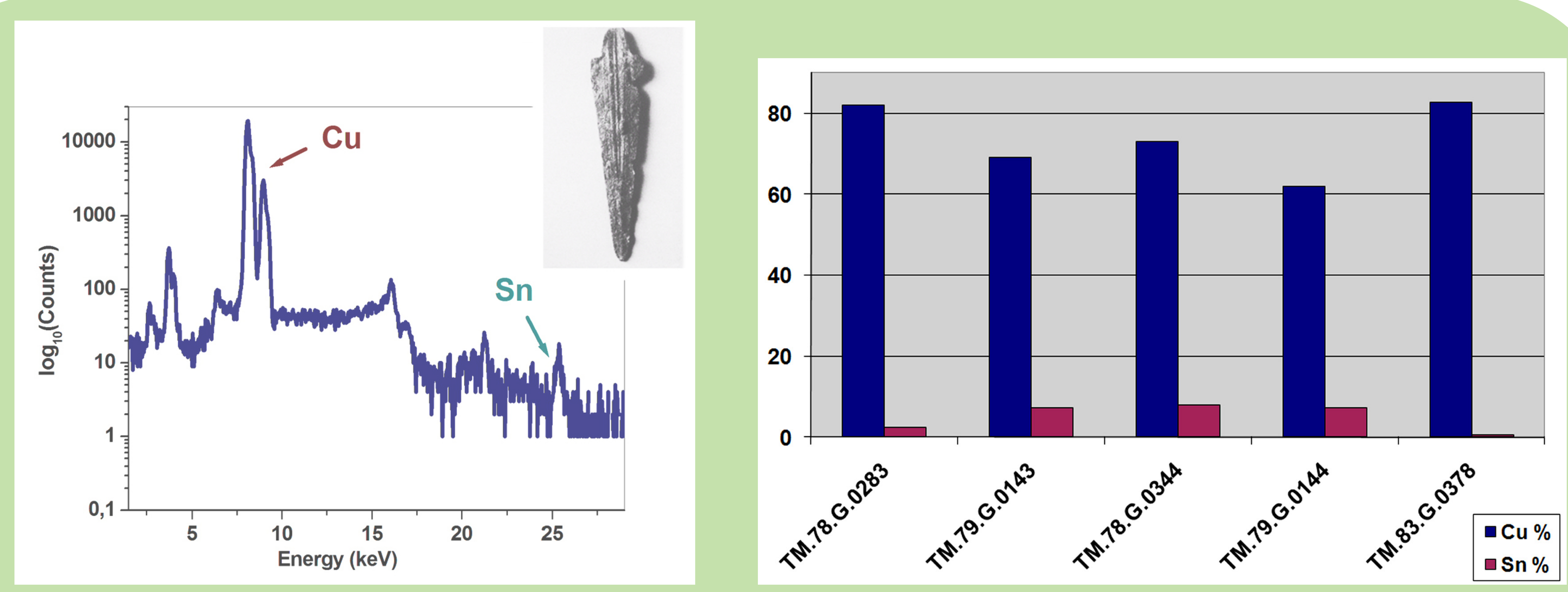

Fig. 2. – Copper (Cu) and tin (Sn) concentrations (wt. %) obtained by ED-XRF analysis (TM.83.G.378) and ICP-OES analysis (TM.78.G.283, TM.79.G.143, TM.78.G.344, TM.79.G.144).

Architectural Components Analysis

Several quarters of the Royal Palace G were brought to light in a good state of preservation. Most of the walls stands to a height of 2,50-4,50 m, with a maximum preserved height of 7,10 m. The Palace was built with the traditional building techniques of mud-brick architecture. Rectangular sun-dried mud bricks (ca. 60x40 cm), were laid with clay mortar on a stone foundation of local limestone. The wall surfaces were covered by a lime plaster. Samples from floors, bricks and plasters are analyzed by thermal analysis (Thermogravimetry (TGA) combined with Differential Scanning Calorimetry (DSC), X-Ray Diffraction (XRD) and optical observation by microscopy (SEM).

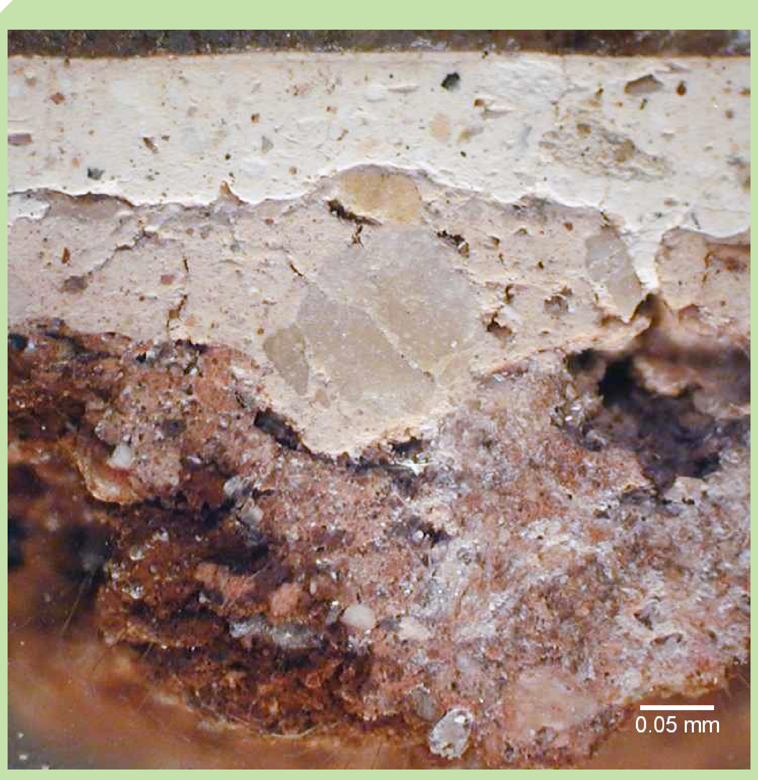

Fig. 1. – Stratigraphy of the three layers of plaster covering the brick.

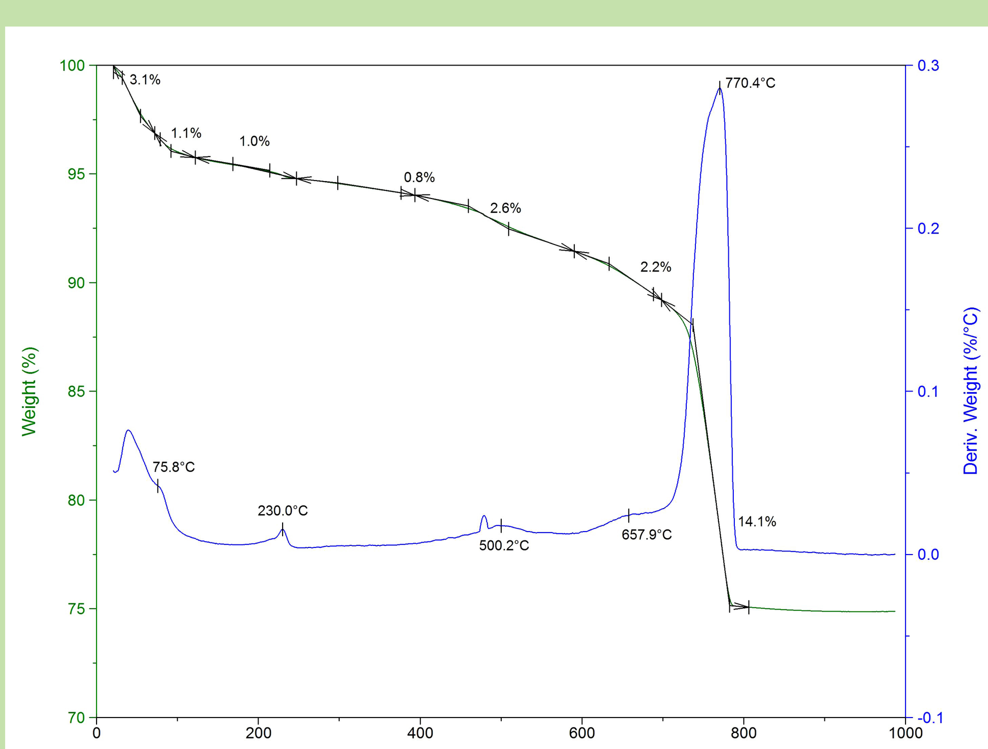

Fig. 2. – Thermal Analysis showing the presence of a high percentage of calcium carbonate.

A stratigraphy of three layers of plaster has been detected over the brick (**Fig. 1**): the first is over the brick and levels the the wall's surface, the second is the real plaster, while the third is the final level where a simple color was applied. The analysis shows the presence of calcium carbonate in the first layer (30%), mixed to the clay. In the second layer the main component of the plaster is the calcium carbonate (90%). The colored layer shows a little percentage of gypsum and the presence of fine clay, used as pigment, but the main component is still calcium carbonate (45%). A high percentage of calcium carbonate (up to 45%), besides clay and straw, is also present in the bricks (**Fig. 2**). The clay contained in earth acts as a binding material thank to his adhesiveness. Calcium carbonate improve the hardness of the paste, while chopped straw tempers the clay preventing it from cracking and breaking up as it dries.
Particular attention was paid in laying the floors of the palace, consisting of preparation layers topped by a smooth hard surface. The analysis of the floors show the only presence of calcium carbonate (84%) as the main component, mixed to a fine calcareous sand. They are perfectly compacted, avoiding porosity on the bulk of the sample. The surface is flattened and in some cases colored.

Pottery Analysis

The archaeometric study of pottery is based on a systematic characterization of the clay, sampled from different vessels from Royal Palace G. Sixty potsherds related to different functional categories (Cooking Pot, Simple and Preservation Wares) and morphological shapes (cups, goblets, small and medium jars and jugs, pots and pithoi) have been analyzed by thin and thick sections, X-ray diffraction (XRD), Thermogravimetry combined with Differential Scanning Calorimetry (TGA/DSC).
The results allow to determine the temperature of firing, the composition of the clay and the nature of aggregates. In the sample of a Cooking Pot Ware, here illustrated (**Fig. 1**), the thick section shows the structure of the ceramic with the gray color aggregates.
The results of TGA/DSC and XRD analysis show the presence of a great quantity of calcium carbonate in the structure of the clay. The presence of calcium carbonate is due to the aggregate and its grey color is due to uncompleted oxidative atmosphere during the firing. The presence of a calcareous aggregate (decomposition at around 800°C) correlated to the absence of neo-forming product like gehlenite or diopside identifies the temperature of firing around 700-750°C.

Fig. 1. – Thick section of Cooking Pot TM.83.G.341-106.

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