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Microstructural study of the treasure of tomb #7 of Monte Alban, Oaxaca

M. Ortega-Aviles[1], G.A, Camacho-Bragado[2], M. Jose-Yacaman[2*]

1. Instituto Nacional de Investigaciones Nucleares, Carretera Federal Toluca-Mexico Km. 36.5, Ocoyoacac, Edo. de Mex. CP 52045, Mexico.
2. Chemical Engineering Department and Texas Materials Institute, University of Texas, Austin, Texas, 78712, USA
*yacaman@che.utexas.edu

We present a study of a series of samples from the objects found in the tomb #7 in Monte Alban, Oaxaca, Mexico. The tomb, discovered in 1932, is zapoteca in origin. It was built during the Classic period and reused in the postclassical (1300-1600 AC) by the mixtecas to bury a character of the nobility. This study aims to the determination of the processing methods of alloys used by the mixteca culture.
It is believed that the mixtecas used to sieve river sand to obtain gold and then alloyed it with some other metals. In most cases they cold-worked the resulting alloys to shape and strengthen the material but some hot-worked items have also been found.
The samples were classified in 4 groups according to their colour as a first approach to differentiate them. They were analyzed with JEOL 5900-LV scanning electron microscope to determine corrosion products formed through the time. The composition of such products was determined by EDS with an Oxford spectrometer.
For the metallographic analysis the samples were mounted in resin and grinded and polished according to standard methods (ASTM/E93). The microstructure was revealed by using an etching solution of nitric acid and hydrochloric acid suitable for Au and Ag alloys (ASTM/ E407-93).
The samples were then observed with a metallographic optical microscope and with the SEM.
It was found that all the pieces were made out of Au-Ag-Cu alloys and that the differences in colour agreed with the differences in composition. The average composition of the samples is shown in table 1.
In the samples of group 1 presented high porosity (pores of 20-180 μm) were Cu was lost in form of oxide. They have a granular structure with grains of 0.5 μm. From the elemental mapping and the distribution of colours in the metallographic images (figure 1a.) it was observed that the Au is homogeneously distributed while Ag and Cu are segregated.
For the samples of group 2, the structure was also granular but the size of the grains was about 0.2μm. In figure 1b. the etched surface of one of this group samples is shown, it is observed a red region, rich in gold chloride, were gold seems to be segregated. It was necessary a transmission electron microscopy (TEM) analysis to determine the presence of ternary alloys. On the surface layer of one of this samples there was observed a zone with dendrites that indicates the 3 elements were alloyed.
Group 3 samples had the largest concentration of Cu and so they were the most damaged by corrosion. There were found multiple foreign materials encrusted in the pores.
Similarly to group 3, the samples of group 4 (figure 1c,d) showed porosity higher to group 2 and group 1 samples. The structure was also granular with a grain size of 0.3 μm. In these samples the silver was segregated to the surface of the sample as it was observed in the cross-sectional analysis.
TEM analysis, high resolution imaging and electron diffraction, was carried out in a JEOL 2010 F analysis was used to determine the intermetallic phases present in the different groups.

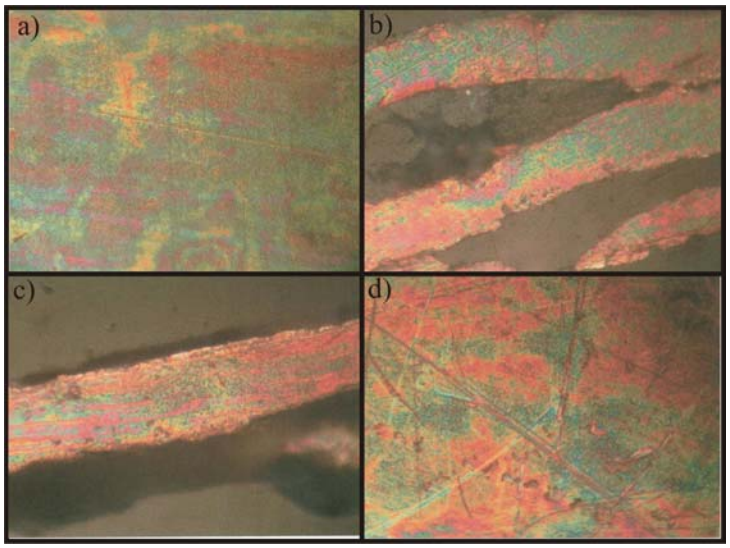

Figure 1. Optical microscope images taken at 600X. a) Group 1. b) Group 2. c) Group 3. d) Group 4

Table 1. Elemental composition determined by EDS.

Sample	AU	AG	CU
Group 1	43.46	38.83	7.11
Group 2	39.91	55.98	4.11
Group 3	32.41	52.35	15.24
Group 4	31.33	52.14	16.53

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