XXIX.—*Chemical Composition of two Silver Ornaments from Inca Graves at Chimbote, Peru.*

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A FORMER student in the laboratory of the University of Virginia (U.S.), Mr. J. Lawton Taylor, now a mining engineer at Santa Cruz de Alaya, in Sinaloa, Mexico, was in 1875 engaged in connection with mining work in Peru, and at Chimbote, on the coast, some seventy-five miles southwards from Truxillo, he obtained a number of silver ornaments from Inca graves antecedent in age to the Spanish Conquest. These he afterwards brought back to the United States, and presented several of them to Dr. Mallet, of the University of Virginia. At the suggestion of the latter, I undertook the analysis of two of these ornaments, which are believed to have been worn by the dead persons in whose graves, near Chimbote, they were found. Prescott (*History of the Conquest of Peru*, 1, 151, 152), says:—"The royal magazines and the *huacas*, or tombs of the Incas, have been found to contain many specimens of curious and elaborate workmanship. Among these are vases of gold and silver, bracelets, collars, and other ornaments for the person."

One of the two specimens examined, A, consisted of a silver plate, which, when spread out, had the form and dimensions shown in Fig. 1; it was 68 mm. long, with nearly circular ends of about 20 mm. in diameter, which were somewhat concave on one side, and

a small perforation in the middle of the length, apparently to afford means of attachment. As received, the plate was bent double near the middle of its length. It weighed 4.099 grams.

FIG. 1.

A. von Humboldt (*Vues des Cordillères et Monuments des Peuples Indigènes de l'Amérique*. Paris, 1810, 87), referring to Plate XIV in that book, says of Figs. 1—4: "Quatre guerriers mexicains: les trois premiers portent le vêtement appelé ICHCAHUEPILLI, sorte de cuirasse de coton qui avait plus de trois centimètres d'épaisseur, et qui couvrait le corps depuis le col jusqu'à la ceinture. Les soldats de Cortez adoptèrent cette armure, qu'ils désignèrent sous le nom d'ESCAUPIL, dans lequel on reconnaît à peine un mot de la langue aztèque. L'ICHCAHUEPILLI résistait parfaitement aux flèches." Round the lower border of this cotton cuirasse in each of the three figures appears a row of ornaments of the form of the Inca silver specimen examined.

The other ornament, B, was a ring, made of a flat band of silver, which, when cut across and straightened out, was 65.5 mm. long and 9.7 mm. wide, and weighed 2.4265 grams. As received, it was crumpled, and presented the appearance of Fig. 2.

FIG. 2.

FIG. 3.

Belonging to this ring, but detached from it, was a small ornament rudely carved from the mother-of-pearl inner side of some shell, apparently intended to represent the head of an animal. It had four small perforations for attaching it to the ring. Von Humboldt (*Vues des Cordillères*, Plate XXVII) shows hieroglyphic figures of the Mexican calendar much resembling this head in general character.

Before making the analyses, both ornaments were gently and care-

fully washed with water, to remove any particles of mere earthy matter adhering to the surface, but not so as to disturb the firmly attached crust which had formed by chemical alteration of the metal beneath; after this cleansing they were dried and weighed.

The crust was then removed by treatment with aqueous solution of ammonia, with exposure for some time to the air. This treatment dissolved the silver chloride and compounds of copper, of which the crust proved to be in large measure composed. The chloride of silver was recovered from the ammoniacal solution by the addition of nitric acid, and the copper was precipitated as cupric oxide by sodium hydroxide. Loosened by the ammonia, but not dissolved, there was a residue of siliceous material (earth and sand), with a very little organic matter.

The metallic portions of the ornaments, thus stripped of incrustation, were then treated with nitric acid, which dissolved nearly the whole. The small residue insoluble in the acid was, after treatment with a few drops of ammonia, ignited, weighed, and cautiously fused before the blowpipe; in each case it yielded a minute globule of gold. The silver was precipitated by hydrochloric acid, and the chloride ignited with the usual precautions and weighed. Lead, which was present only in the ring, was removed by sulphuric acid. Copper was determined as cupric oxide; iron and zinc also as oxides, the last two metals being also found only in the ring.

Of the gross weight of the ornament A, the crust, removed by aqueous ammonia, formed 2.41 per cent. This crust was composed of

Chloride of silver	0.43
Basic carbonate of copper, of a green colour	0.83
Siliceous (and a little organic) matter	1.15
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	2.41

The quantity of the basic copper carbonate was far too small to allow of its composition being accurately ascertained; from the amount of copper actually determined as cupric oxide, it has been calculated as $\text{Cu}_2(\text{HO})_2\text{CO}_3$, or malachite. The metallic portion of this ornament consisted of

Ag.	Cu.	Au.	Total.
85.24	13.96	0.15	99.35

In the case of the ring, B, the crust represented 1.52 per cent. of the gross weight. It contained but a trace of silver chloride, and was composed almost entirely of cuprous oxide, with a very little siliceous matter.

The percentage composition of the metallic portion of the ring, taken as a whole, was as follows:

Ag.	Cu.	Au.	Fe.	Zn.	Pb.	Total.
25·51	72·09	0·25	1·21	0·50	0·10	99·66

Notwithstanding the small proportion of silver, the colour of the alloy on the surface was fairly white. The ring was made from a strip of metal by lapping the ends and soldering them together. It was not possible to separate the solder itself, but, in order to form some idea of its composition, the soldered part was cut away from the rest and analysed separately; the constituents found are included in the tabular statement of the composition of the whole ring, given above. All of the lead and zinc, and the greater part of the iron, were found in the soldered part, and may be assumed to have formed part of the solder.

The results of these analyses seem worth recording, as a small contribution to our knowledge of early Peruvian metallurgy. I have seen no reference to the form in which silver was known by the Incas to occur in nature, but the presence in each of these ornaments of a minute amount of gold, the well-known occurrence in the Andes of Peru and Chili of native silver and copper, sometimes in very considerable masses, the easy utilisation of the metals when thus found—while the reduction by furnace methods of the sulphurous ores of silver (or even the chloride and bromide), in their most commonly observed condition of admixture with large proportions of siliceous or calcareous vein-stones, would not be so simple or easy—may perhaps be taken to suggest that these relics of primitive Inca workmanship were made from the native metals simply melted down in the furnaces, of which A. de Herrera (*Historia General de los Hechos de los Castellanos en las Islas y Tierra Firme del Mar Oceano*, Madrid ed., 1726, Decada V, f. 77) has the following notice:—

“*Los Indios se aprovechaban de la Plata, por fundicion en Hornillos, adonde el viento soprase recio, i con Leña, i Carbon: los Castellanos lu beneficiaban con Açogue, i es mas provechoso.*”

Further on, in the same passage, reference is made to the use of both forced blast (“viento da Fuelles”) and natural draught.

The statement that the Spaniards obtained a better yield of silver by using mercury than the “Indians” of Peru by means of their furnace fires was written long after the Conquest. If it be assumed that the native furnace methods referred to had been applied to like natural material in the early days of Inca civilisation, before the arrival of Europeans, this statement would seem to imply that silver *ores*, in the proper sense of the term, were then worked, as well as the native metal.