

THE CRUCIBLE: SOCIOLOGICAL AND TECHNOLOGICAL FACTORS IN THE DELAYED DIFFUSION OF METALLURGY TO MESOAMERICA

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INTRODUCTION

In the Americas the invention of complex metallurgy can, on present evidence, be shown to have happened in two, perhaps, three regions.¹ Two of these centers of innovation combined to form a single tradition, that of the central Andes, and it was this tradition which spread northward, eventually arriving in Mesoamerica. In the central Andes, metallurgy first appears in the Initial period, an era roughly contemporary with the Mesoamerican Early Formative (Lechtman 1980). Smelting and casting of metals and alloys was widespread in the Andes by the turn of the millenium; metal-working having spread first into Ecuador and Colombia and then into lower Central America (Balsler 1964; Bruhns 1974; Reichel-Dolmatoff 1975; Bray 1980). From here metallurgical technology diffused north to Mesoamerica, specifically to the cultures of the Pacific slope and southern Mesoamerica, some 2500 years after the first developments in this technology had been made in the Andes.²

There is no evidence of any other origin for the later Mesoamerican metal-working traditions. When metallurgy appears in Mesoamerica, the techniques, the tools and many of the artifact forms were borrowed outright from the cultures of the southeast, specifically from those of Costa Rica and the Isthmus (Bray 1977, 1978, 1980; Bruhns and Hammond 1982).³ Origins then are quite certain, but the vexing question remains: why did the spread of metal-working from lower Central America to the not very distant cultures of the northwest take so long?

CHRONOLOGY AND RESOURCES

Metallurgical technologies including smelting, the creation of numbers of alloys of gold, copper and silver, depletion gilding, lost wax and open mold casting, and various cold working techniques were present in northern South America by a period corresponding to the Mesoamerican Late Formative-Early Classic. The ratio of clandestine to scientific archaeological investigations in Colombia is very high and firm dates for the introduc-

tion of metallurgy to the cultures of that country are lacking. It is slightly whimsical that the earliest untested date for a northern Colombia metallurgical tradition comes from Mesoamerica. A *tumbage* (gold-copper alloy) bead in the purest Sinú style (a style native to the Gulf of Urubá region) was found in Early Classic contexts at Altun Ha in Belize (Pendergast 1970). Within the next few centuries the Columbia metallurgical complex seems to have moved into Costa Rica, although again firm dates for the introduction of metal-working to that nation are lacking.

From the Early Classic onwards the Maya had sporadic, but apparently growing, access to metal objects. The number of metal artifacts found in Classic contexts in southern Mesoamerica, especially on the Pacific slope, is impressive (Bray 1977). There are some problems with dating metal objects in southern Mesoamerica because of the often unquestioned doctrine that all metal must be Postclassic. Other problems in dating Mesoamerican metal stem from the lack of detailed chronologies for most of Mesoamerica and Central America. It is nearly impossible to seriously consider technological and social change when one's units of contemporaneity are several centuries in length. There are also many chronologically unclear situations, such as that of the Sacred Cenote of Chichén Itzá, a source of a great many metal objects (Lothrop 1953). The relative paucity of controlled excavations that have yielded metal artifacts in lower Central America and the lack of any detailed style analyses of metal artifacts of known provenience and associations make it impossible to judge temporal context on style alone. The only relatively certain statement that can be made is, with the possible exception of the Soconusco disks (Lothrop 1936a), all Classic period metal objects found in Mesoamerica are obviously southeastern in manufacture.

There is some evidence that Mesoamerican contact with the cultures of lower Central America intensified through the Classic. The region of Mesoamericanization, of sites and artifact complexes with strong Mesoamerican affinities, moved across the Lempa River

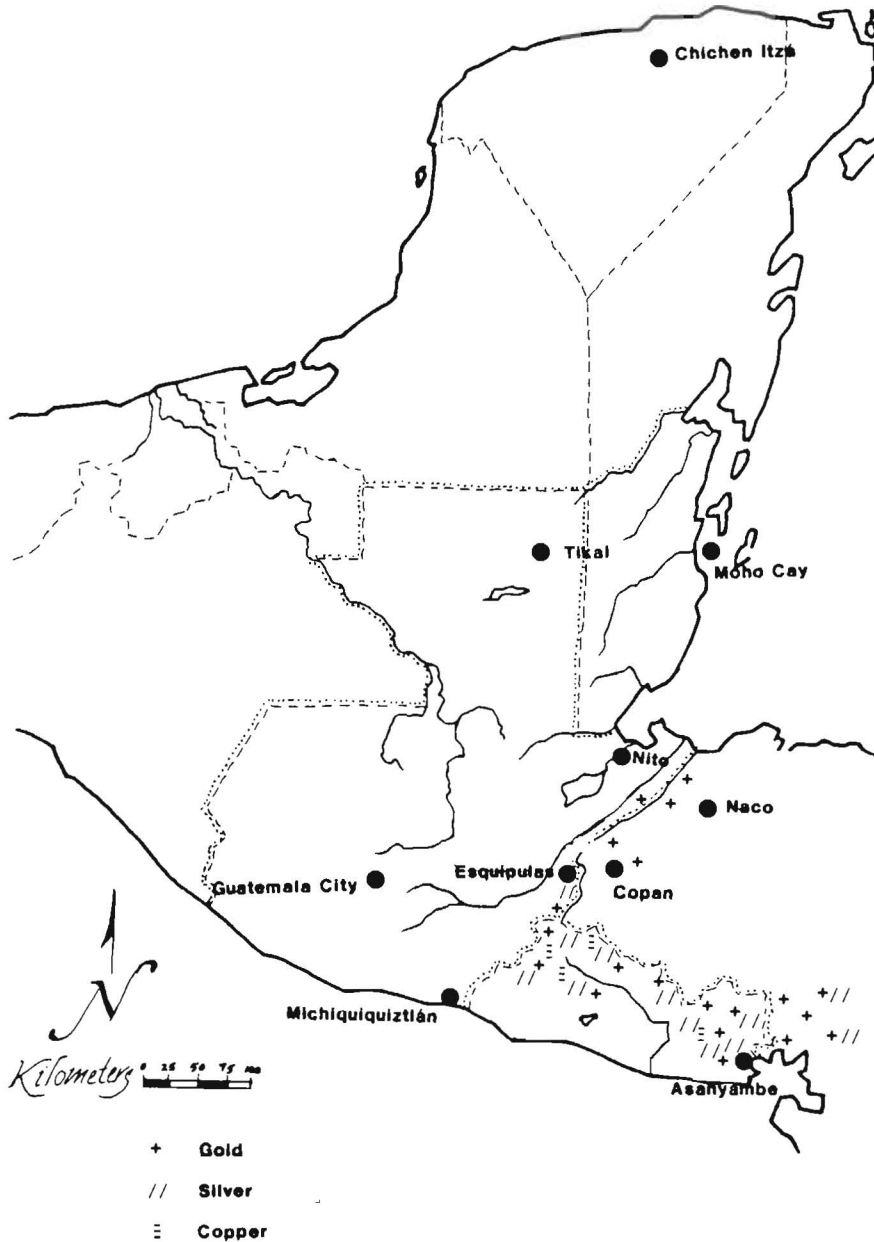


Figure 12.1 Silver, gold and copper sources in southern Mesoamerica (after Arbingast *et al.* 1979:11, 27, 35).

into eastern El Salvador where numbers of sites show strong Maya and/or Veracruz affinities (Andrews 1976; Crane 1978, and personal communication; Bruhns 1979, 1980a; Fox 1981; Solís-Tucker, personal communication; Boggs, personal communication). A further indication of the strength of this Mesoamerican cultural thrust is that at approximately the same period, Mexican/Maya inspired motifs begin to appear in the native sculpture

styles of the Nicaraguan lakes (Zelaya, Bruhns and Dotta 1974; Bruhns n.d., 1982). Quantities of Mesoamerican valuables also appear in Costa Rican graves and caches (Stone 1972, 1977, 1978; Lange, Bishop and Van Zelst 1981).

Given this situation it does seem unusual, at first glance, that the northerners, who obviously had some interest in metal objects, were content for centuries to rely

on obtaining the odd finished piece. It was not that they lacked the natural resources for metallurgy. A very cursory glance at any Central American mineralogical map will show how many sources of gold, silver and copper there are in the highland regions of southern Mesoamerica. Many of these were being exploited at the time of European contact, although there is little information on how long they had been exploited (Cerrato *et al.* 1548-1551; MacLeod 1973). Several of the more important of these deposits are located on or are very close to major ancient trade routes, a location claimed to have been of importance in the spread of metallurgy in other lands (Beale 1975). There are mining locales in the vicinity of the Postclassic (and earlier?) market and pilgrimage center of Esquipulas; there is a still (intermittently) important mining region slightly inland from the Gulf of Fonseca and near a recently discovered Classic-Postclassic trade center; and there are a series of lesser known mines along the Lempa-Acelhuate access route from the Pacific plain of El Salvador and Guatemala to the Classic and Postclassic trade centers of Honduras (Arbingast *et al.* 1979:11, 27, 35; Boggs, personal communication) (Figure 12.1). One might also note that a lack of a local supply did not curtail either local use or manufacture of jade and obsidian artifacts (Hammond 1972; Sidrys 1976 *inter alia*; Hammond *et al.* 1977). Thus it would seem that other, less readily visible, factors must have been operative in the delayed diffusion of metal-working technology to the Mesoamericans.

THE SOCIAL SCENE

When one looks at the southern Mesoamerican cultures of the Classic as sociological entities one can see that there were several factors which may well have functioned as barriers to diffusion. One of these may have been the nature of southern Mesoamerican trade during the Classic. Archaeological evidence shows that extra-regional trade during this time became increasingly focused upon the elite and was primarily concerned with the distribution of status maintaining goods (Webb 1973). If it is legitimate to project the Late Postclassic Maya organization of trade this far back into time, the administrative personnel in commerce, the people who made the decisions concerning goods, were members of the upper class (de Landa 1978:15-16). It is evident that Classic Maya society had a very marked division of labor and socio-political importance. One would not expect a Maya nobleman-trader to know much more about technology than did Bernardino de Sahagún, a priest of a good (Spanish) family. The latter's descriptions of Aztec

metallurgy show a certain confusion about the processes he observed and had described to him (Sahagún 1959:73-78). Sahagún was highly motivated to observe, understand and describe native metallurgy technology, yet it would be very difficult for a person who was not previously familiar with metallurgical practices to reconstruct Aztec metallurgy from his descriptions. The need to observe a process in action, to understand it by seeing it as well as from oral or written descriptions, is amply documented for preindustrial and early industrial Europe (Cipolla 1980). Although full documentation, including diagrams, was available for such devices as clocks and silk throwing machines, their spread was delayed until persons with technological training were able to observe working ones in action (Cipolla 1976:185-188). Thus the organization and directing personnel of Maya trading ventures may have mitigated against any diffusion of this complex technology.

We cannot know if the Central Americans tried to keep this technology secret. It is quite possible that they did, this type of "economic protection" being very common on the world scene. Western history shows innumerable examples of the usually vain attempt to monopolize a valuable manufacture. The Hittites are credited with trying to keep iron working secret (Waldbaum 1980); the Chinese certainly attempted to keep first silk manufacture and then porcelain production away from foreigners (Gibbon 1776-1783, Vol 2:494-499; Le Corbeille 1974:1-11); Brazilians attempted to hold onto the source of rubber (Wolf and Wolf 1936:156-161); and the United States in recent years has tried to keep certain aspects of computer technology as classified information (Kolata 1982a, b, c; Walsh 1982 *inter alia*). Although none of the historic attempts to keep technological secrets has ultimately been successful, delays of up to several centuries in transmission of the desired technology have been effected (especially in the case of the re-invention of porcelain in Europe [Coe 1959]).

Even without attempts at concealment on the part of the possessors of this technology, a commercial system focused on elite exchange of sumptuary items, perhaps even operating in a down-the-line manner (as seems quite likely during the earlier Classic), is not ideal for the spread of a complex technology unless the party lacking this technology is very interested in acquiring it, and, just as important, has an adequate technological base to support the imported technology.

On the social front it is quite possible (although we have no way of knowing it) that the Maya were not really interested in metal. Central American metal-working was almost totally concerned with the fabrication of

elegant ornaments chiefly for display (cf. Helms 1979). The Maya had, and had possessed for centuries, a well developed set of sumptuary items fulfilling the same function, groups of ornaments which by the Classic were hallowed by antiquity, tradition and religion. These objects were evidently integrated into the symbolic system in a way in which imported objects, representatives of a quite different display and symbolic system, could not be. An intrusive element into as conservative and coherent a display system as that which the Maya evidently had, would need to be rather special to either substitute for an item in the royal garb or to be added to this official set.⁴ The only products that the Central American metalsmiths seem to have produced which were immediately transferrable and evidently superior were bells. It is significant that bells are predominant both among Classic imports and Postclassic manufactures in Mesoamerica.

PYROTECHNOLOGY IN SOUTHERN MESOAMERICA

Another block to any easy and swift transfer to metallurgy to the Mesoamericans was technological. It seems evident that southern Mesoamerican competence with pyrotechnology, i.e. the manipulation of heat, was not such that they could have easily adopted or adapted the metal technology of their southeastern neighbors. To work metals one must be able not only to achieve high temperatures, but to sustain them. The flow of oxygen must also be controlled; specifically oxygen must be kept out of the smelter. The simpler smelting techniques, the only ones known in Central America, are mainly reduction methods.

During the Early Classic and for much of the Late Classic and Postclassic, the people between the metal working cultures of Central America and the rest of Mesoamerica were the Maya. The above requirements were not met by Maya pyrotechnology. Although it is true that the Maya manufactured several high temperature products, the specifics of where these were made, how they were made and the social conditions surrounding their manufacture were not such that would lead easily or naturally to an adoption of metallurgy.

By the time the Maya are first identifiable as an ethnic group (the Early Formative) they possessed sufficient skills in heat manipulation to produce both ceramics and lime plaster. By the second millennium BC in northern Belize plaster was being used as an architectural material (Hammond 1980) and it appears just slightly later in other areas. The transformation of

limestone into calcium oxide requires temperatures of 800 - 900° C. There is no evidence of any permanent lime burning installations being used, either at this early date or at any later one, in southern Mesoamerica. The open method of lime burning described by Morley (1956:320) and by Littman (n.d.) requires immense amounts of fuel and a fair amount of ingenuity to keep temperatures elevated for the 36 hours or so that it takes to convert the stone. Lime burning is largely confined to the lowlands north of the southern periphery of Mesoamerica and has not been noted in Prehispanic contexts in the interface region between Mesoamerica and Central America. The technique of lime burning is very different from other, small-scale, artisan manipulation. Owing to the uses of lime plaster, which were almost entirely architectural, one would expect there to have been occupational and, perhaps, social barriers between burners and other specialized craftsmen.

The manufacture of ceramics was the only other pyrotechnological craft of southern Mesoamerica and was, of course, much more widespread than lime burning. Firing ceramics does not require either a very high temperature nor a sustained heat. Although it is commonly averred that temperatures in excess of 750 - 800° C are necessary to change clay into pottery, ethnographic and technological studies have shown that this is simply not the case. Modern Guatemalan Maya potters in the town of Chinautla seldom achieve temperatures above 620° C (and only this high for very short periods of time). Their pottery is not functionally nor technically inferior to most other American folk ceramics. Other native ceramic traditions fire at temperatures in the same or lower ranges (Reina and Hill 1978:24; Rye 1981:102-103). In very few cases are these temperatures kept for even as long as an hour. Considerably higher temperatures (950 - 1050° C) are necessary for vitrification to begin, but vitrification is not observable in Mesoamerican ceramic traditions until the Terminal Classic (Bruhns 1980a; Rye 1981:108). There are also good reasons for trying to avoid high temperatures. If the clay being used for ceramics manufacture contains calcium carbonate, which many of the clays of the Maya lowlands do, then temperatures in excess of ca. 750° C will cause the vessels to spall and rupture (Rye 1981:107).

For comparison, a campfire will reach temperatures of 600 - 700° C, but pure copper requires a temperature of 1982° C to melt. The oxides and carbonates of copper melt at 700 - 800° C as do gold and gold alloys, such as *tumbaga* (Forbes 1964; Lechtman 1976). These temperatures must be sustained for much longer periods than are necessary for firing ceramics.

It is probably also important that potters working in the traditional manner avoid firing in windy areas or on windy days since an uncontrolled draft will make the fire burn unevenly and give hot flashes which are undesirable in ceramics manufacture. However, a draft is necessary to achieve high temperatures with the fuels that were available to the ancient metal-workers and, indeed, Peruvian smelting involved placing specially built furnaces on extremely windy hillsides specifically to take advantage of the natural drafts (Lechtman 1976).

Traditional methods of ceramics manufacture in southern Mesoamerica involved open firing. This term simply means that vessels are not fired in a permanent installation, although large sherds, bricks, etc., are often used to create temporary walls protecting the vessels being fired from the heat source and from falling fuel. However, all open methods lack a mechanism for the creation of a controlled draft.

Most of the ancient ceramics in the Maya region show clear evidence of having been fired by one of the open methods: few have been fired at high temperatures, many have fire clouds or char marks, many wares are incompletely oxidized, and so on. There is very little archaeological evidence of ceramic production other than the vessels themselves since Maya archaeology has only relatively recently been featuring the types of excavations that might uncover artisans' workshops. However, the remains of a late Chicanel (Late Formative) workshop discovered in 1980 at Cuello, Belize, indicates a technology nearly identical to that of the modern folk potter, including the use of ring coils, the *molde* or *kabal* (a tournette or slow wheel techniques), and firing on an ordinary floor (Bruhns 1987). Technological data concerning ancient ceramic complexes are not as good as one might wish, but an examination of published ceramic studies suggests that, from the Late Formative through the Middle Classic, there were few changes in basic ceramic technology.

LATE CLASSIC INNOVATIONS AND THE DIFFUSION OF METALLURGY

It is quite evident then, if one looks at southern Mesoamerican culture in social and technological terms, that the Maya possessed neither a situation of contact with metal using peoples conducive to diffusion nor did they have the facility with heat manipulation which would have allowed them to re-invent (stimulus diffusion in standard anthropological terminology) metallurgy for themselves. Events during the Late Classic altered both these factors.

One of the major economic developments of the Late Classic was a change in trading patterns. Thompson (1970) has postulated an increasing importance of coast-wise trading routes on the east coast of the Maya region. The same seems to have been true on the west coast as well, although the only Mesoamerican ports known archaeologically are Asanyamba (El Chapemalito) on the Gulf of Fonseca and Michiquihuitlán near the Guatemala-El Salvador border (Boggs, personal communication; Feldman, personal communication).

Also beginning in the Late Classic were a series of political fluctuations which, added to the changing economic scene, eventually culminated in the Maya "collapse." Certainly by the Epiclassic a much different commercial situation was emerging. This involved specialized manufacture of bulky, low unit value items (especially ceramics) intended for a market trade which was not wholly focussed on elite needs and desires. Market trade of a more egalitarian type was, in its turn, closely linked to the increasing use of waterways in interrealm trade as well as to social factors which made service of the non-elite market possible.

The changes in trade and vehicles of trade in their turn must have facilitated technological development, since a growing market for items which must be acquired from a considerable distance is sure stimulus to diffusion or re-invention. The history of porcelain in Europe, for instance, is an example of this. A desire to have more porcelain, linked to its cost and the problems of shipping led, by the the 15th century, to attempts to make porcelain in Europe. In the attempt to rediscover how this ware was made, discoveries, including the soft pastes and "Delft" wares were made, although it was not until the 18th century that the art of making true porcelains was painstakingly rediscovered (Cox 1959:625 ff). The early European imitations and true porcelains show their inspiration in the line for line copies of Chinese pieces. Much the same is visible in the early Mesoamerican metal pieces.

One of the social factors in this change in trade and manufacture which is visible archaeologically is the Mexicanization of the southern periphery (cf. Andrews, V 1974; Casasola 1976-1977; Fox 1981, inter alia; Bruhns 1982). Involvement in trade which was not exclusively (or nearly so) elite centered and specialized manufacture for a commoner market were typical of the central Mexican cultures beginning with the Late Formative. The civilization of Teotihuacán was supported largely by this broad based trade and the Teotihuacán tradition was continued by the smaller polities which succeeded the city (Millon 1973; Sanders 1978a; Lee and Navarrete

1978, *inter alia*). It could well be due to Mexican stimulus that the large commercial cotton and salt manufacturing of Yucatan were organized or expanded; trade ceramics such as Mayapán Red, the slate wares and Tohil plumbate were produced in great quantities; and the cacao lands of Izalco and Usulután were planted. This is pure conjecture, but more intimate encounters with peoples who had a tradition of mercantile manufacture must certainly have aided in the creation of a climate conducive to technological development.

Technological development is, in fact, characteristic of the latter part of the Classic period. The picture of relatively low fired ceramics, a simple technology, and traditions which were largely of oxidized wares began to change. Although the political events of this era have been far more fully documented than the more mundane aspects of society, the Late Classic would appear to have been a time of increasing technological experimentation. This is most easily visible in the ceramics where there is an overall increase in numbers of different wares and in styles of decoration. New decorative techniques, such as the use of very finely divided slips in painting, come to be applied to a large range of wares and used in very different styles. There is also a steady increase in the use of semi-industrial methods such as molds and stamps. Experimentation in firing, both oxidation and reduction methods, including the so-called "double-firing" leading to either superficial oxidation or reduction, appear. Following on the heels of these developments are the specialized trade wares: Fine Orange, Copador and its imitations, the Salua polychromes, the Mixteca-Puebla polychromes and then the first plumbates. All of these appear to have developed out of this new interest in technological experimentation which itself must have been linked to the expansion of trade and its changing forms. Most of these trade wares have been found in lower Central America.

There is one caveat: localized production in quantity does not in itself indicate major changes in a technology. Modern folk potters in many countries manage to produce large numbers of vessels for market using open firing techniques (cf. Reina and Hill 1978; Rye 1981). However, in southern Mesoamerica there was a significant development in basic technology along with experimentation. This was the invention(s) of the updraft kiln. Kilns are now known in Epiclassic contexts in Oaxaca, Puebla and Honduras, and have been reported from Guatemala (Stone and Turnbull 1941; Winter and Payne 1976; Boggs 1983). Using a kiln is more cost effective in large scale production as there is less breakage and less

spot reduction (fire clouds, char marks). Two of the known kilns are associated with the production of polychrome trade wares. Kilns would have been especially useful here because the initial cost of making a vessel to fire is high (pigments, painting, support of artists and artisans, extended time in manufacture). Very shortly thereafter, if not at the same time, the first plumbates appear.

KILNS AND METAL

With a kiln there is a closed environment into which a draft can be introduced and in which the control of this draft is simple. Plumbate, whose initial invention was doubtless a result of the experimentation with slipping materials and techniques widespread in the Late Classic, was fired at temperatures which indicate that there was draft control. Plumbate is often a reduced ware and the temperatures which produce the characteristic vitrification of Tohil plumbate are precisely those which are appropriate for smelting. It cannot be accidental that, hard on the heels of the appearance of kilns and plumbate ceramics, and in precisely the areas where these two items originate, there was a wholesale adoption of Central American metallurgical technology.

The exact mechanisms of this sudden and speedy transfer will never be known, although it is tempting to speculate. Given the situation of contact between southern Mesoamerica and lower Central America in the Epiclassic, the most likely route would seem to be industrial espionage. One is inevitably reminded of a similar situation in European antiquity. Here too, there was an increasing demand for an exotic product which was manufactured a long, dangerous and expensive distance away. The manufacturers desired to keep the secrets of production to themselves, but the recipients had a technological base which made diffusion possible. As Gibbon (1776-1783) reports, Justinian dealt with the desire of the Romans for more and cheaper silk by indulging in a little industrial espionage; perhaps some wily Mesoamerican chief did the same with metal.

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Bray, without whose energetic compilation of data we would all be unable to consider social and technological process.

ENDNOTES

1. These centers were the central Andean highlands (probably in the area around Lake Titicaca), somewhere in the area of northern Peru -- although it is not certain whether this was highlands, coast, or both -- and, more problematically, western Mexico. Here there are some fairly interesting data which places an independent invention of metallurgy in the Middle Classic.
2. Metallurgy, other than cold working of gold and perhaps copper, may not have been practiced in Yucatan. The entire range of Central American techniques, however, are found in the rest of southern Mesoamerica.
3. Doubtless Nicaragua was involved as well, but the history of Nicaraguan metallurgy is completely unknown.
4. Silk was immediately substituted for cotton and wool by native aristocracies in the Early Colonial period. Political and economic disruption in the Late Classic and Early Postclassic may well have caused displacement in traditional display systems along with the elites who were involved in these.