COPPER TIN BRONZES IN MESOAMERICA

DOROTHY HOSLER

INTRODUCTION

One of the most interesting issues in New World archaeology concerns cultural relationships between the Andes and Mesoamerica. A probable example of those relationships is the development of metallurgy in Mesoamerica. While the Andean peoples were using a variety of sophisticated metalworking techniques by 1000 B.C., in Mesoamerica the evidence for metal working prior to 900 A.D. is scant. At present our evidence points to a clear-cut case of the diffusion of metallurgical ideas and techniques into Mesoamerica from the south *(Pendergast,* 1962), and —of particular interest to this paper— diffusion from the Andean area *(Mountjoy,* 1969; *Meighan,* 1969).

The study of the diffusion of metallurgy into Mesoamerica has been greatly facilitated by Pendergast's classificatory framework and distributional analyses of Mesoamerican copper artifacts *(Pendergast,* 1962). Based upon Pendergast's study, Mountjoy (1969) was able to demonstrate stylistic similarities between West Mexican and Andean copperworking traditions. These studies have contributed to our knowledge of Mesoamerican copper working, and possible Andean/Mesoamerican relationships. However, little specific attention has been focused on an equally important issue: Mesoamerican copper-tin alloys (bronze), and their possible relationship with Andean bronze-working traditions. A few studies have touched upon various aspects of the question of Mesoamerican bronzes *(Root, in Lothrop,* 1952) *(Arsandaux and Rivet,* 1921) *(Brush,* 1962). However, there has been no systematic effort to gather and organize extant data on Mesoamerican bronze artifacts, nor have there been studies of Andean and Mesoamerican relationships. This paper represents a preliminary step in that direction.

I have attempted to organize and classify data pertaining to Mesoamerican copper-tin bronze artifacts that were readily accessible in the literature. All objects treated here have been chemically analyzed; most are illustrated, and have information relating to provenience. Dates were included where available. I have also compared the illustrated bronze artifacts to Pendergast's classification of Mesoamerican copper types.

A summary section of the paper will indicate the patterns of geographical distribution of the bronze artifacts identified in the literature search. It will also include a brief discussion of the techniques of manufacture characteristic of both utilitarian and nonutilitarian artifacts.

In a final discussion section, I will consider the introduction of bronze-working into Mesoamerica. Based on the data in this paper and from other sources, I will focus on the possible relationships between Mesoamerican and Andean bronze-working traditions. This question is of particular interest in view of recent evidence that the Northern Andean peoples —a possible source for the diffusion of bronze into Mesoamerica— did not use copper-tin bronzes until after the Inca expansion. The data in this paper suggest that bronze-working diffussed from zones farther to the south than have previously been suggested either for copper or for bronze.

Mexican Bronze

Before presenting and discussing the various artifacts, I will briefly summarize the considerable archeological and historical evidence for the alloying of copper and tin in precolombian Mexico. I will also discuss the claim that some of the Mexican "bronzes" are actually unintentional alloys derived from the smelting of stanniferous copper ores.

Figure 1. is a map of presently-known copper and tin deposits in Mexico.[1] Copper and tin exist in close proximity

[1] Fig. 1. Map is composite of maps of the distribution of copper and tin ores in González Reyna (1956).

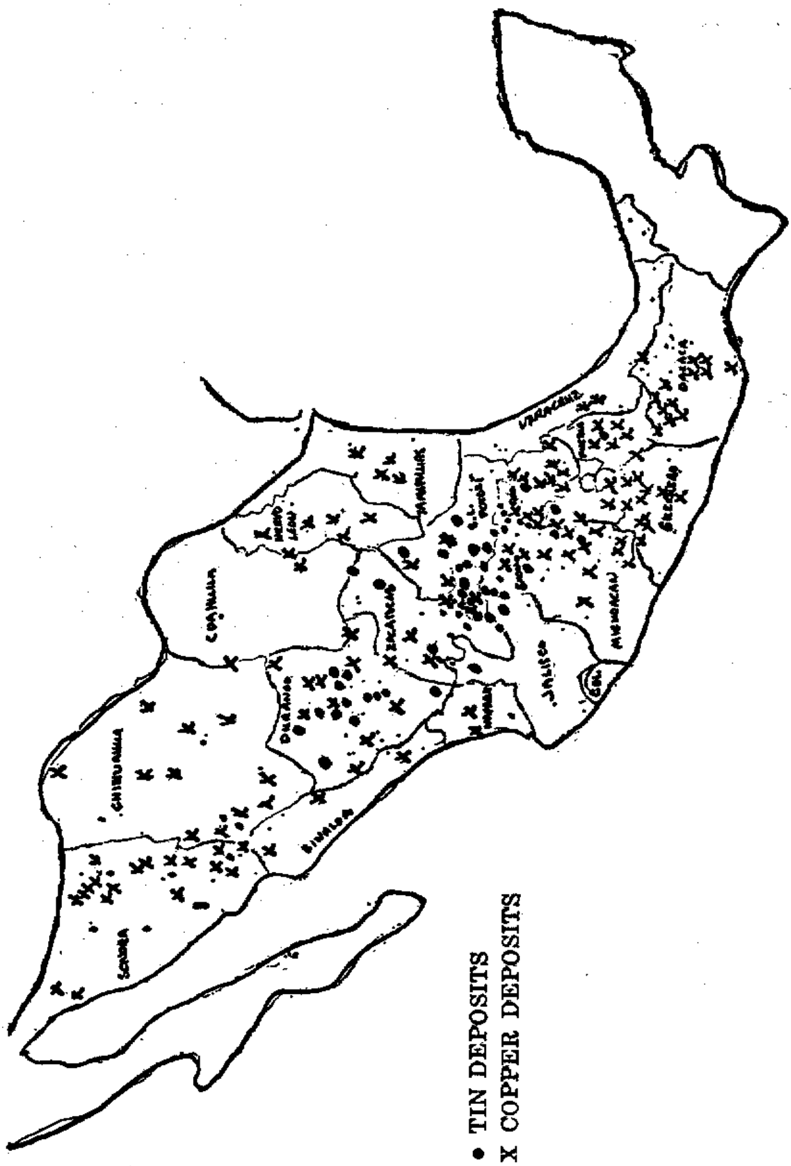


FIG. 1. Copper and tin deposits in Mexico.

in both Sonora and Durango, and particularly in the north central areas: the region encompassing Aguascalientes, Querétaro, Zacatecas and Guanajuato. While we do not know which, if any, of these deposits were mined in prehispanic times, their close geographical association in some areas certainly suggests that the alloying of copper and tin derived from these deposits was feasible.

Mexican copper deposits are found in many areas of the country, as the map indicates. Copper deposits are composed of native copper and also occur in oxide and sulphide ores. Most common among the oxide ores are malachite and chrysocolla. Common sulphides are chalcopyrite, chalcocite and covellite.

Mexican tin deposits are concentrated in the central and north central areas of Mexico. They apparently consist almost entirely, if not entirely, of cassiterite, an oxide ore of tin. Only sketchy information is available concerning the composition of Mexican tin ores. Although no tin deposits in Guerrero are indicated on the map, tin deposits are apparently found there also. Caley and Easby (1967) have analyzed a cassiterite nodule from the northeastern part of that state, that contains indium, an extremely rare trace element.

In addition to the copper and tin deposits that are known through gelogical surveys, and which theoretically could have been mined before the conquest, we also have historical and archeological evidence of prehispanic sources of copper and tin.

The chronicles report that copper was mined at the time of the conquest in Guerrero and Michoacan *(Bargallo,* 1955, p. 30), and also in Colima *(Root, in Lothrop,* 1952). The information about Guerrero is corroborated by a report that evidence for preconquest copper mining and ore treatment has been found along the Balsas River *(Hendrichs,* 1945). Helene Dunbar[2] reports that she has good evidence of aboriginal copper mining (including slag) from Guerrero.

Tin mining apparently occurred in Taxco, located in northeastern Guerrero. Cortez, in fact, in a letter to Carlos V reports that he sent miners to Taxco to obtain tin.

[2] Personal communication, November 1975.

He also reports tin was used as a medium of exchange in that area *(Caley and Easby,* 1964a). As previously mentioned, Caley and Easby have evidence that cassiterite ores do exist in that region. To my knowledge no precolumbian ore sources for tin but that of Taxco are reported in the chronicles.

Some of the ore sources for copper and tin mentioned above were used prior to the conquest in the production of both copper and tin artifacts. We also have evidence that artifacts made from copper-tin alloys were produced prior to the conquest.

Copper artifacts were distributed throught Mexico and Guatemala by about 1000 A.D., and were used for a wide variety of both utilitarian and ornamental purposes. The way in which those artifacts were produced —whether by oxide or sulphide smelting— is currently being debated. While Friedman (1966) presents evidence that the smelting of copper sulphide ores was indeed practiced in precolombian Mexico, Patterson (1971) strongly questions that conclusion. We have such scant evidence for techniques of ore processing of any sort in Mesoamerica, that definitive conclusions probably cannot be made at this time.

Archeological evidence for the production of tin artifacts in precolombian Mexico is not abundant. However, in a recent paper, Caley and Easby (1964a) present good evidence for the smelting of metallic tin. A portion of their paper contains an analysis of two cast tin earplugs from Guerrero, both of which, interestingly enough, contain unusually high proportions of the trace element indium. In view of the fact that in a later paper *(Caley and Easby,* 1967) they identify indium as a constituent of cassiterite ores from Guerrero, their argument is particularly strong for local precolombian manufacture of tin artifacts.

We also have evidence that the alloying of copper and tin occurred in precolombian Mexico. López de Gómara (1852 p. 440) states:

> "La mejor y más fuerte piedra con que labran y cortan es el pedernal verdenegro. También tienen hachas, barrenas y escoplos de cobre mezclado con oro, o plata o estaño."

In addition to the bronze objects that are presented in this paper, the best evidence for local alloying of copper tin comes from the Bernard site in Guerrero. Bronze artifacts were excavated containing indium, the trace element identified by Caley and Easby present in local Guerrero cassiterite ores. This constitutes conclusive evidence for local manufacture.

To summarize, we do have archeological and historical evidence that copper and tin were used separately in the production of metal artifacts in precolombian Mexico. We have some information about the location of prehispanic mining activities —which generally seem to be in West Mexico. And, finally we have both archeological and historical evidence that the alloying of copper and tin was practiced.

Before presenting and discussing the bronze artifacts, it is important to address a question that has been periodically voiced in the literature; whether Mesoamerican bronzes actually represent intentional alloys. Various investigators have discussed this issue *(Phillips,* 1925) *(Root in Lothrop,* 1952) *(Arsandaux and Rivet,* 1921) with varying conclusions. The question is revelant only in the case of low-tin bronzes. The recent discoveries of high-tin bronzes *(Brush,* 1962) resolves the debate about whether intentional alloying of copper and tin actually occurred in Mesoamerica. Nevertheless some of the artifacts presented in this paper have a low in content (below 3%). Consequently, the issue of intentional versus unintentional alloying with tin is one I will briefly discuss here.

The consensus among most metallurgists is that a tin content of between 2-3% in a copper artifact represents a deliberated alloy. Amounts below 2%, however, may often be deliberate also. Tylecote and Friedman, for example, argue that tin content of 1% is sufficient to indicate an intentional alloy. *(Tylecote,* 1962, p. 39) *(Friedman,* 1966, p. 1505). While phe presence of tin in a copper artifact can be caused by numerous factors (i.e. the melting down and reusing of bronze artifacts), the principal concern, in terms of Mesoamerican low-tin bronzes, revolves around the possibility that the artifact may have been made from the smelting of a stanniferous copper ore *(Root in Lothrop,* 1952) *(Bargallo,* 1955, p. 27-28).

Stanniferous copper in its original form is stannite, a sulfide mineral of copper, iron, and tin. However, it contains substantial proportions of both copper and tin (approximately 29% each), in addition to goodly amounts of iron and silica. In the oxidized zone, it becomes altered to separate layers of copper minerals and to a dense form of tin oxide known as "wood metal". Since both the copper and the tin will occur in the same ore deposit, it is not unreasonable to suspect that they might inadvertently be smelted together. A copper artifact would then be produced with enough tin to make it seem like an intentional alloy.

Do stanniferous copper deposits exist in Mexico? We do not know. We have no archeological or geological evidence that would indicate that they do. On the contrary, the fact that Mexico does not have extensive tin deposits makes it unlikely that it would be a source of stanniferous copper.

> "In view of the scarcity of tin ores, it can be assumed that if stanniferous copper does occur it is of infrequent ocurrence." *(Root in Lothrop,* 1952).

In fact, tin apparently is a very rare trace element in copper ores; it generally occurs in concentrations of less than 0.001% *(Friedman et al,* 1966). Friedman goes on to say that the only exceptions are copper ores from major tin producing areas, of which he identifies three: Cornwall, England; Bolivia, and Peru. He assumes that a tin content of more than 0.1% from any area other than these three tin-producing areas strongly suggests intentional alloying.

According to *(Root in Lothrop,* 1952) the source for the speculations about the use of stanniferous copper is a statement by Herrera, a 16th century chronicler. Herrera reports that indians from Colima and Guerrero had two kinds of copper —one was a hard copper used for tools, the other a soft copper used for ornamental objects. The "hard copper" may have been derived from stanniferous copper ores. However, as I have indicated, we have no evidence for the mining either contemporary or aboriginal —of a stanniferous copper ore. With the exception of the above report, all evidence indicates that stanniferous coppers probably do not exist in Mexico.

In Bolivia and Perú, where stanniferous copper deposits do exist, any quantity of tin above 1.5% is most probably a deliberated alloy. Copper artifacts with less than 1.5% tin, however, may come from stanniferous deposits (*Lechtman*, 1979, foot note 16, p. 42). The southern Andes however, is one of the world's major tin producers. Mexico is not. Therefore, if we use a 1.5% for the lower value of tin content for deliberate alloys in Mexico, we will be erring on the conservative side, especially in view of Friedman's discussion. For the purpose of this paper, I will use 1.3%, because that is the lower limit of Paul Rivet's chemical analyses, some of which will be cited here.

MEXICAN BRONZE ARTIFACTS

The data presented in this section are subdidived into three groups. Artifacts in the first group are illustrated, their chemical analyses are presented, and they are organized according to provenience. Artifacts in the second group have no illustrations but do have a chemical analysis, and they too are organized by provenience. Artifacts in the third group have illustrations, a chemical analysis, but exact provenience is unknown. This latter group seemed to merit inclusion in the hope that provenience might eventually be assigned based on stylistic ground or via trace elements identified in the chemical analysis.

Each illustrated bronze artifact is also compared to Mesomerican copper artifacts (primarily from Pendergast's classification) to see to what extent the bronze artifacts are typologically similar to copper and to what extent the geographical distribution is parallel.

One problem inherent in these data is that definite dates are often not available. Many of the bronze artifacts presented here are not from controlled excavations. While the dated material we do have is enormously valuable, establishment of a clear sequence, tracing the introduction of bronze types into Mesoamerica, requires many more chemical analyses of metal artifacts from controlled excavations. Another problem in the data is that Arsandaux and Rivet's chemical analyses (in lieu of a specific value for tin) sometimes indicate a range of values of tin for a particular artifact:

"notable" 1.3-3.9% and "très notable" 2.8-9.3%. The approximate nature of these classifications limits interpretations we might make. For example, it makes correlation of artifact function with tin content very difficult.

GROUP I: Bronze Artifacts — with illustrations

A. *West Mexico*

1. Chisel or knife[3]
Provenience: Morett, Colima
Chemical analysis: SN 10%
(No analysis of other elements)
Comment: Excavator suggests a date prior to 1,000 A.D., and that as such this is the earliest bronze in Mexico. No corresponding copper type in Penderdgast classification.

4.4 cm long
1.2 cm wide

2. Celt[4]

Provenience: Bernard, Guerrero
Chemical Analysis:

Cu	Sn	Au	Ag	Pb	Ni	Al	Fe	In	S
Maj	.75	—	+	.15	.025	+	—0.05	—	0.04

Comment: Probable dating between 1,200 and 1,500 A.D. Edge of celt has been cold-worked and has a hardness of 97 at cutting edge, 53 at non-cutting edge. In Pendergast[3] classification of copper types, it is similar to IVB.

10 cm long
7 cm wide

3. Needle[5]

Provenience: Bernard, Guerrero
Chemical Analysis:

Cu	Sn	Au	Ag	Pb	Ni	Al	Fe	In
Maj	.10—15	—	0.2	+	+	+	+	+

Comment: Recovered during excavation; dating between 1,200-1,500 A.D. Similar to Pendergast type IA is present in copper in West Mexico.

Approx. 5 cm long

[3] Meighan (1972). Drawing is from photograph, p. 190.
[4] Brush (1962). Drawing is from photograph, p. 1337.
[5] *Ibid.* Could not be determined from photograph if needle has an eye.

4. Bracelet[6]

Provenience: Bernard, Guerrero

Chemical Analysis:

Cu	Sn	Au	Ag	Pb	Ni	Al	Fe	In
Maj	10—15	—	.03	0.2	+	+	+	+

Comment: Recovered during excavation; dating between 1,200-1,500 A.D. Bead bracelets of rolled sheet metal, each bead cold-worked and annealed. No corresponding type in Pendergast classification.

Approx. 10 cm long

5. Wire[7]

Provenience: Bernard, Guerrero

Chemical Analysis:

Cu	Sn	Au	Ag	Pb	Ni	Al	Fe	In
Maj	10	+	0.2	+	.01	+	+	—

Comment: Recovered during excavation; dating between 1,200-1,500. Pendergast Type X. Appears in copper in southern, western and northern Mexico.

5.08 cm long

6. Wire[8]

Provenience: Bernard, Guerrero

Chemical Analysis:

Cu	Sn	Au	Ag	Pb	Ni	Al	Fe	In
Maj	10	+	0.1	+	.01	+	+	—

Comment: Recovered during excavation; dating between 1,200-1,500 A.D. Corresponds to Pendergast copper type X.

7.62 cm long

7. Ring[9]

Provenience: Bernard, Guerrero

Chemical Analysis:

Cu	Sn	Au	Ag	Pb	Ni	Al	Fe	In
Maj	.10—	+	.05	0.1	+	—	—.01	—

Comment: Purchased. However, presence of indium indicates local ore. Corresponds to type VII in Pendergast's classification. Copper rings of this type are found exclusively in western Mexico.

2.5 cm in diameter

[6] *Ibid.*
[7] *Ibid.*
[8] *Ibid.*
[9] *Ibid.*

8. Bell[10]

Chemical Analysis:

Cu	Sn	Au	Ag	Pb	Ni	Al	Fe	In
Maj	30	—	Q3	0.3	+	+	+	+

Comment: Recovered during excavation. Dating from 1,200-1,500 A.D. Corresponds to Pendergast's type 10.2A with initial appearance in northern Mexico. This type also appears in southern Maya area.

2.54 cm long

9. Tweezers[11]

Provenience: Barra de Navidad, Jalisco

Chemical Analysis:

Cu	Sn
Maj	5%

Comment: Dated prior to 1,200 A.D. Probably between 1,200-1,500 A.D. No analogous copper type appears in the Pendergast classification.

2.5 cm long

B. *Central Mexico*

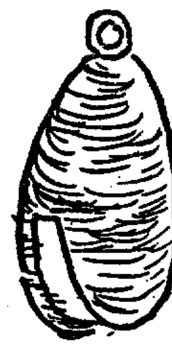
1. Bell[12]

Provenience: Nochistlan, Zacatecas

Chemical Analysis:

Cu	Sn	Pb	Phos	Ant	Fe
92.40	6.95	.02	.05	<0.1	<.1

Comment: Dating uncertain. The Pendergast classification has no examples of copper bells with wirework over entire body. Lothrop classifies it as type f (e),[13] and comments that most bells of this type are from Central Mexico. Microscopic analyses revealing dendritic structure indicates bell was cast.



Actual size

2. Bell[14]

Provenience: Valley of Mexico

Chemical Analysis:

Cu	Sn	(no other elements analyzed)
Maj	2.8-9.3	

Comment: This bell is either from Teotihuacan or Azcapotzalco. Dating uncertain. However, copper bells of this type (Pendergast type 1A1a-i) occur in West Mexico and Central Mexico.

Actual size

[10] *Ibid.*

[11] Long and Wire (1966). Photograph, p. 59. Tweezers analyzed by Root; have a tin content of 5% (Personal communication, C. Meighan, November 1975).

[12] Hultgren (1925). Drawing from photograph, p. 207.

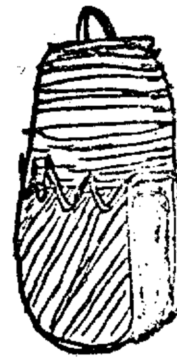
[13] Lothrop (1952), p. 91.

[14] Arsandaux and Rivet (1921). Drawing from photograph plate 6, No. 3.

3. Bell[15]
Provenience: Valley of Mexico
Chemical Analysis:

Cu	Sn	Pb	Si	Au	Fe	As	Ant	Bi
Maj	4.7	—	—	—	0.1	—	—	—

Comment: Dating uncertain. Pendergast has no copper bells of this type (simulated wirework over entire body of bell with raised designs). Lothrop (1952) however has examples of this type and says they are probably from the Valley of México.



Actual size

4. Axe[16]
Provenience: Valley of Mexico
Chemical Analysis:

Cu	Sn
Maj	2.8-9.3

Comment: Dating uncertain. However, this axe corresponds to the Pendergast copper type IVB, found in Central Mexico, Western and Southern Mexico.

5 cm long
2.8 cm wide (bottom)
1.7 cm wide (top)

5. Awl or punch[17]
Provenience: Valley of Mexico
Chemical Analysis:

Cu	Sn
Maj	3.6

Comment: Dating uncertain. This particular type is not included in the Pendergast classification, or in other illustrations of Mexican copper artifacts.

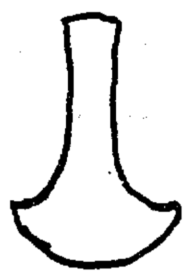
21.3 cm long

[15] *Ibid.* Drawing from photograph plate 7, No. 11. Analysis in Lothrop (1952), p. 12.
[16] Clement (1935). Drawing from p. 445, fig. 46 (No. 18479).
[17] *Ibid.* Drawing from p. 452, fig. 49 (No. 24465).

6. Knife or chisel[18]
Provenience: Valley of Mexico
Chemical Analysis:
Cu Sn
Maj 1.3-3.8
Comment: Dating uncertain; no corresponding type in Pendergast classification.

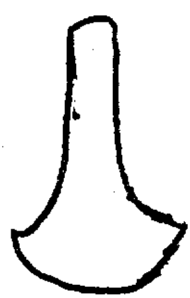
8.5 cm long
1.7 cm wide

7. Axe[19]
Provenience: Valley of Mexico
Chemical Analysis:
Cu Sn
Maj 1.3
Comment: Dating uncertain. Stylistically unlike Pendergast's copper artifacts. However, Aguilar axe "d" (from Oaxaca) and "f" (from Michoacan) are quite similar.



Dimensions unknown

8. Axe[20]
Provenience: Valley of Mexico
Chemical Analysis:
Cu Sn
Maj 1.3-3.8
Comment: Dating uncertain; stylistically unlike other Mexican Copper artifacts identified by Pendergast, but Aguilar (1946, Fig. II f p. 19) Shows similar types from Oaxaca.



[18] *Ibid.* Drawing from p. 445, fig. 46 (No. 18478).
[19] Arsandaux and Rivet (1921) (chemical analysis). Drawing from Clement (1932). (No. 2705). (Fig. 4, p. 90). See also Aguilar (1946 figure II, p. 19) for axe types.
[20] *Ibid.* (Chemical analysis). Drawing from photograph Plate 6. fig. 2 (No. 2704).

9. Axe[21]
Provenience: Valley of Mexico
Chemical Analysis:
Cu Sn
Maj 1.3-3.8
Comment: Pendergast has no axes of this type, but Aguilar shows an example of one from Michoacan (Aguilar 1946 fig. IIc, p. 19).

10. Axe or Chisel[22]
Provenience: Valley of Mexico
Cu Sn
Maj 9.3
Comment: Typologically similar to Morett chisel but larger. Unlike any of the copper artifacts appearing in Pendergast's classification.

15.5 cm long

11. Lancepoint[23]
Provenience: Valley of Mexico
Chemical Analysis:
Cu Sn
Maj 2.5
Comment: Dating uncertain. No analogous types in copper in Pendergast. However, Clement (1935, p. 445) has examples of similar types in copper.

12.2 cm long

21 *Ibid.* (Chemical analysis). Drawing from photograph Plate 7, fig. 3 (No. 2703).

22 Clement (1935). Drawing is from photograph, plate 18. Provenience (p. 443) stated to be from Valley of Mexico (No. 24401).

23 Arsandaux and Rivet (1921). Drawing from photograph Plate 7, fig. 3 (No. 24458).

12. Lancepoint[24]
Provenience: Valley of Mexico
Chemical Analysis:

Cu	Sn
Maj	3.4

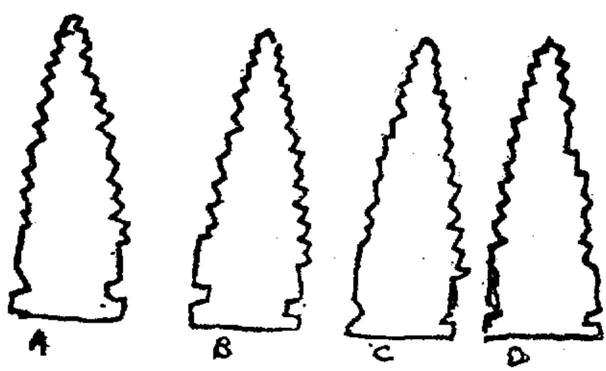
Comment: Dating uncertain. See comments for Item 11 above.

12.2 cm long

13. Lancepoints (A-D)[25]
Provenience: Valley of Mexico
Chemical Analysis:

Cu	Sn
Maj	1.3-3-8

Comment: See 11, above.



12.2 cm long

[24] Clement (1935). Drawing from p. 445, fig. 46 (No. 24454).
[25] Arsandaux and Rivet (1921) (chemical analysis). Drawing from Clement (1935), p. 445, fig. 46.

14. **Needle**[26]
Provenience: Valley of Mexico
Chemical Analysis:
Cu Sn
Maj 2.8-9.3
Comment: Not in the Pendergast classification, but shown in Aguilar (1946, p. 143).
Bronze needles have been cast.
Aguilar examples are from Michoacan.

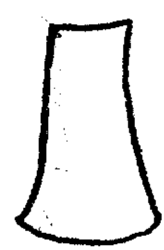
Dimensions unknown

15. Needle[26]
Provenience: Valley of Mexico
Chemical Analysis:
Cu Sn
Maj 2.8-9.3
Comment: See 14 above.

Dimensions unknown

C. *Southern Mexico*

1. Axe[27]
Provenience: Oaxaca
Chemical Analysis:
Cu Sn
Maj 3.7
Comment: Stylistically similar to IVb in Pendergast classification.



4.7 cm long

[26] *Ibid.* IB14, IB15 (No. 24462, 24463) typologically identical to figure 2 plate 7 *(Ibid,* p. 266) chemical analysis p. 270.
[27] Clement (1935). Drawing from figure 46, p. 445 (No. 18481).

GROUP II: *Bronze Artifacts* — no illustrations

	Chemical Analysis Cu	Sn	Pb	Au	Ag	Fe	As	*Provenience*
A. *West Mexico*[28]								
1. Wire-like bell	Maj >	2.0	.001	2.0	—	—	.001	Guerrero
2. Chisel[29]	Maj	3.07	.82	—	—	.53	—	Guerrero, (Acatlan)
B. *Central Mexico*[30]								
1. Filagree ring	Maj	2.0	—	.1	.1	—	.01	Calaxtlahuaca
2. Mask	Maj >	2.0	4.0	.1	—	—	—	Calaxtlahuaca
3. Wire-like bell	Maj	7.0	—	—	—	—	—	Valley of Mexico
C. *Southern Mexico*[31]								
1. Filagree mask	Maj >	2.0	.01	.1	.1	—	.01	Nochistlan, Oaxaca
2. Bell	Maj >	2.0	—	—	.001	—	.01	Carmen, Campeche
3. Tool fragment	Maj >	2.0	—	.1	.1	—	—	Nochistlan, Oaxaca
D. *Eastern Mexico*[32]								
1. Bell	97.4	1.86	.41	—	—	—	—	Northern Veracruz
2. Axe	96.8	2.17	.39	—	—	—	—	Panuco, Veracruz
E. *Yucatán*								
1. Bell[33]	Maj >	2.0	—	—	.1	—	.001	Huy, Yucatan

28 Lothrop (1952), p. 13.
29 Phillips (1925). Chisel cast in open mold, 3 cm long, 2 cm wide.
30 Lothrop (1952), p. 14 and 15. Wirelike bell (No. 3) is style F.
31 *Ibid.*
32 Staub (1926), p. 294.
33 Lothrop (1952), p. 15.

GROUP III: *Bronze Artifacts with Provenience "Mexico"*

1. Cat-faced bell[34]
Provenience: Unknown. (Dredged from cenote of Sacrifice)
Chemical Analysis:

Cu	Sn	Ag	Au	Fe	As	Ant	Bi
Maj	2.0	.1	—	—	.1	—	.005

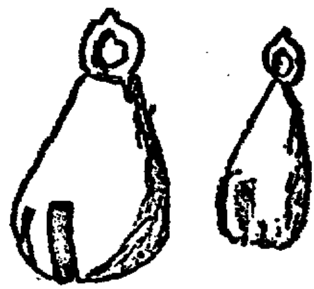
Comment: Zoomorphic copper bells in Pendergast's classification are known in West and Southern Mexico.

Actual size

2. Bell[35]
Provenience: Unknown (from Cenote of Sacrifice)
Chemical Analysis:

Cu	Sn	Pb	Ag	Au	Fe	As	An	Bi
Maj	2.0	0.1	.1	.01	.01	.01	.05	.05

Comment: Style "F" from Lothrop's classification. Pendergast reports this type in copper (IDIA) throughout Mexico.

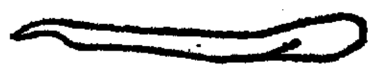


Actual size

3. Chisel or Punch[36]
Provenience: Unknown
Chemical Analysis:

Cu	Sn	Au	Zn
97.87	2.13	+	+

Comment: Referred to as "Aztec". No correspondin;, types in Pendergast.



Approx. 10 cm long

4. Needle[37]
Provenience: Unknown
Chemical Analysis:

Cu	Sn
Maj	2.8

Comment: Pendergast illustrates no needles of this type loop at the top. Aguilar, however, has photographs of a group of these which he says came from Central México (Aguilar, 1946, p. 143).

Dimensions unknown

[34] Lothrop (1952), p. 91 (drawing); p. 92,chemical analysis.
[35] Lothrop (1952), p. 88 (drawing); p. 90, chemical analysis.
[36] Mendoza (1879), p. 117 (drawing).
[37] Arsandaux and Rivet (1921), plate 7, fig. 2.

5. Needle[38]
Provenience: "Mexico"
Chemical Analysis:

Cu	Sn
Maj	3.8

Comment: These needles in copper (Pendergast type 1A are reported from central, western, and southern Méxic if it is typologically similar to needle excavated at Guerrero. Unable to determine from photograph of Guerrero needle.

10 cm long

SUMMARY

The data presented in the previous section will be treated by first grouping artifacts with known provenience by geographical area. Then artifacts from each geographical area will be discussed, with particular attention to typological comparisons with copper artifacts from that same area. These comparisons are intended as a preliminary step toward identifying what may eventually be established as metallurgical traditions for particular regions: stylistic elements or techniques of manufacture characteristic of both copper and bronze. Bronze artifacts which have no parallels in the cooper artifacts from a particular region will be noted as will bronzes which have no typological parallels whatsoever in Mexican cooper artifacts. The lack of typological parallels may imply that some artifacts are trade pieces, or that perhaps a class of artifacts is being made exclusively from bronze for a particular function.

Finally, all bronze artifacts presented in this paper are divided in two categories: utilitarian and nonutilitarian. The tin content for each category is indicated, and techniques of manufacture are discussed for each group. Inferences from this data relating to the use of bronze and the treatment of the metal will be drawn.

The geographical distribution of the bronze artifacts described in the previous section is shown in figure 2 on the following page. Exact provenience is indicated where available. Table 1 indicates the number of artifacts from each of the geographical areas of Mexico.

Central Mexico, as indicated in Table 1, is the source of the largest number (45%) of bronze artifacts. In view of the ore deposits in central Mexico, it is not surprising

TABLE 1

Provenience	*No. of artifacts*
Central Mexico	21
West Mexico	11
Southern Mexico (includes Oaxaca) (and Campeche)	4
Eastern Mexico	2
Yucatan	1
Unknown	5

[38] *Ibid.* Plate 6, fig. 9.

that the majority of the artifacts are from that area. North central Guerrero was probably also a source of copper and tin for Central Mexico, based on the evidence of preconquest tin mining at Taxco, as well as the evidence for aboriginal and contemporary cooper mining there.

As noted in the previous section, the vast majority of the central Mexico bronze artifacts are similar to copper objects from central Mexico identified by Pendergast and others. Two items, however, are anomalous. To my knowledge, the awl (Ib5), and the chisels (Ib6, Ib10), have no parallel forms in copper either in central Mexico or elsewhere. Three of the axes (Ib7, Ib8, Ib9) have no copper parallels from Central Mexico but are known from Oaxaca and Michoacan *(Aguilar,* 1946, p. 23).

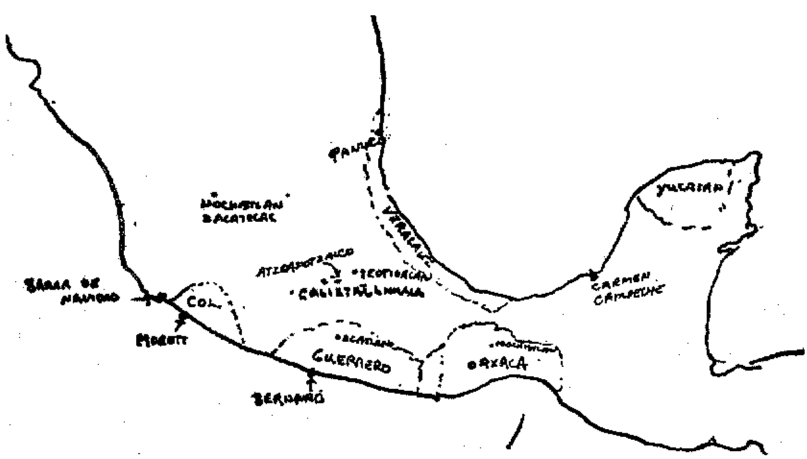


FIG. 2. Location of sites yielding bronze artifacts.

West Mexican material comprises 25% of the bronzes presented here. Presently known sources for copper are plentiful, particularly in Guerrero and Michoacan. As mentioned earlier, there is evidence of precolombian mining activity in Guerrero, and a report of copper mining in Colima. In West Mexico tin would be more difficult to obtain. There is one deposit in Nayarit and another in Northeastern Michoacan. Taxco is a likely tin source, particularly for the artifacts from the Bernard site in Guerrero.

We have illustrations of nine of the eleven bronze artifacts from Western Mexico. Five have corresponding types in copper in the Pendergast classification and have been found in Western Mexican sites. One, the bell (IA8) exists in the Pendergast classification in copper (from North Mexico and the Southern Maya areas) but is not known from West Mexico. Three of the West Mexican bronze artifacts have no equivalent types in copper. The bead bracelet (IA4), the tweezers (IA9) and the chisel (IA1) do not exist in the Pendergast classification nor could I find examples of them elsewhere.

The evidence for indium-bearing cassiterite ores in Guerrero (Caley and Easby 1967), in conjunction with the presence of indium in some of the artifacts from the Bernard site mentioned previously, constitutes excellent evidence for local manufacture of these bronzes. There also may be some local cassiterite ores which do not contain indium, since not all of the Bernard artifacts did show traces of it. The celt, for example, contained no indium. The fact that copper celts which are stylistically similar have been excavated from numerous West Mexican sites suggests it may be of local manufacture.

The artifacts from Eastern Mexico, Southern Mexico and the Yucatan are not illustrated, with the exception of the knife from Oaxaca, which is known in copper from that area. The closest known tin source for the Oaxacan knife is either Puebla or perhaps Guerrero. Puebla would also be the closest tin source for the items from Yucatan. Both tin and copper for the artifacts from Eastern Mexico would be available in the state of San Luis Potosí. We have no reports of aboriginal mining from that area, however.

We do not have data on provenience for the artifacts from Group III, and have no basis for grouping them by geographical area. Most, however, are stylistically and functionally similar to Mexican copper artifacts identified by Pendergast and others, which in most cases are found in several different parts of Mexico. The needles with the loop at the top (IB14) are known in copper from Central Mexico (Aguilar, 1946) but to my knowledge have not been found elsewhere. Establishment of definite provenience for these artifacts will require more information regarding the typological distribution of Mexican bronze objects, and particularly important, careful chemical analyses of both ore deposits and the artifacts themselves.

Table 2 divides the bronze artifacts into two categories: utilitarian and nonutilitarian, and indicates the percentages of tin included in each.

The majority of these bronze artifacts are utilitarian objects such as knives, chisels, needles, etc. The scant available evidence concerning manufacturing techniques indicates that these utilitarian artifacts were both cast and hammered. Since hardness would be a desirable attribute of utilitarian objects, tin may have been added with that objective in mind. It is important to remember however that hammered objects of copper can be, in some cases, as hard as cast objects to which tin has been added. Unfortunately, due to the lack of complete information concerning manufacturing techniques for these objects, or for their functional counterparts in copper the extent to which hardness was controlled for various artifacts classes is unclear. There is evidence that both methods the addition of tin, and hammering were used to increase hardness in the objects in this particular sample. The lance points (IB 11, 12, 13) an the celt (IA2) are both-harder at the cutting edge than at the center indicating that the edges were hammered following fabrication.

The non utilitarian bronze artifacts simillarly lack information concerning manufacturing techniques. The bells were presumably cast. The only artifacts that were definately hammered are the bracelet and the ring (IA4, IA7). Each was subsequently annealed. The remaining objects were also probably cast. The casting process is facilitated by the addition of up to 10% tin. The generally low quantities of tin in these

TABLE 2

TIN CONTENT IN UTILITARIAN AND NONUTILITARIAN ARTIFACTS

No.	*Utilitarian Artifact*	*% Sn*	*No.*	*Nonutilitarian Artifact*	*% Sn*
IA1	Chisel	10	IA4	Bracelet	10-15
IA2	Celt	5	IA7	Ring	10-12
IB4	Axe	2.8-9.3 (6%)[39]	IIB1	Filagree Ring	> 2
IB5	Awl	3.6	IIB2	Mask	> 2 (4% LZAD)
IB6	Knife/Chisel	1.3-3.8 (2%)	IC	Filagree Mask	> 2
IB7	Axe	1.3	IA8	Bell	30
IB8	Axe	1.3-3.8 (2%)	IB1	Bell	6.95
IB9	Axe	1.3-3.8	IB	Bell	2.9-9.3 (6%)
IB10	Axe or Chisel	9.3	IB3	Bell	4.7
IB11	Lance point	2.5	IIA1	Bell	2
IB12	Lance point	3.4	IIB1	Bell	> 7
IB13	Lance points A-D	(4) 1.3-3.8 (2%)	IIC2	Bell	> 2
IC1	Axe	3.7	IID1	Bell	> 2
IIA2	Chisel	3.07	IIE1	Bell	1.86
IIC3	Tool frag.	> 2.0	III1	Bell	2.0
IIE2	Axe	2.17	III2	Bell	2.0
III3	Chisel	2.13			
IA3	Needle	10-15			
IB14	Needle	2.8-9.3 (6%)			
IB15	Needle	2.8-9.3 (6%)			
B15	Needle	2.8-9.3 (6%)			
III4	Needle	2.8			
III5	Needle	3.8			
IA5	Wire	10			
IA6	Wire	10			
IA9	Tweezers	> 5			

[39] Root (in Lothrop, p. 78) estimates that Rivet's category of "notable" corresponds to 2% tin, and the category of "très notable" corresponds to 6%.

bronze artefacts suggests that the mexican metalsmiths were probably not using the new alloy in the most appropriate way.

Discussion

The issue of the origin of bronze working in Mesoamerica is a problem I wish to discuss here, bringing to bear the data presented in this paper as well as information from other sources. While the indigeneous development of bronze working from the Mexican copper tradition will be considered, the bulk of the evidence seems to point to the introduction of copper-tin metallurgy into West Mexico. Recent authors favor the Northern Andes as the source of the diffusion of metallurgy, including bronze, into West Mexico. However, the data in this paper suggest that the copper-tin bronze working tradition did not diffuse from Northern Andean sources, as Meighan argues and Mountjoy's evidence for the diffusion of copper working suggests, but from sources in the Southern Andes.

Certainly one possibility to consider is whether bronze could have developed independently in Mesoamerica from the copper working tradition. An argument could be made for this possibility, because copper "prototypes" exist for almost all of the bronze artifacts we have considered here. However, most of the evidence makes the independent development of bronze appear doubfful. Bronze working is unequivocally present in Mexico between 1200 and 1500 A.D. The chisel at the Morett site is probably earlier than 1000 and the tweezers are definitely dated before 1275 A.D. (Meighan 1969). We know that copper artifacts were not present in Mexico until 900 A.D. or slightly before. Given the fact that it took the Peruvians a period of experimentation of over two millennia before copper-tin alloys were produced, and an even longer period of time in the old world it is unlikely that the Mexicans could have produced a copper tin alloy in only three to four hundred years.

If we assume that bronze working was introduced into Mesoamerica, It is important to determine the geographical area of its initial appearance. Coper as well as bronze is of interest to us, because copper working clearly diffused from

[40] I am using Root's estimate here as discussed in footnote 39.

sources outside Mesoamerica. Both may derive from a common metallurgical tradition. Pendergast (1962) for example argues that copper working was introduced almost simultaneously into two areas: West Mexico (via sea trade) and the Southern Maya area. He suggests that Central America may have been the source. Mountjoy's (1969) position is that copper working was introduced into West Mexico via sea trade, but from the Andes (Ecuador and perhaps the central coast of Peru.) He notes that little copper working is known in Central America. The evidence supports Mountjoy's view, although Lothrop (1952) does discuss locally produced copper bells from Northwestern Honduras, which might indicate the development of centers of local manufacture. Some copper working may have diffused via overland trade. Meighan (1969), in discussing the diffusion of bronze working, argues that it was introduced initially into West Mexico, also via sea trade, but from the Northern Andes. He, too, cites evidence that no bronze working is known in Central America as support for his hypothesis.

The idea that copper and bronze were introduced vía sea trade is not a particularly novel one. Evidence for precolombian cultural contact by sea along the West coast of Mexico, Central America and the Northern South American coast is fairly well-established. West (1961) in a recent article translates an early Spanish account of sea trade reported by inindians living at the mouth of the Balsas River. They speak of trading with seagoing peoples from the south. Based on certain pottery type trait similarities, West argues that the traders were probably the Manateño from Ecuador. Recent archeological evidence indicates that these West Mexican and Ecuadorian trading contacts had considerable time depth. Isabel Kelley (1972) points to various stylistic similarities between the preclassic Capacha complex at Colima and the South American pre-classic. She also believes that sea trade was the most likely means of contact, since no continuous distribution of these particular traits exist. Sea trade which would involve the difussion of metallurgical ideas and techniques is thus a very real possibility.

Mountjoy's comparison of West Mexican and Andean copper artifacts also supports the hypothesis that metallurgy was introduced initially into West Mexico. Easby's (1962) comparison of Oaxacan and Andean gold working techniques offers yet another piece of evidence of diffusion of metallurgical ideas and techniques into approximately the same geographical area.

The data provided in the present paper serve as further support for the hypothesis that bronze was introduced initially into West Mexico. Eighty percent of the artifacts with known provenience come from West and Central Mexico. Pendergast suggests trade in copper artifacts between these two areas, and it is likely that trade in bronze occurred also. In addition, our information on aboriginal copper and tin mining indicates that the focus was in West Mexico: in Taxco Guerrero, along the Balsas River in Guerrero and in Colima. Quite probably, the first alloying of copper and tin occurred there.

While West Mexico appears to be the area of introduction, the geographical area from which the ideas were carried is an open question. (As an aside, it is unlikely that any technique as complicated as the alloying of copper and tin could have "diffused". Individual metalsmiths were probably involved). Most archeological evidence of precolombian contacts with West Mexico points to the north coast of Ecuador as the likely source of contact (Evans and Meggars, p. 263). Pendergast however in his discussion of the introduction of copper to Mesoamerica argues that Central America is the source from which ideas and techniques were diffused. Pendergast's suggestion however is improbable in view of the evidence that little copper working was indigenous to Central America. Mountjoy, on the other hand believes that coastal Ecuador is the most likely source, although his data consist of a sufficient number of copper artifacts from the central coast of Peru that he posits an interchange of artifacts and ideas between coastal Ecuador (the Guayas basin) and the coast of central Peru. Both regions, then, could be considered as sources from which these metallurgical techniques diffused. Meighan points to an area between northern Peru and Colombia as the source from which bronze metal working was diffused. Based on this evidence, it seems fair to conclude that both bronze and copper metal working were introduced from the Andes.

It is illuminating in this regard to briefly compare precolombian Mexican bronze artifacts with Andean bronze artifacts. A preliminary effort to compare three bronze items from the Andes, with three from Mexico produced some extremely interesting stylistic parallels, as shown below.

Tweezers

West Mexico

Sn > 5
2.5 cm long

Peru (Pachacamac)[41]

Sn 5.5%
2.5 cm long

Chisel

West Mexico
Central Mexico

Sn 10%, 4.4 cm

Morhuasi Argentina[42]

Sn 7.9 approx. 4 cm

Needle

Valley of Mexico

Sn 2.8-9.3

Peru (Machuu Pichuu)[43]

Sn 5.6

41 Nordenskiold (1921), p. 79 d.
42 *Ibid* (1921) p. 98, No. 15.
43 *Ibid* (1921) p. 92, No. 14.

Comparison of these Mesoamerican and Andean bronzes demonstrates stylistic similarities. The three Andean bronzes were encountered in a rather coursory examination of the literature. I suspect that a more thorough investigation might expand the number of artifact types and styles common to Mesoamerica and the Andes. Two of the three mexican bronze objects (the chisel and the tweezers) do not have counterparts in copper from Mesoamerica. The chisel is of particular interest, because it is the earliest bronze known in Mesoamerica (before 1000 A.D.), occurs in West Mexico, and in the opinion of the excavator is a trade piece. The Andean counterpart is from Argentina, although there are similar examples from Chile. The bronze tweezers from West Mexico, like the chisel, have no counterpart in copper in Mexico. These tweezers from West Mexico are earlier than 1275 A.D., according to Meighan (1969). Numerous examples of this type of bronze tweezer do exist in the andean region. The Mesoamerican bronze needles are from the Valley of Mexico; we have no dates for them. They do have parallels in copper, although like the bronze, they are not firmly dated. The Peruvian bronze needle is from Machuu Pichuu, and therefore is probably late horizon.

One of the most striking features of this data is that the tweezers and the chisel are dated before 1275, and before 1000 respectively, making them extremely early for Mesoamerican bronze. Both are from West Mexican sites, and neither have Mexican copper prototypes. These data strongly suggest that they are trade pieces from Peru.

Obviously we cannot prove "diffusion" of bronze working from the Andes to Mexico based on a few artifacts, particularly since dating of the Andean material is not available. These comparisons do however demonstrate suggestive stylistic and functional similarities in bronze objects found beween Mexico and the Andes, disregarding the temporal dimension. Conclusions based on evidence of this sort would require earlier examples of Peruvian copper-tin bronzes and a much larger sample.

The various data presented here suggest that bronze metallurgy was introduced into West Mexico from the Andean area via sea trade. However, Meighan's suggestion that it originated in the northern Andes, and the idea that it may have come from the sources Mountjoy suggests for copper are untenable in light of the recent studies of Andean metallurgic of Heather Lechtman (1975).

Lechtman's work clearly delineates two distinct Andean metalworking traditions in copper alloys. The northern Andean peoples had traditionally produced bronzes that were alloys of copper and arsenic, a trend that became particularly pronounced during the late horizon (1000-1400) among the Chimu people on the north coast of Peru.

The southern Andean peoples, in contrast, in the altiplano of Peru, Bolivia and northern Argentina, for the most part produced bronzes that were alloys of copper and tin. Alloys of copper and arsenic were also known, however. These two distinct areal traditions prevailed until the Inca conquest, when the use of copper-tin alloys was imposed upon the newly conquered peoples on the north coast of Peru and in Ecuador. The Inca conquest of northern Andean areas occurred about 1470 A.D.

This evidence raises new questions about the assumption that copper-tin bronze working was introduced into West Mexico from the northern Andes. Meighan's' argument for diffusion from the area between northern Peru and Colombia is doubtful in view of Lechtman's studies. Mountjoy also cites Ecuador as the major source of the diffusion of copper artifacts into Mexico. Yet unless we allow a very late introduction of bronze working into West Mexico, the source for the introduction of bronze into Mexico cannot be the northern Andes, since there were no copper-tin bronzes in that region. The Central Peruvian coast-Ecuador (Guayas basin) route Mountjoy postulates for copper objects does not appear to apply to bronze as copper-tin bronzes were unknown in Ecuador until the Inca expansion. On the central coast of Peru, we find both copper-tin and copper-arsenic bronzes. We know that copper-tin bronzes were primarily centered in the southern highlands of Peru and Bolivia (near tin sources), until the Inca horizon. Dates for the Coastal material are unavailable and a mixing of the two traditions may have occured in that region (Lechtman personal communication).[44] The source of the Mexican bronzes consequently cannot be the Northern Andes, since the Northern Andean peoples were heavily committed ideologically and technologically to copper arsenic. Given this evidence, the peoples who introduced copper tin alloying to Mexico were not the groups suggested by Meighan, nor those Mountjoy has suggested for copper unless we are willing to accept a *very late date* for the introduction of bronze into Mexico. On the contrary, the distribution of bronze artifacts in Mexico, the historical and archaeological evidence for local manufacture and the dates: before 1000, 1000-1275, and 1200-1500 argue strongly for the introduction of bronze metallurgy into Mesoamerica prior to the Inca expansion. Therefore the Southern Andes was the area form which copper tin bronzes diffused, probably via the central coast of Peru.

Future studies of the diffusion of copper tin bronzes from the Andes into Mesoamerica therefore should be directed to that area of the Andes wehere copper tin bronzes were known prior to the Inca expansion: the Altiplano of Peru and Bolivia, and Northern Argentina. Technical studies of copper alloy objects from datable contexts on the Central Coast of Peru will clarify the bronze-working traditions of that area, important in tracing the probable routes through which copper tin bronzes were introduced to Mesoamerica.

To summarize, the data presented in this paper raise important questions about the areas from which copper-tin bronzes were introduced to Mesoamerica. The spread of bronze working has been treated in this paper as an example of the diffusion of a cultural trait. Such a study contributes to our knowledge of the culture history of the two areas. The broader issues, and more important ones, concern the kind of contact that was occuring between the Andean area and Mesoamerica through time, represented by the introduction of metalworking, and the impact of those contacts on the culture histories and evolutionary processes in both regions.

44 Personal Communication Jan 1976.

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