3.18

RMG axes and other cutting tools.

The beam design tweezers that characterized this initial period of metallurgy in West Mexico thus met two social requirements simultaneously: they were symbols of rank and sacred power—if the Period 2 evidence can be generalized—and also served as fully operational depilatory tools.

Axes. Only a few axes or axelike cutting tools have been found in reasonably secure Period 1 contexts. One has been analyzed chemically. The largest group is a cache from Tomatlán, but we have no chemical analytical data for them.[14] The RMG collection contains 32 axes; 14 of them are made from copper, the others from bronze alloys. The copper axes range in length from 8.0 to 17.4 cm. Since copper was the primary metal used during Period 1, I will assume that at least some of these RMG copper axes were made then and will describe their production technology here. Results from future excavations might possibly alter their temporal placement, but information concerning their fabrication history remains the same. Figure 3.18 illustrates selected RMG axes and cutting tools.

Substantial evidence concerning these tools' use exists in sixteenth-century documents, and I will refer to that literature in the discussion in chapter 5. These sources indicate that axes were indeed used as cutting implements, but that metal axes also marked social rank and sacred and political power.

The metallographic studies of the copper axes provide unambiguous evidence concerning their use. Some were used as cutting tools. Others were not used at all. Six of the 14 specimens show no macroscopic evidence

3.19

Longitudinal section through the blade of an RMG copper axe left in the annealed condition. Note equiaxed grains and annealing twins. Sample etched in potassium dichromate (mag.: 200).

for use, and the microstructures of three of these six confirm that observation. Two were left in the annealed condition, one was left cold-worked. The two annealed axes were far too soft to have served as cutting tools. Metallographic studies of a section removed from the blade of one reveals a few elongated inclusions and a fully annealed and recrystallized structure in which none of the grains is deformed (figure 3.19). Hardness tests of this blade section and of a section removed from the butt of the axe gave values ranging from 60 to 80 Vickers Hardness Number (VHN). These values are consistent with standard hardness data for annealed, unalloyed copper.[15] The blade is sufficiently soft even in the one cold-worked example (VHN = 128 maximum) that microstructural and macroscopic evidence would be visible if the axe had been used for cutting. Metallographic studies were carried out on sections removed from the blade and butt end of all axes.

Why were metalsmiths making axelike objects that either were mechanically incapable of use or were never used? In Mesoamerica, the axe form traditionally represented divine authority. The axes described here provide concrete evidence that such "symbolic tools," made from metal, actually existed. These particular examples could represent utilitarian specimens that were recycled because they were unusable for mechanical reasons not apparent in the microstructure (e.g., the presence of an internal fissure or some other casting defect). As flawed tools, they were later annealed and used in ritual or for status ends. These axes also may have been intentionally made as ritual items. They do differ in design from axes showing evidence for use: they are thinner in proportion to length (Hosler 1986). Since copper is not an especially strong material, any usable copper axe needs to maintain a certain minimum thickness. These axes did not do so, either by accident or by design.

Eight of the RMG copper axes (table 3.6) were unquestionably made to be used, and laboratory examination shows use wear. The photomicrograph in figure 3.20, which illustrates a section through the tip of the blade of one of these axes, exhibits somewhat elongated grains with annealing twins in the interior portion of the metal that become highly elongated at the blade edge, where some of the metal exhibits plastic flow and severe distortion. A section farther in from the blade edge exhibits completely equiaxed grains. This microstructure reveals that after the axe was cast roughly to shape it was heavily cold-worked, subsequently annealed, then cold-worked again, a process that left the grains deformed and hardened the metal. At the extreme tip of the blade, the metal folds upward to form the blunted edge that is also visible macroscopically. The hardness data confirm the metallographic data; microhardness values for the blade range between 83 and 128 VHN. The highest values occur at the cutting edge, the lowest values at the center of the sample. These microhardness values demonstrate that this tool possesses the range of properties required: it must be harder at the cutting edge and tough at the center. Toughness is a measure of a metal's resistance to brittle fracture. The axe must be able to absorb impact during use.

All axes in this group were made in the same way, and the microstructural and macroscopic evidence demonstrate unequivocally that they were used. Metal as soft as that used to make these axes invariably shows evidence of deformation if any occurred. Maximum hardness values at the blades measure only 130 VHN. However, even work-hardened copper axes with a cutting edge hardness slightly higher than that—of about 135 VHN—are not hard enough to cut hard woods or to fell trees. Copper is an unlikely material for an axe if the purpose is to cut. It is far more probable that these tools were used for splitting. Wood splitting requires the tool to be sufficiently tough to resist brittle fracture but not especially hard or sharp. Because the metallographic studies showed no deformation of the butt ends of these tools, they probably were hafted in such a way as to prevent it. Sahagún (1950–1982, book 11, plate 371) shows a tool apparently used for log splitting that is hafted like an adze, and some of these copper axes were probably used in this way for splitting logs or branches.

Cold Working: Utilitarian Objects

Needles. Sewing needles comprise one of the most abundant types of Period 1 utilitarian copper objects. Before metallurgy developed, needles had been made