Metallographic examination of iron artefacts from Gansu Province, China

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ABSTRACT: A number of cast- and wrought-iron artefacts from Gansu Province, China were examined by metallography to determine the nature of the ferrous materials. The iron objects date from the Eastern Zhou Dynasty (770–221BC) and Western Han Dynasty (221BC–AD8). A large cast-iron bell from the later period of Dajing Mingchang (AD1190) was also studied. A variety of different ferrous technologies was found in the artefacts examined, including: wrought iron—probably derived from bloomery manufacture; steel made by decarburisation or fining of a cast iron; grey cast iron; mottled cast iron; and white cast iron. Electron probe microanalysis was used to obtain elemental composition for some of the artefacts, which in the case of the wrought iron showed extensive banding due to arsenic, nickel or copper enrichment. In some corroded material, pseudomorphic retention of microstructure within iron oxyhydroxides allowed the morphology of the original microstructure to be inferred.

Introduction

The iron objects examined originate from Li, Jiuquan and Lingtai counties, in the prefectures of Longnan, Jiuquan and Pingliang respectively, all located within Gansu province, China (Fig 1). During the period from 770–221BC, Lingtai and Li counties were the seat of the Qin state. It is thought that the earliest capital of the Qin State was located in Li County (Li-xian) before it moved to Shanxi province. Many iron artefacts have been found in the area, and there has been speculation that the iron production techniques may have a relationship with those used in Western or Central Asia, as Gansu lies at the eastern end of the ‘Silk Route’, connecting China to these areas. However, no samples from the area have been analysed or studied by metallographic techniques previous to this report, as far as the authors are aware.

The iron ding or tripod, MaFe1, is in the collections of the Li County Museum in Gansu Province. Its cultural origin is not absolutely certain, some archaeologists holding that it belongs to the Spring and Autumn period (770–476BC), while others regard the Eastern Zhou Dynasty (770–221BC) to be more probable. Samples MaFe2, MaFe3, MaFe6 and MaFe7 were excavated from Lingtai County before 1983, but not from a controlled excavation so the archaeological context is unclear. A sword, MaFe8, from Jiuquan, also dated to the Western Han Dynasty (206BC–AD8), was examined, but is completely corroded and only mineralised remnants of its microstructure remain. MaFe9 came from an excavation at Yunxinxiang in Li County, but the sample was so totally corroded that no useful information could be gained from it. MaFe10 is the largest iron bell from the Lingtai county museum, the date of manufacture being cast into its surface. Samples MaFe4, from a sword, and MaFe5, a bronze-handled iron knife, originate from Gansu Province but do not have known archaeological provenances.

Experimental methods

Small samples were cut from representative areas of the objects in China for metallographic examination in the laboratory at UCLA. Not all of these samples proved to contain remnant metallic structures and three were almost entirely composed of iron oxyhydroxide corrosion products. All were examined as they were the only samples which were allowed to be removed from China for the purpose of this study.