THE USE OF METALS IN PREHISTORIC AMERICA

AS long as prehistoric man was held down to the use of bone and stone implements he could make very little progress in civilization and culture, but with the discovery and use of metals his advancement became rapid and continuous. The first period may be measured in tens of thousands of years while the second began only yesterday in comparison.

Certain metals such as gold, silver, copper, tin and meteoric iron occur in nature in a metallic state and would be the first to attract the attention of man. Gold was fairly abundant and widely distributed over the world. It was found in glacial gravels and stream beds in fine particles or in lumps of considerable weight. Man very soon learned that gold was a most worthless metal for all practical purposes. It could be used for ornaments only and consequently had very little part in the development of primitive culture. Later on it became important in the development of the arts. The American Indians could not understand the craze of the Spaniards to obtain their beautiful golden objects only to melt them down.

Copper was found in its metallic state in great abundance about Lake Superior and all along the Andes Mountains. The Indians of these regions had discovered it and had become acquainted with its valuable qualities long before the advent of Europeans. Silver occurs in wirelike forms and in thin sheets. Tin occurs in Bolivia in stream beds as cassiterite and in mines as crystallized prisms. Lead was found in native form but was too soft for common use. Meteoric iron was used by the Indians in many parts of America.

In the beginning the natives quite naturally used copper as they had used stone, shaping it into the same forms and applying the implements to the same purposes. They learned that copper would not break like stone, that it could be beaten into any desired form and, what was more striking and more important, that it became harder when hammered. An implement made in the form of an old stone axe could be hammered thin and then ground into a keen cutting edge. When it became dull from use it could be heated, rehammered and ground into as perfect implement as before.

All this was a great advantage over the old stone implement. A tribe in possession of such implements could easily overcome its neighbors and extend its boundaries and influence. With better tools and implements the industries and arts developed.

It often happens in the development of culture that the people fail to make what would seem to be a perfectly obvious step and the advancement stops short. The Indians about Lake Superior for some reason never learned to cast their copper implements, while the Indians of the Andes made open stone moulds very similar to those used by the ancient inhabitants of Europe. By some means, possibly by some happy accident, men in different parts of the world independently learned to extract metals from their ores, and thus made possible the rapid development of all the industries and arts.

At present there is no method by which we can determine whether in a given case the composition of metal used in the manufacture of an object was the natural one or was made up by the metallurgist at will. Throughout the Andean region from central Ecuador to southern Argentina the natives were in the habit of using bronze, a composition of copper and tin, for the manufacture of many of their implements and ornaments. The proportions of tin and copper vary considerably from place to place and from object to object. On this account it has been supposed the composition was a natural one, but upon examination no native metals of corresponding composition can be found.

The copper of the Lake Titicaca region contains lead; that of southern Bolivia, iron, lead and antimony; that of Urubamba region, silver. So it is possible sometimes to locate the place of origin for the copper. From analysis it would appear that certain metals were particularly desired in certain localities. The Argentinians imported copper from Titicaca, southern Bolivia and Urubamba. The people of the coast near Lima liked silver in their copper and so imported it from Urubamba. There is evidence also of trade in finished products over wide areas. The characteristic bronze axe of Peru has been found in the Amazon forests far to the east of the Andes and in southern Brazil. At the time of the first contact, the Indians of the Paraguay River were making long journeys into the Inca country for the purpose of trading. The Portuguese as early as 1506 had heard rumors of a land to the west rich in silver and gold. It is stated that a ship captain took home with him an Inca silver axe for the King of Portugal.

While there is abundant evidence of trade in manufactured products there is evidence also of trade in raw materials. Bronze objects are found in southern Ecuador where there is no tin, but these objects are made in the form of old Ecuadorian objects, proving that they were manufactured in situ and that the tin was introduced by trade. In Argentina bronze objects are found in a region where there is no native tin. The objects are of local pattern and furnaces, moulds for casting and slag containing tin have been found, thus proving that the tin had been brought in by trade and the objects manufactured on the ground.

Pure tin was found by Bingham in bulk at Machu Picchu. Garcilasso and Bara tell us that tin mines at Corocolla, Bolivia, were worked before the coming of the Spaniards and that the Indians knew the secrets of mixing copper and tin to harden their implements. They did not know the use of the bellows for melting down metals but used instead tapering tubes of copper for concentrating the breath upon the flames. Many of these pipes were often used at one time when greater heat was desired. They also built furnaces on the mountain tops where the strong wind furnished the needed blast. From all this evidence it would appear that the Indians knew the desirable qualities of tin and introduced it as required for their purposes. The ancient metallurgist soon learned that bronze made a better implement than did copper. It was harder, it could be hammered into thin sheets, it could be cast in closed moulds and it took a better impression from the mould.

When all the abundance of analyses is considered it must be accepted as true that the proportion of tin in a given bronze object could not have been selected because of the use for which the object was intended. Some authorities believe that the presence of tin is accidental, "since it is found in greatest quantities in those implements which require it least." If we accept the quotation as the statement of fact, we must conclude that there was probably some very good reason for such proportions of tin rather than that the whole thing was accidental.

It has been shown in laboratory experiments that a composition of about ten per cent of tin receives the best impression in casting. Bronze of this composition expands in solidifying and registers the finer details of the mould. When objects high in tin are examined it is found that they are nearly always ornaments, delicate small objects or the very finest castings. Hence the ancient worker must

have experimented until he discovered the proper proportion of tin for the best impressions. Again, those tools, such as knives and axes, which would seem to require the most tin for use on account of desired hardness, usually have the smallest amount of tin, or from three to five per cent. This is found to be true in such tools coming from Ecuador, Peru, Bolivia and Argentina. We must find some explanation for this uniform practice. It cannot be due to accident in the selection of native material or chance in making up the composition. The reason may be found in the methods of treating these cutting implements. They were first cast then modified by forging and annealing as each individual case required. The final stiffness and hardness was produced by cold hammering. It has been demonstrated by laboratory methods that bronzes containing a high per cent of tin lose their ductility and cannot be cold hammered. For free working of cast metals the tin content should not be above seven or eight per cent at the very highest. It is thus revealed that the ancient smith was compelled to sacrifice the desired hardness of his implements by increasing the tin content to the necessity of free working the bronze. He learned by repeated trial the limits within which he could combine the two elements. There was no accident nor chance, nothing more than an intelligent metallurgist who used his materials to the best advantage for the desired purpose for which the objects were intended.

As there was a copper culture in Colombia and northern Ecuador where tin does not occur, and copper objects are found, although rarely, in the whole bronze area, it may be inferred that there had been an earlier copper culture extending over the whole area. The scarcity of copper objects in the bronze area may be due to melting down the old copper objects in the manufacture of the bronzes. The ruins of Tiahuanaco belong to an old culture. The great stone blocks are held in place by clamps of pure copper but this does not necessarily prove that Tiahuanaco belongs to the copper age. The workmen of the time probably knew that pure copper was better adapted than bronze for the purpose of holding blocks of stone together.

It is to be regretted that the age of prehistoric bronzes cannot be determined with accuracy. There is always an abundance of patination or oxidation present but no law has yet been determined for the rate of oxidation. This depends upon the purity of the metal and the processes to which it has been submitted. Cast

objects oxidize more rapidly than worked specimens on account of their more porous condition. Recrystallization if present may be due to reworking the metal rather than to age. At present there is no guide.

Much has been written on the old story of the lost art of tempering copper and bronze. Like so many such stories the facts of tempering are lost sight of in the story of the art. All competent metallurgists today agree that the art as practiced by prehistoric man has not been lost. The ancients of Europe and America in tempering their metals used the same simple method of cold hammering and nothing more. The fine cutting edge was obtained by grinding.

A Remarkable Bronze Knife

Among the numerous objects of special interest in the Paris collection of gold which the Museum has recently obtained, is a knife of unusual form and manufacture. It is cast in solid bronze with a snake of the same material crawling along the back of the blade towards the handle. On the end of the handle stands a bird cast in solid high grade gold. The blade is very thin at the point and along the cutting edge. The total length of the knife, handle and bird is 5½ inches; the length of the knife and handle is 4½ inches; the length of the cutting edge is 3½ inches and the width of the blade is 1¼ inches (Plate IV).

The ancient Peruvians were in the habit of using animal and bird forms in all their art products. They wove them into the patterns of their fine cloth, moulded them in clay and metal and painted them upon their pottery. These ancients were expert artisans as well as accomplished artists. Even their common implements were often decorated with artistic designs. The knife here represented has a serpent two inches long and a quarter of an inch thick so coiled along the back of the blade that it does not interfere with the use of the knife. The serpent may be the individual fetish or totem of the man who made it. It is difficult to identify the serpent, but from the rather heavy body, the short tail and the diamond markings on its back it would appear to be a rattlesnake. It was evidently cast separately and later welded on the blade.

The gold bird was cast separately and then set into a socket in the end of the handle. The bird is one inch high and three-eighths

of an inch thick. It is difficult to be sure about the identification of the bird. The prominent distinguishing marks are, the divided tail, the deep wing marks and the large crooked bill. The one bird that possesses these characteristics to a marked degree is the flamingo whose home is around lake Titicaca in the central Andes. It has a short tail but its long wing feathers when folded give it the appearance of having a forked tail; its wing coverts are scarlet but its wing quills are black giving the bird the appearance of having a deep depression across its back and its heavy bill is decidedly bent down. The neck and legs are too short and heavy for accuracy but they have been made so for the greater security. While the flamingo nests and lives for the most part about the lakes in the mountains at an elevation of twelve or fourteen thousand feet it makes frequent visits to the seacoast where it may be seen wading in the surf along the shore.

The knife in most common use by the ancients was in form much like that used today by our harness makers. Nearly the same form was used in prehistoric times in Alaska, Mexico, Peru and Argentina. It was this kind of a knife the Peruvians used in decapitating their enemies and in all personal combats as is shown by illustrations on their pottery. The cutting edge was held on the ulnar side of the hand. The same knife was used as an ornament on the top of their headdresses.

The knife illustrated differs entirely from those found in the ancient graves along the coast or those painted on the pottery of the region. We have no information as to where or when the knife was discovered or how it reached Paris and should be at a loss to determine its provenience but for the finding of a very similar one by Dr. H. Bingham at Machu Picchu in the mountains of central Peru. An analysis of the composition of this knife was published by C. H. Mathewson in the *American Journal of Science*, December, 1915. The knife is described as the "finest example of casting practice furnished by the entire collection." The analysis revealed 88.08 per cent of copper and 9.39 per cent of tin. From the general appearance and description of this knife it may be inferred that an analysis of the one in our collection would give about the same results. It seems unwise therefore to mutilate this perfect specimen for chemical analysis or metallographic examination. Such treatment would not give us all the information desired, not even the clue to the smelting methods used in preparing the metals. It would not tell us whether

Gold Bells from Colombia. The one on the left is in the form of an animal standing in the loop of a rope having the rattle in his abdomen. Gift of Mr. Clarence S. Bement, The bell on the right has a mythical figure seated on the top. Gift of Robert G. Le Conte.

FIG. 1

the ores were mixed in this proportion by nature or by the metallurgist who had combined the pure metals in the proportions most desirable for his purpose. It would give us some information concerning the annealing processes but this is hardly sufficient to justify the partial destruction of such a valuable object.

The use of the knife can be conjectured only. The handle is too short for use in the hand as an ordinary knife. The blade must have been held between the thumb and fingers. It could not have been used for ordinary purposes. It was more than likely a razor but we shall never know unless a picture of one in use is found.

TWO GOLD BELLS

In Fig. 1 are shown two bells natural size cast in fine gold by the process of using wax in making the moulds. The object on the left is in the form of a bat standing in a loop of twisted gold wire. The body is a bell three-quarters of an inch deep containing a tongue of gold. The bell shows much wear on the outside and especially on the inside where the tongue has come into contact with the

lips of the bell. We call the object a bat because of the characteristic canine teeth, the absence of the incisors and the very prominent breasts. The bell probably came from Chiriqui and was presented to the Museum in 1891 by the late Clarence S. Bement. It was formerly the property of the late Dr. Leidy.

The second is the most perfect bell in our whole collection. It is unique in form, having a flat top upon one side of which sits a small animal, probably a bat, holding in his hands a loop of twisted gold wire which ends in two loops on top of his head. He carries in his mouth a small two-headed snake. The bell is supposed to have come from Peru a long time ago and was presented to the Museum by Dr. Robert G. Le Conte.

W. C. F.