Table 4.5 Quantitative Chemical Analyses of Artifacts from Cerro Alto and OGSE-Ma-172 (Santa Elena Peninsula)

		Composition (weight percent)											
Type	ID No.	Ag	As	Au	Bi	Co	Fe	Ni	Pb	Pt	Sb	Sn	Zn
Regional Developmental Period													
Awl	3650	0.05	—	na	—	—	na	—	—	na	—	—	0.001
Fishhook	3645	0.03	—	0.13	—	—	na	—	—	na	—	—	0.002
Fishhook	3651	0.01	—	na	—	—	na	—	—	na	—	—	0.001
Needle	3644	0.09	3.24	na	—	—	na	—	—	na	—	—	0.002
Tweezer	3649	0.05	0.21	na	0.03	—	na	0.05	0.15	na	0.06	—	—
Integration Period													
Needle	3652	0.02	1.37	na	0.02	—	na	0.04	0.18	na	0.05	—	0.001
Star	3647	0.02	—	na	—	—	na	0.02	—	na	—	—	0.26

Note: Analyses carried out by atomic absorption spectrometry. A dash indicates element not detected; "na" indicates element not analyzed quantitatively because not detected in qualitative analysis.

per. The copper-arsenic alloys contain arsenic in concentrations between approximately 0.5% and 1.0%, high enough to have altered the working properties of the metal. Even when arsenic is present in these low concentrations the alloy can be made somewhat harder by cold working. Formal design can be modified, too. Yet, as the MAG data presented subsequently will show, these ancient smiths rarely used the properties of this particular alloy to alter or optimize object design.

At Ayalán, the large Integration Period cemetery southwest of Guayaquil, archaeologists excavated a large corpus of metal objects from urn and extended burials (Ubelaker 1981): rings, nose rings, pendants, tweezers, and axe-monies. Axe-monies are thin, axe-shaped pieces of sheet metal (Hosler 1986; Hosler, Lechtman, and Holm 1990), often stacked and bound in packets. They are almost always made of a low-arsenic copper-arsenic alloy. The earliest axe-monies in this region appear at Ayalán. Axe-monies are also common in West Mexico after A.D. 1200 and are discussed in chapters 5 and 6. Radiocarbon determinations show that the earliest date for a burial with associated metal at Ayalán is A.D. 750. The cemetery continued in use until shortly before the Spanish invasion.

Loma de los Cangrejitos, a ceremonial complex with five small pyramids and an elite cemetery, was occupied from A.D. 900 to the historical period. The 125 metal artifacts excavated there all derive from burials, and include bells, tweezers, needles, axes, axe-monies, knives, and awls. Implements and sumptuary objects are present in almost equal proportions. Three phases are represented at Loma (Marcos 1981); most metal artifacts come from the earliest of these (A.D. 900 to A.D. 1150).[18] Bells are more numerous than any other objects and make up 35%

Table 4.6 Quantitative Chemical Analyses of Artifacts from Salango

		Composition (weight percent)											
Type	ID No.	Ag	As	Au	Bi	Co	Fe	Ni	Pb	Pt	Sb	Sn	Zn
Awl	3656	9.6	0.09	0.12	—	—	na	0.02	0.12	na	0.03	—	0.01
Awl	3662	4.5	0.06	0.07	—	—	na	0.01	0.23	na	0.02	—	0.001
Bell	3658	0.3	—	0.01	0.08	—	na	—	0.16	na	—	—	—
Fishhook	3654	0.03	—	na	—	—	na	0.02	0.05	na	0.03	—	—
Needle	3659	0.06	0.78	na	—	—	na	0.03	0.19	na	0.03	—	—
Needle	3660	0.08	0.38	na	—	na	na	na	0.44	na	0.03	na	0.001
Needle	3661	0.22	0.2	0.004	—	—	na	0.03	0.09	na	—	—	—
Needle	3665	0.85	—	0.02	—	—	na	0.02	0.08	na	0.03	—	0.003
Open ring	3655	45.5	—	0.39	0.11	—	na	—	0.41	na	—	—	0.02
Open ring	3663	0.01	0.70	na	0.06	—	na	—	1.60	na	0.1	—	0.004
Open ring	3666	0.03	—	na	—	—	na	0.02	0.41	na	0.05	—	0.005
Tweezer	3664	0.06	0.46	na	—	—	na	0.03	0.39	na	0.03	—	—

Note: Analyses carried out by atomic absorption spectrometry. A dash indicates element not detected; "na" indicates element not analyzed quantitatively because not detected in qualitative analysis.

of the assemblage; qualitative analyses show that all bells are made from copper or a very low-arsenic copper-arsenic alloy. These Ecuadorian bells are cold-worked to shape, unlike their counterparts from Mexico which are lost-wax cast. All the utilitarian objects analyzed—tweezers, needles, awls, knives, and axes—are also made from a low-arsenic copper-arsenic alloy (table 4.7), which served as a kind of stock material for the metal objects found at this site. The awls and axes contain arsenic in concentrations between 0.5% and 2.0%. Axes and tweezers together comprise 33% of the corpus. The axe-monies recovered at Loma de los Cangrejitos, like all Ecuadorian axe-monies, are made from copper-arsenic metal (Hosler, Lechtman, and Holm 1990). The absence of objects made from gold, silver, and their alloys is unusual and may reflect some aspect of the excavation strategy.

Metal artifacts never were as abundant at the coastal centers as they became in the inland area. We have no evidence thus far that coastal artisans crafted metal objects on any significant scale, although they probably did so occasionally. At Salango, for example, a ceramic mold was recovered that could have been used for casting metal tools. Most items were likely imported to these sites as finished objects. The distributional evidence indicates that by the late Integration Period (A.D. 800 to A.D. 1530), the inland Milagro-Quevedo area was an important zone for metal production, and it is highly probable that earlier this region also constituted a primary production locus. Two large excavated assemblages of metal objects, both dating after A.D. 900, come from sites located on the inland plain: one from La Compañía, and the other from

Table 4.11 MAG Collection Copper-Arsenic Alloys: Arsenic Concentration and Artifact Design Characteristics

Type	Number Analyzed	As Level (wgt. %)	Mean As Concentration (wgt. %)	Mean Ratio
Tweezers	11	> 0.4	1.01	42.0 l:th
	9	< 0.4	0.21	42.0
Axes	23	> 0.4	1.38	47.5 l:th
	15	< 0.4	0.13	37.0
Bells	18	> 0.4	1.08	29.0 h:th
	4	< 0.4	0.18	15.2
Rings	7	> 0.4	0.86	10.1 d:th
	11	< 0.4	0.21	9.8

Note: l = length; th = thickness; h = height; d = diameter.

gold alloys were common, as were extraordinary gilding and silvering techniques.

The Character of Ecuadorian Metallurgy. These people fashioned an array of metal objects that make clear they were interested in metal for two purposes: for ritual and status objects that were worn—such as nose rings, rings, and bells—and for axe-monies, items that served as a standard of value or medium of exchange. Technical study of Ecuadorian axe-monies (Hosler, Lechtman, and Holm 1990) has shown that they were consistently made from a low-arsenic copper-arsenic alloy. In addition to their intrinsic social and symbolic worth deriving from their axelike shape, Ecuadorian axe-monies like their West Mexican counterparts may have served as a repository for copper-arsenic metal (Hosler 1986), from which the large majority of Ecuadorian copper-based metal objects were made.

Metal was also utilized for its resonant properties, although far less so than in West Mexico. Metallic sounds were produced by small bells ranging in height from about 0.4 to 3.5 cm, with most measuring between 1.0 and 2.0 cm. They were hammered to shape, and hammering clearly mitigated any significant variation in form. Most are round, and all exhibit smooth exterior surfaces. Since resonator size and shape vary far less than in the West Mexican designs, the range of pitches produced by these bells is correspondingly more limited. Pitch is also compromised as a result of the manufacturing process because these bells were shaped by hammering, and the consequent compression of the metal grains acts to dampen vibrations.

One of the striking characteristics of Ecuadorian metallurgy is the limited range of metals and alloys employed, at least in the copper-based component I have examined here. The range of artifact types is also restricted. Metalworkers focused primarily on three artifact classes—rings, axe-monies, and bells (see table 4.8)—and they usually made them from a stock low-arsenic copper-arsenic alloy. Yet the data also indicate, surprisingly, that Ecuadorian metalsmiths were not systematically using these copper-arsenic alloys to improve artifact design.

One of the common artifacts made from arsenic bronze, axe-monies, served as a medium of exchange.

rication methods, and metals and alloys resemble one another, even where cultural affiliations, as seen in other aspects of the material record, seem minimal. Both archaeological and documentary evidence indicates that the primary center for metalworking was the Tarascan empire, whose capital, Tzintzuntzan, lay in the basin of Lago Pátzcuaro in highland Michoacán. The empire eventually extended over 75,000 square kilometers, reaching from the Balsas to the Lerma river system, and included all of the modern state of Michoacán. Tzintzuntzan encompassed slightly more than six square kilometers and had a population of 25,000 to 35,000 people. The city itself consisted of a ceremonial precinct as well as low-, middle-, and high-status residential zones. The surrounding Pátzcuaro basin is estimated to have supported a population of around 80,000 people at the time of the European invasion (Pollard 1993). Numerous metal objects have been recovered at Tzintzuntzan, primarily from burials.

Metal objects also come from other sites in highland Michoacán: for example Urichu,[4] Milpillas,[5] and Huandacareo (Macías G. 1990). Most were excavated from burials. Urichu was one of eight Tarascan communities in the Pátzcuaro basin that served as a local administrative center. Tarascan nobility governed Urichu, reporting directly to the royal dynasty at Tzintzuntzan (Pollard 1993). There, Pollard excavated four burials that contained a total of 19 metal objects.

Milpillas, a Postclassic center to the north near Zacapu, covered at least 54 hectares. Twenty-two metal objects were recovered from burials, a test trench, and a midden deposit, all of which date to after A.D. 1200. Cultural affiliations are unclear. Tarascan ceramics are present but infrequent. Domestic ceramics resemble those Pollard has excavated at Urichu.[6]

A large assemblage of metal artifacts was excavated at Huandacareo, a major Tarascan administrative center in the Lago Cuitzeo basin. Huandacareo was founded by the Tarascans when they conquered the basin in about A.D. 1440. Tarascan elite pottery appears at this site associated with metal objects; 117 sumptuary artifacts and 17 tools have recently been excavated there, primarily from burials and test pits (Macías G. 1990).

The adjacent Valley of Toluca seems also to have been an important metalworking center. Virtually no datable metal objects have been recovered, but numerous items are reported from the site of Calixlahuaca, a few kilometers to the northwest of the modern city of Toluca. Calixlahuaca was conquered by the Aztecs in 1476.

During Period 2, metal artifacts have also been recovered at a number of sites in the Pacific coastal lowlands. Some assemblages are associated with Tarascan materials, others are not. Kelly (1947) recovered 107 metal objects from burials, refuse mounds, and test trenches at sites in the Apatzingán region, located in the Balsas depression of Michoacán. She also recovered a few examples of what she thinks is copper ore. Kelly believes that the metal objects represent local production and use (1947: 143). The ceramic complex at the site is unrelated to Tarascan state material, the basis for Kelly's contention that there is no evidence for a Tarascan presence there, and extremely little evidence for even casual trade relations.

Many objects from the Infiernillo sites, discussed in chapter 3, and from La Villita on the lower Río Balsas also date to this period. The ceramics from Infiernillo represent ties with both the Tarascan state and other regions of West Mexico, specifically northwest Jalisco, Nayarit, and Colima.

Kelly (1949) also extensively surveyed a number of sites in Tuxcacuesco (Jalisco), then carried out limited excavations at six of them, recovering 42 objects from burials, surface collections, and test pits. Several pieces of what seems to be partially processed metallurgical material appear among these items. The predominant ceramic material at Tuxcacuesco is a local style showing some relationships with Colima, to the south.

Metal objects have also been found at Lo Arado, a large Postclassic site in the coastal lowlands of Jalisco. Lo Arado has not been scientifically excavated (Covarrubias V. 1961; Mountjoy 1970). Covarrubias, who wrote a brief report on the site, observed burial mounds lined up in rows along a north-south axis and ceramics that he describes as Postclassic (A.D. 900 to A.D. 1521). He also describes a few of the many metal objects recovered there as made from copper, silver, and gold. Artifacts ascribed to Lo Arado appear in the RMG collections and were analyzed in the course of this study.

Numerous metal objects have been reported from the site of El Chanal (figure 5.1) in Colima, a large Late Postclassic ceremonial center 45 kilometers from the coast (Kelly 1980). El Chanal, which has been extensively looted, dates to A.D. 1250 or later and encompasses at least 5 acres. El Chanal seems to have remained outside of the Tarascan empire, judging from materials recovered in surface collections, seen in private collections (Kelly 1980), and described in historical records.[7] The ceramic material from the Chanal phase in Colima represents a local West Mexican base (Kelly 1980), but contains certain elements that also relate it to Central Mexico. Many El Chanal metal objects also made their way to the RMG collection.

Large numbers of undatable metal artifacts have been reported to the southeast, in Guerrero. The only reasonable temporal assignments at the moment are from the Bernard site on the coast, where 26 metal objects were recovered from limited test excavations; all date to after A.D. 1250. The excavators also identified pieces of material that they interpret as slag, and suggest that metal production was probably taking place at the site (Brush 1962).

In Sinaloa, the northwestern limit of the metalworking zone, metal objects have been excavated from a burial mound at the site of Guasave (Ekholm 1942). Guasave lies on the coastal plain of Sinaloa a few kilometers from the shore (see figure 6.1) and dates to about A.D. 1200 (Meighan 1974). Excavations revealed 166 complete burials; 134 metal objects were recovered, all in burial contexts. Multiple examples of elaborate polychrome ceramics, identified as Aztatlán, were excavated at Guasave. In addition, 19 metal artifacts were recovered from burials and middens at Culiacán (see figure 6.1), at a series of sites surveyed along the Río Culiacán valley south of Guasave (Kelly 1945). Some are associated with polychrome pottery similar to that found at Guasave; the assemblage dates to the same period.

Evidence for Period 2 metallurgy appears primarily at the sites discussed here. However, artifacts from these sites constitute only a small proportion of the metal items known from the metalworking zone; many others come from casual finds and looters' activities.

The Metallurgical Technology of Period 2: New Materials and New Designs

During Period 2, metalsmiths explored the properties of the alloys to make major changes in the formal designs both of lost-wax cast bells and of objects that were hammered to shape: open rings, tweezers, needles, axes, and awls.[8] They also used the alloys for new artifact types. The most abundant of these were sheet metal ritual and status objects and axe-monies. Both these new types required the strength, toughness, and ductility of these alloys. In the Tarascan region, copper-silver sheet metal ritual items—shields, neck pieces, pendants, breastplates—became so common that the Spaniards referred to the alloy as the metal of Michoacán (Warren 1985). From it, smiths crafted extremely thin, delicate designs with highly reflective, silvery surfaces. Axe-monies, thin, T-shaped objects, were made primarily from copper-arsenic alloys. They appear in Oaxaca and in some areas of the West Mexican metalworking zone (Hosler 1986; Hosler, Lechtman, and Holm 1990). The West Mexican variety is found in Guerrero and Michoacán and has its closest counterparts on the coast of Ecuador.

We have too few dated assemblages to know the extent to which Period 2 smiths continued to make Period 1 designs from unalloyed copper. The evidence from Cuexcomate, Tzintzuntzan, Urichu, Milpillas, Bernard, Huandacareo, and Calixlahuaca[9] suggests that perhaps they did not continue to do so; at these sites most metal artifacts are designs optimized by using the alloys. However, in other regions, for example at Apatzingán, Tuxcacuesco, and La Villita, the impact of this second wave was more limited. People living in these areas probably were marginal with respect to obtaining either finished objects or raw materials. At these sites, as well as at the more distant sites in southern Mesoamerica, only certain artifacts have been recovered that represent the new technical complex. To the north and northwest, in the state of Sinaloa at the sites of Guasave and Culiacán, these developments were barely felt, and the Period 1 tradition persisted.

Lost-Wax Casting: Bells

Bells were the focus of a great deal of technical experimentation during this period. West Mexican metalsmiths used the tin and arsenic bronze alloys to create at least five new bell designs (4, 7, 8, 9, 10) and numerous variations on them, as well as new versions of earlier types (1b). Bell designs that first appear during Period 2 are illustrated in figure 5.2; all types illustrated here are found

Table 5.1 Period 2 RMG Bell Types (Lost-Wax-Cast): Composition and Number Analyzed in RMG Collection, and Archaeological Sites of Appearance

		Specimens from RMG Collection		
RMG Type	Datable Archaeological Sites*	Number Made from Alloy	Number Analyzed	Number in Collection
1b	Milpillas (Cu-Sn)	—	—	3
4a	Tzintzuntzan	4	5	10
7a	Cuexcomate (Cu-Sn)	6**	9	30
	Milpillas (Cu-Sn)			
	Tzintzuntzan			
7b	Tzintzuntzan			
7c	Tuxcacuesco			
7d	Milpillas (Cu-Sn)			
8a	Tzintzuntzan	12**	12	41
8b	Tzintzuntzan			
8c	Tzintzuntzan			
8d	Tzintzuntzan			
9a	Bernard (Cu-Sn)	6	11	185
	Tzintzuntzan			
10b	Milpillas (Cu-Sn)	18	18	27
	Tzintzuntzan			

* Composition, if available is indicated in parentheses.

** The numbers found in the columns for 7a and 8a encompass 7a–c and 8a–d respectively.

5.2

Period 2 bell types identified in RMG collection and present in datable archaeological contexts.

new materials to create golden and silvery reflective colors associated with the concepts of the sacred discussed in chapter 8, and with the solar and lunar deities. They did so for objects whose design characteristics often disallowed the use of pure metals. Golden colors were achieved with high-tin bronze alloys in bells, open rings, tweezers, and occasionally sheet ornaments; silvery colors with high-arsenic bronze in bells, and with copper-silver alloys for objects that were cold- and hot-worked to shape, such as open rings, tweezers, and sheet metal ornaments. Copper-silver alloys are difficult to cast, and copper-arsenic alloys become brittle when worked if the alloying element is present in high concentrations. The metalworkers' solution to creating silvery-looking metal was precisely in keeping with the properties of these particular alloys.

Cold Work: Tools and Axe-Monies

Nearly all other objects made using these new materials are implements for woodworking and woodcutting, cloth production, metalworking, and related activities. They include needles, axes, unipointed and bipointed awls, and awls with narrow blades. Tools used for subsistence activities—such as hoes, fishhooks, and digging stick points—while not abundant, also figured in the technical repertoire. One artifact type, axe-monies found in Guerrero, Michoacán, and Oaxaca, pertains to a wholly different functional category. Documentary sources suggest that the variety found in the West Mexican metalworking zone was used for tribute.

Axes. Datable axes are found infrequently in this region, although they are mentioned in many ethnohistoric sources from the Late Postclassic Period. The documents indicate that in Michoacán metal axes were used for woodcutting and woodworking. In fact, the *Relación de Michoacán* relates that a guild of woodcutters represents one of the craft specialties supported by the king of Michoacán. The guild is depicted in the *Relación,* and their leader holds a hafted metal axe, the symbol of their vocation (figure 5.14). The primary task of the guild was to gather wood for temple fires. Wood gathering itself apparently could be a ritual act. For example, the *Relación* states that a man who remarried was required to spend four days gathering wood beforehand as a kind of penance. The *Relación* illustrates such an individual, burdened with wood, wielding a hafted metal axe (figure 5.15). In Central Mexican sources, metal axes are shown being used as tools, dissociated from ritual contexts. A

5.14

Tarascan woodcutters holding a hafted, metal axe. (From Craine and Reindorp 1970, plate 3.)

it also makes for a softer needle. We do not know how these distinctive needles were used at Cuexcomate. However, these implements support Smith and Heath-Smith's (1994) contention that Cuexcomate was a zone of specialized cloth production.

Both needle designs, the perforated eye and loop eye, have also been found in the Balsas drainage in burials at Infiernillo and La Villita (see table 5.6) but these examples have not been analyzed. Apart from Cuexcomate, where needles were recovered from household contexts, loop eye needles have been excavated from burials at a number of other sites: at Urichu, Tzintzuntzan, Huandacareo, and Tres Cerritos. The perforated-eye needle has also been found at Apatzingán.

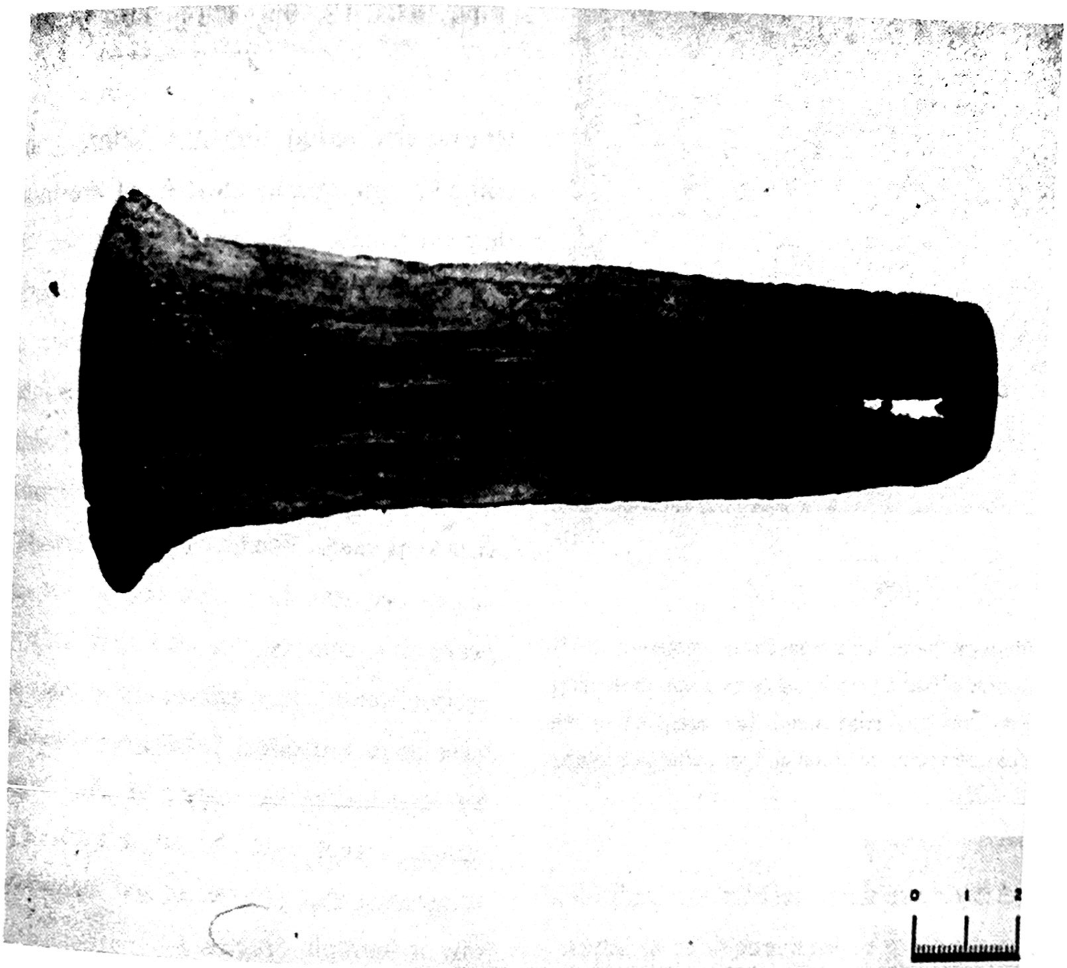
None of the Cuexcomate needles measures longer than 11 cm. The bronze alloys were not being used to make longer needles but to fashion sturdier designs. The chief design requirement was to achieve a very narrow metal loop eye: the loops measure only 0.05 cm in some cases. However, needles excavated at Urichu did take advantage of the properties of the alloys for length and a finer design: for example, one measures 16.5 cm in length and is only 0.1 cm thick, with an extraordinarily narrow (0.03 cm) loop eye.

Axe-monies. Axe-monies constitute a unique artifact class. Axe-monies have been reported most frequently from Oaxaca (Easby, Caley, and Moazed 1967; Hosler 1986; Hosler, Lechtman, and Holm 1990), but the variety found in Guerrero and along the Michoacán-Guerrero border do not appear outside this metalworking zone (figure 5.27). The West Mexican axe-monies measure from 14 to 20 cm in length, are thin (mean thickness measures 0.05 cm), and are shaped like an axe.

Axe-monies have rarely been found in archaeological context in this region, and never with secure dates. The Oaxacan variety dates to after A.D. 1200. Ethnohistoric evidence for the West Mexican type indicates that these objects were tribute items. Objects that closely resemble them are illustrated in the Codex Mendoza as tribute items to the Aztec from two provinces in Guerrero, and similar artifacts, but made from silver, were tribute to the king of Michoacán (Clark 1938; Schöndube B. 1974). *Hachuelas* is a term in Spanish sometimes used to describe the axe-shaped objects that were used as tribute. An inventory of the Casa de Munición in Mexico City, drawn up in 1528, lists among the copper objects stored there eight hundredweight of copper, 500 copper shields, and 113 cases of copper *hachuelas* (Barrett 1981: 12). The probability is good that these *hachuelas* were the type la axe-monies described and illustrated here.

In descriptions of archaeological explorations in Naranjo, central Guerrero, Weitlaner reports acquiring a "packet of 13 copper leaves [*láminas*] in the form of an axe but with the thickness of heavy paper, about whose use we were unsure" (Weitlaner 1947: 79). Fragments of *láminas muy delgadas* [very thin leaves] were excavated at La Villita on the Michoacán-Guerrero border (Cabrera C. 1976), and villagers at the site of Xochipala, Guerrero, also report finding them, again referring to them as *láminas* (Hosler 1986; Hosler, Lechtman, and Holm 1990).[18] A group of 30 were collected from the Balsas drainage in Guerrero and are housed in the regional museum of Cuernavaca in the state of Morelos. Examples from Guerrero are also found in the British Museum, the Museo Nacional de Antropología e Historia in Mexico City, and the American Museum of Natural History in New York.

The distinctive characteristics of these objects, determined from studies of the RMG collection, is that they are usually made from arsenical copper and often from an alloy of copper and arsenic (see appendix 2). Arsenic concentrations range from 0.05% to 6.35% by weight. Axe-monies were fashioned from an original cast blank; successive sequences of cold work and annealing pro-

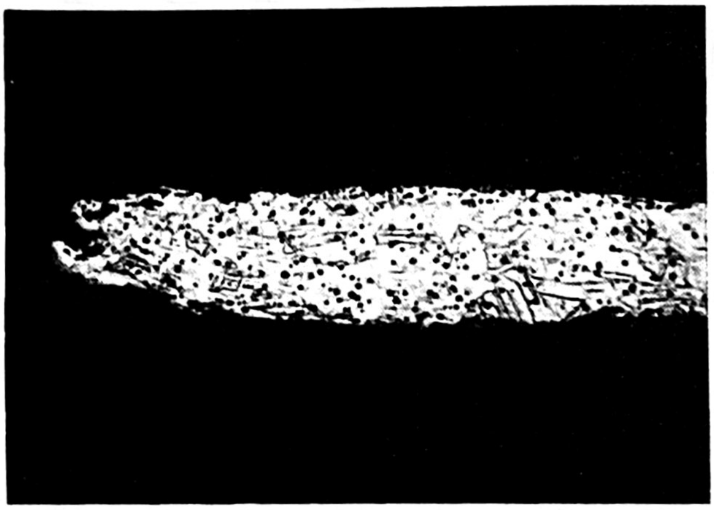


5.27

Axe-money (type 1a), found in Guerrero.

duced the extremely thin metal sheet used to shape them. The photomicrograph in figure 5.28 of a longitudinal section through a typical Guerrero specimen shows a fully annealed structure with some very slightly elongated inclusions reflecting prior cold work. An alloy optimizes the design of these leaflike objects because the metal is so thin. Most axe-monies were left annealed, although some were left in the cold-worked condition. If metalsmiths consistently had made them this thin from copper, they would have retained their shape with difficulty. Even so, the concentration of arsenic is highly variable and clearly was not systematically controlled.

The use of the copper-arsenic alloy for this West Mexican design and for all other axe-monies suggests that they, like their Ecuadorian counterparts (see chapter 6), may have served as a repository for copper-arsenic metal. Lengths range from 14 to 20 cm, as I have noted; thickness varies from 0.02 to 0.06 cm. The fact that lengths are fairly uniform is consistent with their use as tribute items. Axe-monies are made so that they can easily be stacked on top of one another, and Weitlaner's description of a "packet" of 13 leaves suggests that in this zone, as in Ecuador, these objects were packaged and bound in lots. They were easily portable repositories of copper-



5.28

Longitudinal section through the tip of a type 1a axe-money (0.60% As). Microstructure characterized by equiaxed grains with annealing twins; the cold-worked and annealed metal has been left in the annealed state. Sample etched in ammonium hydroxide plus hydrogen peroxide (mag.: 100).

arsenic metal, and their axe shape reflects the traditional importance of the axe form in Mesoamerican societies.

The artifacts described here in some detail—bells, open rings, tweezers, needles, axes, awls, and axe-monies—are the primary metal object classes produced during Period 2 in the metalworking zone. They are by no means the only ones. Fishhooks, hoes, digging stick points, arrow points, nose rings, lip plugs, beads, buttons, hand-held rattles, finger rings, and assorted small ornaments (bells attached to needles, and so forth) were also fashioned during this time and from these same metals and alloys (Hosler 1986, 1988a). However, they appear relatively infrequently in museum collections and in archaeological excavations. Sheet metal gold and silver ritual items, sometimes made from alloys of those metals, are the only significant artifact class that cannot be thoroughly treated here. They do not appear either in museum collections or in archaeological contexts in the numbers suggested by the documentary sources.

The Focus of Period 2 Metallurgy

During the period after A.D. 1200, a new technological complex emerged in the area of the metalworking zone described here. That area includes the Tarascan region of Michoacán, the Valley of Toluca, northwest Guerrero, Colima, and parts of Jalisco. However, apart from occasional references to several mines in Michoacán where ore processing occurred (Hosler 1986; Pollard 1987; Warren 1968, 1989), we do not know where mining and production took place. The few sites mentioned here from which slag or ore have been reported do not constitute primary processing centers. We also have little idea of how the production of these bronze and copper-silver objects may have been controlled. Laboratory data offer little evidence for standardization either in alloy types or in artifact design, except at the broadest levels of property control, suggesting that processing and manufacture were carried out at multiple centers.

A defining characteristic of the Period 2 technological complex is that metalsmiths used copper alloys extensively: the two binary bronzes, copper-silver, and ternary alloys of these metals. New smelting regimes (described in chapter 2) were required to produce this range of alloys. These alloys allowed artisans to optimize the design of objects that had previously been made in copper, employing new fabrication techniques, such as hot work, to manipulate them when necessary. Objects made from bronze alloys were fashioned in only one other region, the Huastec area in eastern Mexico (Hosler and Stresser-Péan 1992), and the data so far indicate that this occurred just before the Spanish invasion. Elsewhere, for example to the north in Sinaloa and at sites along the lower Balsas, smiths continued to work in copper as before. To the south, in Oaxaca, a very different technology emerged centering on the production of lost-wax castings from

Some Period 2 developments had their roots in the metallurgies of lower Central America and Colombia or southern Ecuador and northern Peru, the same two regions from which elements of the technology were introduced earlier. Others derived from metallurgical traditions even farther to the south, from the south-central coast of Peru and the adjacent highlands of Peru, Bolivia, and northwest Argentina. Still others arose independently in West Mexico. Period 2 metalsmiths integrated these diverse elements according to their own precepts concerning how metal should be used and the particular native metals and ores available to them.

ALLOYING

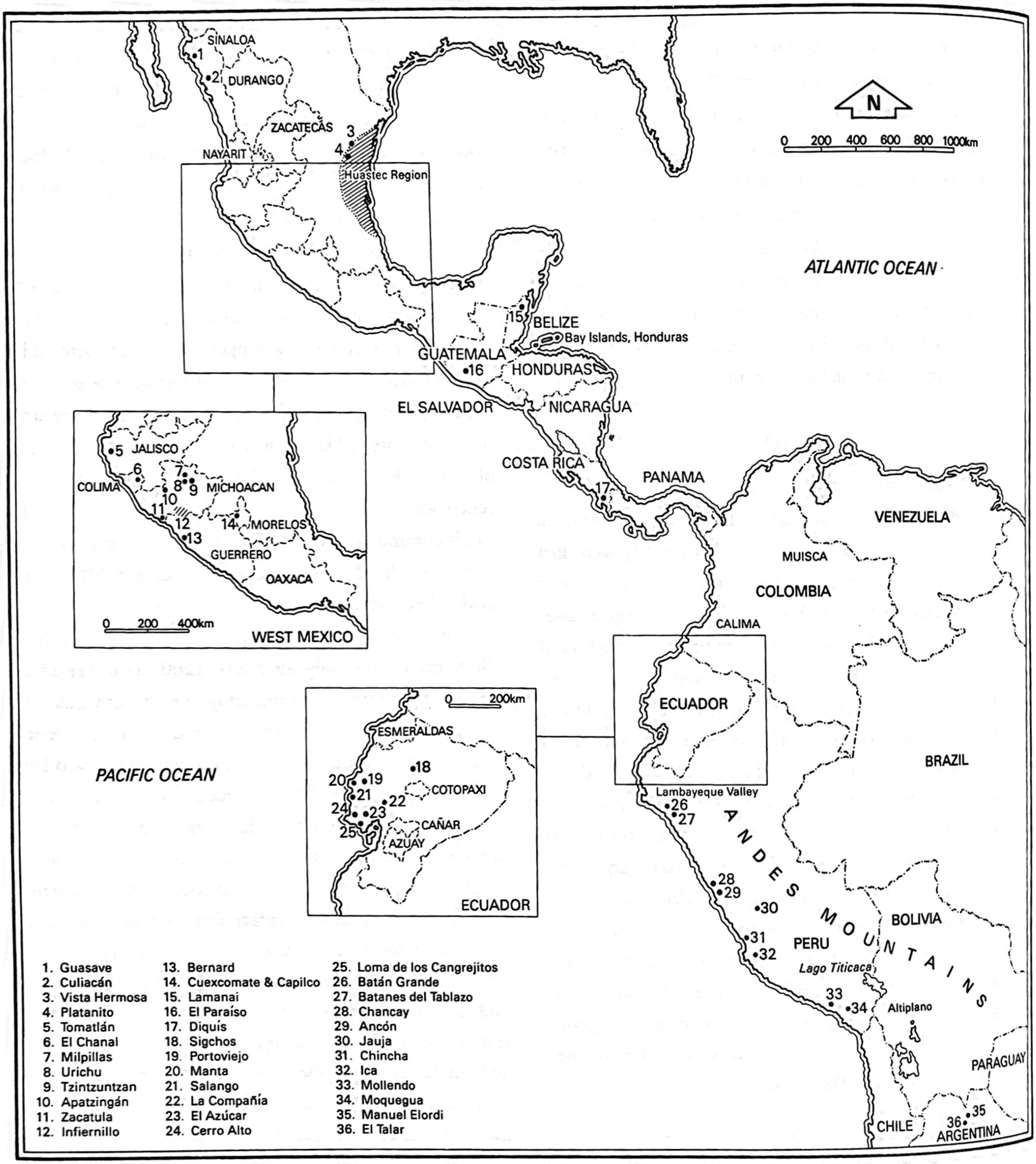
The three copper binary alloys had been developed in South America hundreds of years before they were first used in West Mexico. All three were introduced to West Mexico around A.D. 1200 or slightly before; copper-arsenic and copper-silver alloys seem to predate the alloys of copper-tin. These alloys then were elaborated locally using local resources. A few of the new designs crafted from these copper alloys do derive from South or Central American prototypes. However, as I have pointed out elsewhere, Andean peoples did not export the raw materials, either as ores or in ingot form; nor were the objects themselves ever imported to West Mexico on a large scale.

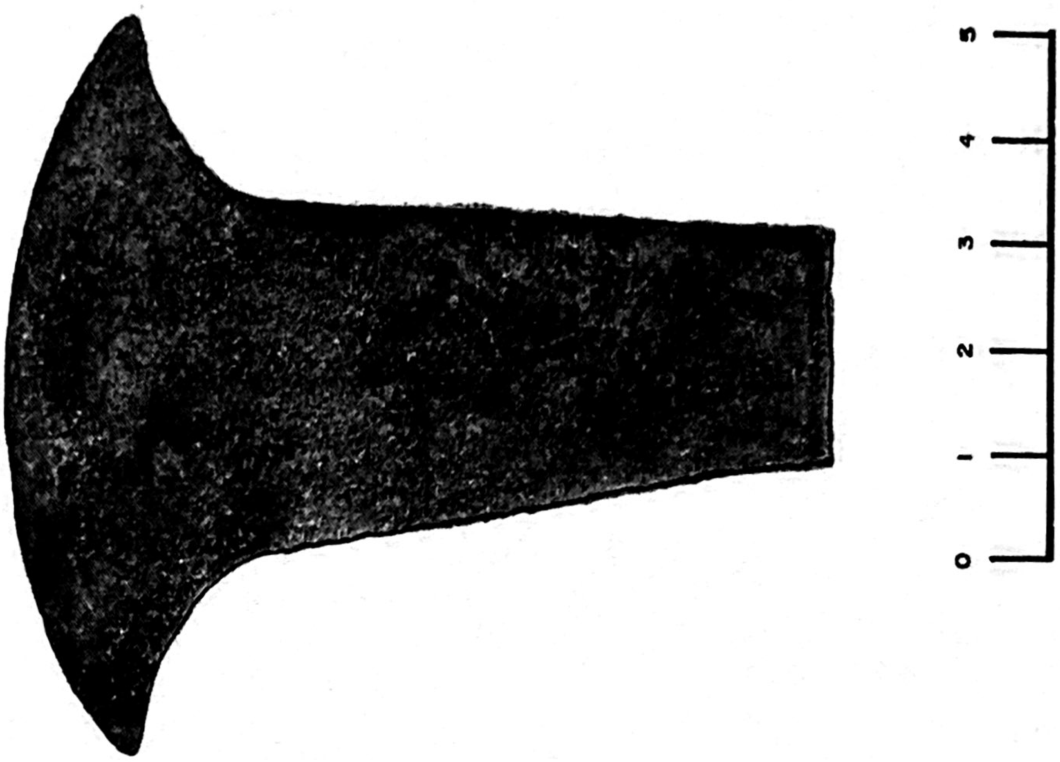
Southern Ecuador and northern Peru contributed two major alloy systems to the metallurgy of West Mexico, copper-arsenic and copper-silver, as well as prototypes for objects made from them. Copper-arsenic and copper-silver alloy objects are extremely common throughout this Andean zone but are largely absent in the area between Ecuador and West Mexico.

Arsenic Bronze. Arsenic bronze artifacts date to as early as A.D. 300 in coastal Ecuador. Metalworkers on the north coast of Peru were also experimenting with this alloy at about the same time. By A.D. 950, and perhaps earlier, low-arsenic copper-arsenic alloys served as stock material in southern Ecuadorian metallurgy. This same alloy, made locally, was also a stock material in northern Peru. Andean smiths used arsenic bronze to fashion open rings, tweezers, bells, awls, axes, needles, and axe-monies.

We do not yet know where in Ecuador the arsenic bronze alloy was produced. The highland provinces are the likely possibility, since arsenopyrite, as well as enargite and other arsenic-bearing copper ores, occur there. Shimada (1985) has argued that most arsenic bronze metal used in Ecuador was imported as ingots from primary smelting centers, like Batán Grande, on the north coast of Peru.[1] Batán Grande (figure 6.1) became a major center for arsenic bronze production by about A.D. 900, and it continued as a primary north coast supplier of that alloy to the Sicán and Chimú until about A.D. 1400 (Shimada 1985; Shimada and Merkel 1991).

In West Mexico, metalsmiths used arsenic bronze alloys extensively only after A.D. 1200. Two Period 2 artifact types made from this alloy most directly link the region with the southern Ecuadorian and northern Peruvian zone. One is the paper-thin axe-money and the other the versions of the distinctive loop eye needle. Metallographic studies show that the fabrication sequence for the axe-monies is identical in both regions; methods used to manufacture the two needle varieties likewise are identical. More generalized artifact forms—axes, awls, and small hand tools—also were made from copper-arsenic bronze in both regions, and their manufacturing methods and design characteristics were also the same. Nonetheless, axe-monies and loop eye needles provide the least ambiguous evidence for contact due to their unusual forms and specialized use. We know that axe-monies were used for similar purposes in West Mexico and Ecuador.


SINALOA
DURANGO
ZACATECAS
NAYARIT
Huastec Region
N
0 200 400 600 800 1000km
ATLANTIC OCEAN
BELIZE
Bay Islands, Honduras
GUATEMALA
HONDURAS
EL SALVADOR
NICARAGUA
COSTA RICA
PANAMA
VENEZUELA
MUISCA
COLOMBIA
CALIMA
ECUADOR
BRAZIL
Lambayeque Valley
ANDES MOUNTAINS
PERU
BOLIVIA
Lago Titicaca
Altiplano
PARAGUAY
CHILE
ARGENTINA
PACIFIC OCEAN
JALISCO
COLIMA
MICHOACAN
MORELOS
GUERRERO
OAXACA
0 200 400km
WEST MEXICO
0 200km
ESMERALDAS
COTOPAXI
CAÑAR
AZUAY
ECUADOR
1. Guasave
2. Culiacán
3. Vista Hermosa
4. Platanito
5. Tomatlán
6. El Chanal
7. Milpillas
8. Urichu
9. Tzintzuntzan
10. Apatzingán
11. Zacatula
12. Infiernillo
13. Bernard
14. Cuexcomate & Capilco
15. Lamanai
16. El Paraíso
17. Diquís
18. Sigchos
19. Portoviejo
20. Manta
21. Salango
22. La Compañía
23. El Azúcar
24. Cerro Alto
25. Loma de los Cangrejitos
26. Batán Grande
27. Batanes del Tablazo
28. Chancay
29. Ancón
30. Jauja
31. Chincha
32. Ica
33. Mollendo
34. Moquegua
35. Manuel Elordi
36. El Talar



6.2

Axe-money from Ecuador (type 2). Photograph by Jeanne Mandel.

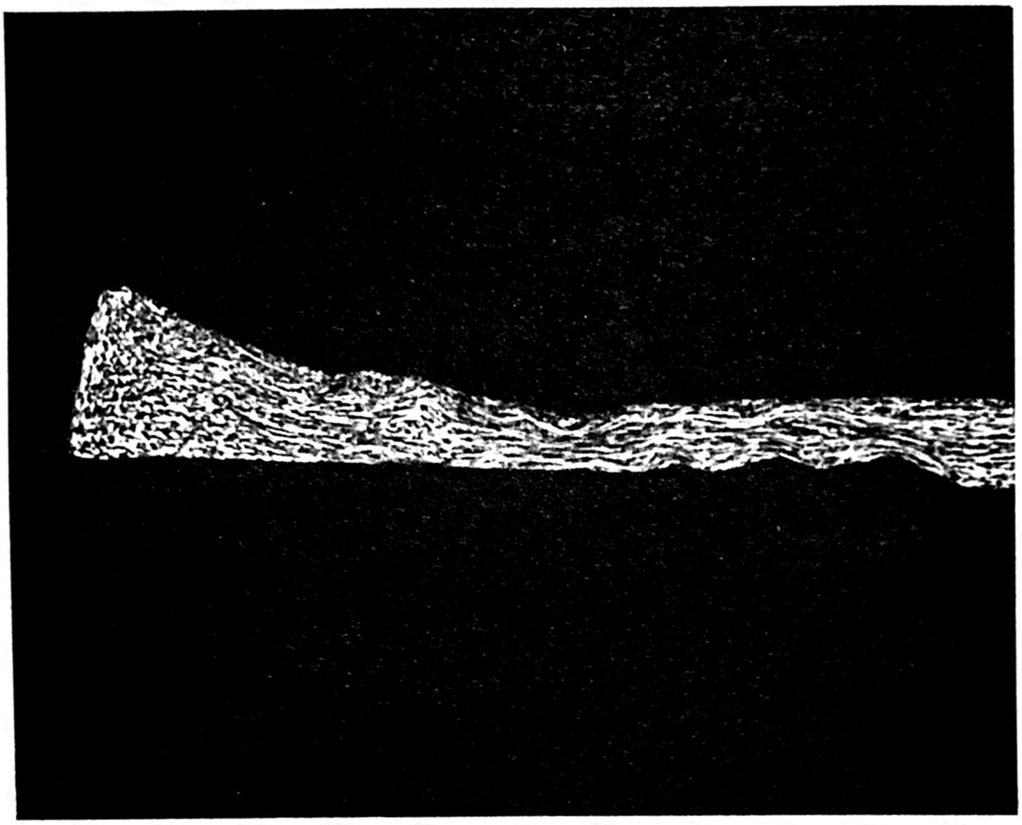
The same probably holds true for the loop eye needles; the design precludes some tasks and facilitates others.

Axe-monies are common in southern Ecuador, and appear in West Mexico (and Oaxaca) after A.D. 1200. Both the Andean and the Mexican varieties are usually made from copper-arsenic alloys. Among the various Mesoamerican, Ecuadorian, and Peruvian designs, three are closely related with respect to dimensions, fabrication techniques, and alloy composition: the Ecuadorian type 2 axe-money (figure 6.2); the variety common to Michoacán and Guerrero, type 1a (see figure 5.27); and type 2a (Hosler 1986).

6.1

New World archaeological sites and regions associated with Period 2 West Mexican metallurgy.

In the coastal polities of Ecuador these thin, axe-shaped objects circulated as a form of wealth. In West Mexico, the type 1a axe-money was a tribute item, and, as I have suggested here, may also have served as a repository for copper-arsenic metal. Both the Ecuadorian and West Mexican varieties are T-shaped, thin to paper-thin; the thinnest varieties have been found stacked and bound in packets. Arsenic, the major alloying element, is present in low concentrations, ranging from 0.1 to 6.4 weight percent. The extreme thinness of the metal (less than 0.05 cm) makes an alloy a requirement of the design. In general, mean values for arsenic concentration in Mexican specimens are somewhat lower than in objects from Ecuador (Hosler, Lechtman, and Holm 1990). Fabrication methods were nearly identical. The Ecuadorian variety (figure 6.3), like its West Mexican counterpart (figure 5.28), was cold-worked to shape, annealed, then left in



6.3

Cross section of Ecuadorian axe-money (1.81% As), severely cold-worked to shape but left in the annealed condition except locally beneath surface indentations. Sample etched in alcoholic ferric chloride (mag.: 11).

an annealed condition. The pronounced evidence of prior cold work in the Ecuadorian example results from its higher arsenic content: 0.60% versus 1.81%.

During Period 2, metalworkers in West Mexico also used copper-arsenic alloys to optimize the loop eye needle design (see figure 5.24). The same design was fashioned from this alloy significantly earlier in southern Ecuador and on the Peruvian north coast. The RMG collection has two loop eye needle varieties and the two also appear at Cuexcomate. Remarkably, both also occur in Ecuador, and at some Ecuadorian sites such as Salango both appear in the same depositional context. Figures 6.4 and 6.5 show the two Andean versions of this design.

West Mexican smiths and their counterparts in southern Ecuador and northern Peru fashioned these two versions of the loop eye needle in exactly the same way. Chapter 5 documents the fabrication sequence for the two West Mexican specimens (see figure 5.24). Photomicrographs of cross sections through two Ecuadorian needles appear in figures 6.6 and 6.7. The Ecuadorian needles were made by folding and hammering a rectangular strip of metal around its longitudinal axis, creating a round shaft with an internal fissure. The loop portion for the eye was flattened, then bent over. In the needle of type a, this tab was tucked into the shaft; for type b needles it was bent back against the shaft and two flaps of metal were hammered around and over to secure it. The tab of the loop protrudes. The final step in both cases was to anneal the metal. The photomicrographs illustrate sections of the needles where the tab tucks into the shaft