Metallographic Analysis of a Spearhead Found Near Fortlet Miñana, Argentina

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ABSTRACT

This article presents an analysis of a spearhead found near Fortlet Miñana, a settlement about 50 km south of the city of Azul in Buenos Aires Province, Argentina. Occupied from 1860 to 1863, the circular fort was protected by a moat and used to defend nearby farms and villages from attacks by indigenous people. Metal spears were used by both the military cavalry forces and indigenous warriors. The Archaeometallurgy Group of the University of Buenos Aires analyzed the spearhead to determine the techniques employed in its manufacture and link these techniques to activities in the area surrounding the fort. The analysis involved electrolytic cleaning followed by a nondestructive optical metallographic inspection.

Introduction

The analysis presented here was performed on a spearhead found near Fortlet Miñana in Buenos Aires Province, Argentina, characterizes the techniques used in the spearhead's manufacture, and links them to the activities which took place in the area surrounding the site. Fortlet Miñana was a military-camp settlement along the south border of Buenos Aires Province near Fort Azul (Figure 1). It was occupied from 1860 to 1863 for the purpose of protecting nearby farms (*estancias*) and villages. The site is 50 km south of the city of Azul and 17 km northeast of Chillar near the Azul River. It consists of a circular fortlet surrounded by a moat. Adjoining the fortlet is a triangular structure that possibly functioned as an animal pen. The settlement had housing structures made of cob, and according to Servicio Histórico del Ejército (Army Historical Service) sources, 21 members of the national guard were stationed at Fort Miñana in 1861 (Gómez Romero 1999, 2007).

Historical documents as well as archaeological investigation revealed no evidence of the existence of a blacksmith's workshop on the site. The nearest blacksmithy was at the fort and town of Azul, about 50 km distant. Outside Fortlet Miñana were the camps of friendly indigenous tribes.

Within Argentina, the spear was a weapon used not only by the military cavalry forces, but also by mounted warriors of numerous indigenous groups. These cutting weapons, unlike the broad range of knives, were not sold by *pulperías* (local general stores) or traveling merchants (Landa 2009). The spears were sent to the military settlements by the government. By the time of Fortlet Miñana's occupation, the spearheads might come from the "Parque de Artillería" and the "Comisaría de Guerra" (armories) in Buenos Aires, which imported them from several European countries or manufactured them on its own premises, or they may have been produced by blacksmiths at different workshops in Buenos Aires or military forts. By 1895, with the standardization of military weaponry, the size and shape of spears was regularized when Solingen, Germany, became the sole supplier to the Ejército Argentino (Isidoro Vides 2009, pers. comm.).

Analysis of the Spearhead

The spearhead was found near the Fortlet Miñana site in the 1950s by Manuel Cairo, a local resident. It was taken to his home and has been exhibited there ever since. For display, the spearhead was fastened to a wooden board with cotton thread. The head seems to have kept its original shape with no fragmentation. It is corroded, and its surface is noticeably rough (Figure 2).

Techniques Employed: Electrolytic Cleaning and Metallographic Analysis

So as not to affect the object's integrity, the metallographic analysis was performed on two areas of the spearhead (Figure 3). Initially the area chosen for the metallographic test was the sharp edge of the spear, referred to as Area A

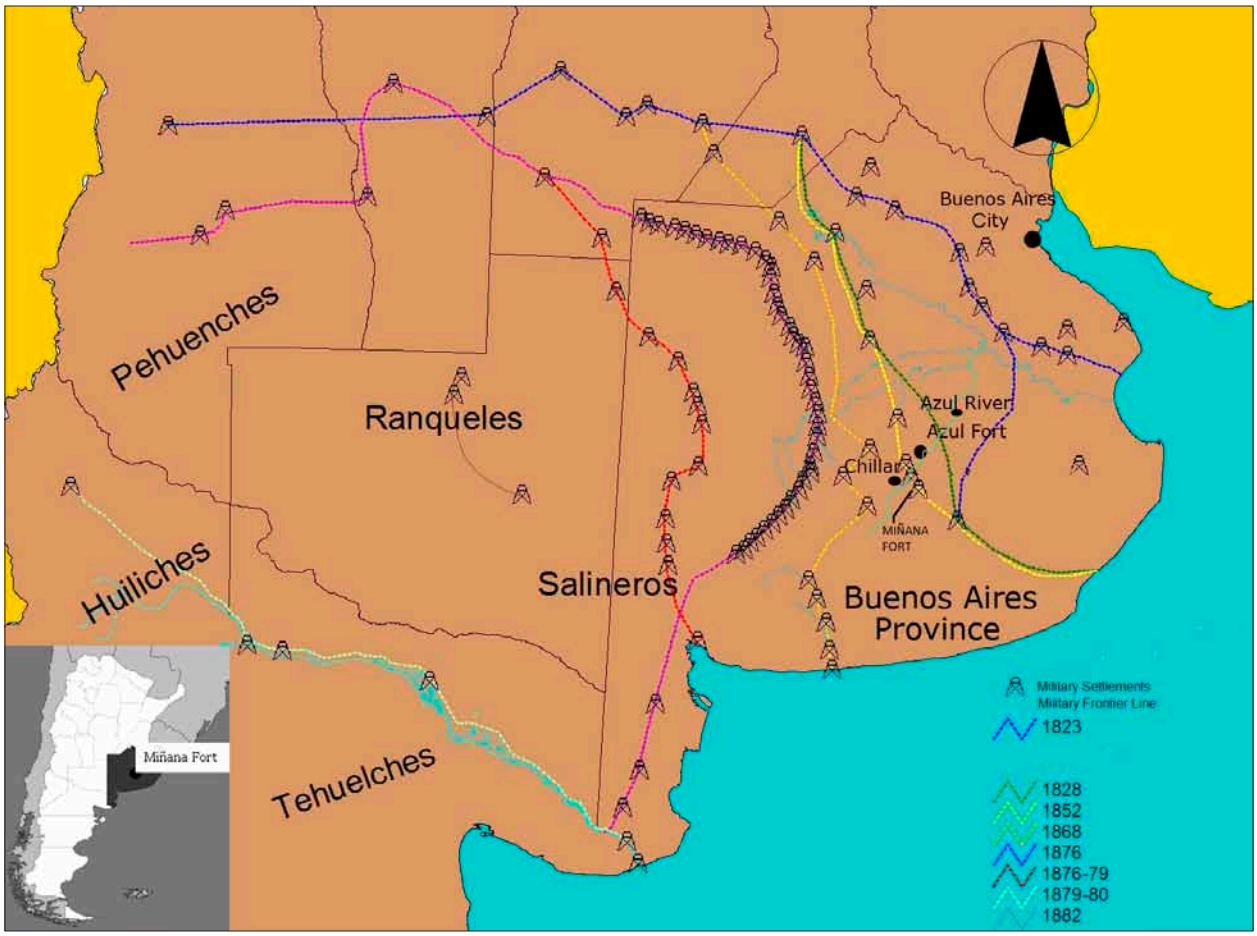

Figure 1. Fort Miñana in Buenos Aires province, Argentina. (Map by Carlos Landa and Maria Lucchetta, 2010.)

Figure 2. Iron spearhead from Miñana Fort. (Photo by Maria Lucchetta, 2010.)

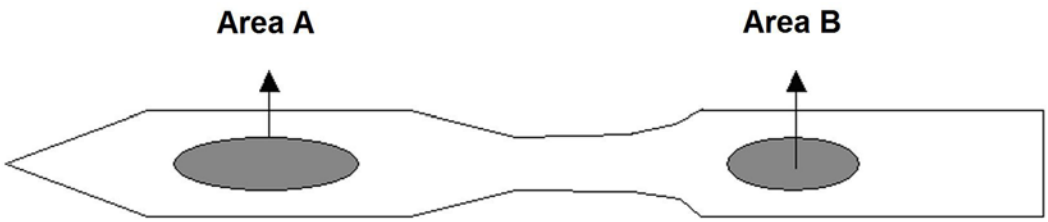

Figure 3. Locations at which metallographic tests were performed: Area A and Area B. (Photo by Maria Lucchetta, 2010.)

Figure 4. Spear image after polishing. (Photo by Maria Lucchetta, 2010.)

(Figure 3). The presence of a 1 mm step in the haft zone (Figure 4), however, brought up the possibility of the object being composed of two welded parts. For this reason, a second testing area was singled out, Area B (Figure 3), in order to confirm or reject this supposition.

The selected testing areas were ground with small-grain sandpaper and later polished to mirror finish with diamond compound. In order to bring forth the metallographic structure Nital 2 (2% nitric acid in alcohol) was used as reagent. When the polished surface was treated with the reagent, a grey stain would come up that made observing the microstructure impossible. Therefore, an electrolytic cleaning was performed, using the object as the cathode in a pH 13 sodium hydroxide solution, and an SAE 1090 anode at a 6 V potential difference (Figure 5). The release of hydrogen bubbles cleaned the surface, getting rid of the weakly adhered corrosion products, as well the substances that interfered with the exposure of the structure.

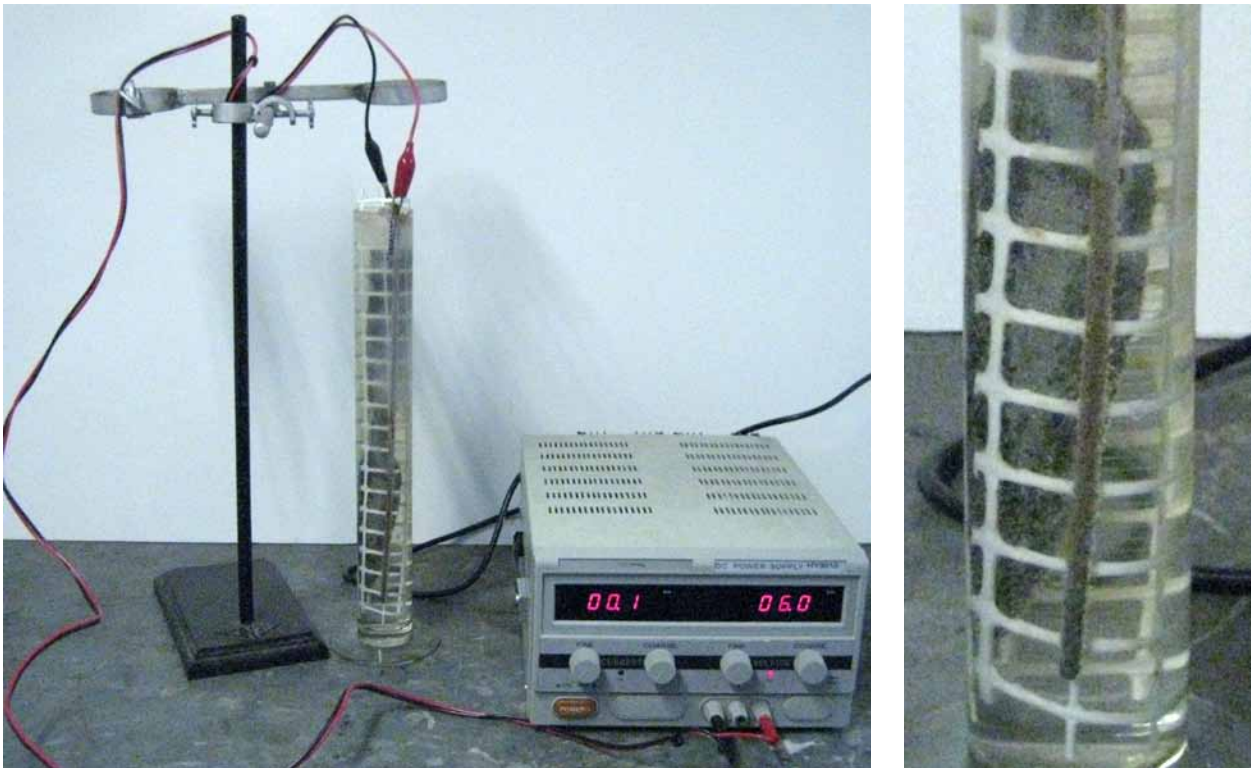

Figure 5. Apparatus for electrolytic cleaning (left). Detail of the container in which the electrolytic cleaning was performed (right). (Photos by Maria Lucchetta, 2010.)

Results

Both areas A and B show a ferrite structure with equiaxed grains with silicate-like nonmetallic inclusions. This structure is ordinarily found in wrought iron as a result of a hot forging process (Figures 6 and 7). The apparent carbon content is very low, as indicated by only a few cementite zones seen in grain border areas (Figure 7). As regards nonmetallic inclusions (Figure 8), they are oriented lengthwise along the object and present two shapes and sizes: on one hand, there are small globular oxide-type inclusions; on the other, elongated formations—larger than the former—consisting of a dark gray continuous matrix with a dispersion of lighter particles, some globular and others dendritic (Figures 9 and 10).

The microstructural characteristics observed match a forged steel–type ferrous material that was worked while warm to shape the object. In opposition to the team's initial suspicions, no union-by-forging zones were seen in the "step" area. The morphology of the nonmetallic inclusions is similar to objects manufactured with similar technology (Wayman 2004; De Rosa et al. 2008), and it is attributed to the use of silicon oxide–based fluxes that fluidized slag so as to simplify its removal at the forging temperature (around 1000°C).

Discussion and Conclusion

Based on its analyzed microstructure, the spearhead recovered near Fortlet Miñana shows characteristics of hot-forge manufacture. The observed nonmetallic inclusions are consistent with the forging temperatures between 1000°C to 1100°C used in this method. The spearhead was forged from very low-carbon ferrous material referred to in the literature as "forged steel" (Wayman 2004). The lack of evidence of welded unions leads the authors to believe that this artifact was made in one piece. The presence of a discontinuity in the shape consisting of an approximately 1 mm step in the hafting zone strengthens the theory that the blacksmith used some sort of support or "matrix" on which he gave the object its definitive shape. At the spearhead's "neck," a double fold is visible that generates an area of higher flexural strength, thus revealing the manufacturing knowledge of an experienced craftsman with access to specialized equipment such as a forge, bellows, anvil, and other tools (Figures 3 and 4). In regard to the raw materials employed, it is uncertain whether they were supplied specifically for this type of manufacture, or recycled iron elements such as barrel rings, strips, or discarded tools were employed.

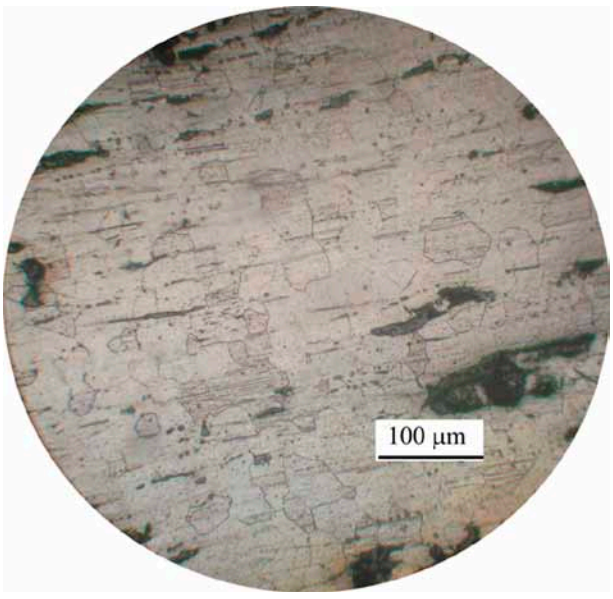

Figure 6. Ferritic structure with aligned inclusions, Area A. (Photo by Maria Lucchetta, 2010.)

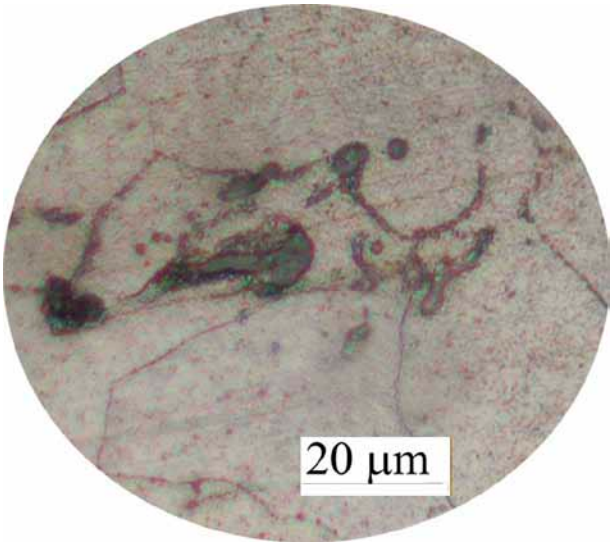

Figure 7. Cementite in the grain border, Area A. (Photo by Horacio De Rosa, 2010.)

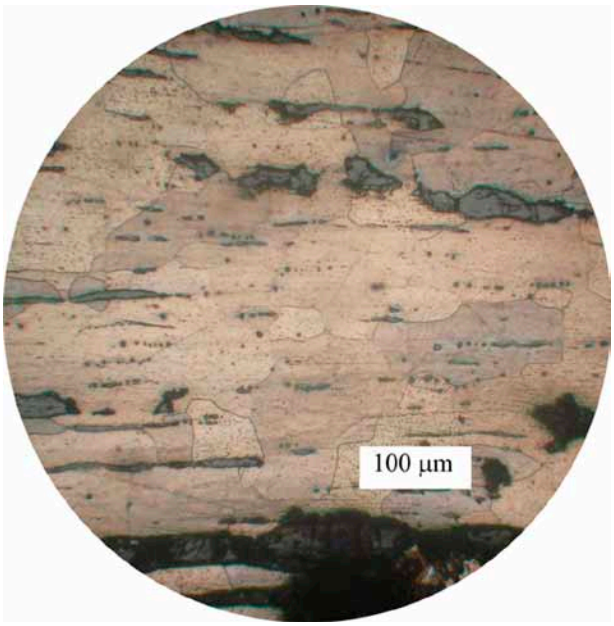

Figure 8. Ferritic structure and nonmetallic inclusions, Area B. (Photo by Horacio De Rosa, 2010.)

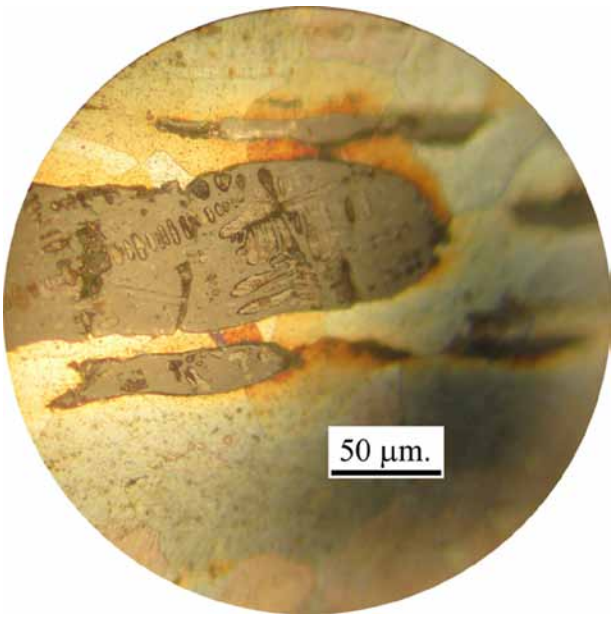

Figure 9. Slag inclusions and oxide dendritic formations. (Photo by Maria Lucchetta, 2010.)

Figure 10. Enlarged detail of Figure 8, showing ferritic structure and nonmetallic inclusions in Area B. (Photo by Maria Lucchetta, 2010.)

Taking into account the characteristics of the team's findings and the manufacturing characteristics inferred by the tests performed, the theory that the spearhead was made by aboriginal techniques can be rejected. Indigenous warriors manufactured spears on their own, but the different Indian groups were unable to produce and cast iron or steel, and their metalworking was confined to silver (Landa 2009).

An Indian spear was an object that could be made in two ways: through the use of the bands of chests, barrel hoops, or scrap iron; or through the use of tools manufactured from ferrous compounds (swords, machetes, knives, scissors, etc.) (Figures 11 and 12). For example:

> All the Indians who have passed next to me, they were armed with long spears. This weapon, formidable in their hands, consists of a sheet of iron or steel, it was taken from an old knife, a sword, a bayonet or scissors to shear the sheep, solidly set at the end of a 'bamboo or tacuara' fifteen to eighteen feet long and perfectly straight, light and polished. It's a particular species of bamboo, because it has not a central cavity or marrow, it grows in certain regions of the Andes and it is the object … of an extensive trade between the Indians, who pay a high price for it to his fellows (Armaignac 1883:118).

The authors believe the spearhead recovered near Fortlet Miñana may have been produced at an urban blacksmith or in one of the forts close to the site that was used by soldiers or the "friendly Indians" (those allied with the government) who inhabited it.

Figure 11. Indian spear made from half of a pair of shears from Sheffield. (Photo by Carlos Landa, 2010.)

Figure 12. Steel shears from Sheffield. (Photo by Carlos Landa, 2010.)

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