The metallurgy of Chinese cast iron statuary

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ABSTRACT: A group of 19 Chinese cast iron objects, mainly statuary and ritual objects, dating from between the 8th and 19th centuries AD, has been subjected to microstructural and compositional analysis. The objects were found to represent a range of cast iron types, including white cast irons with both divorced eutectic and ledeburitic microstructures, ferritic and pearlitic grey cast irons, and mottled cast iron. The microstructure of each object was found to be explicable by the chemical composition of the iron, especially its silicon, phosphorus and sulphur contents. The different chemical compositions can be accounted for by different smelting conditions, such as the use of coke or charcoal as furnace fuel, and the smelting of iron ore from different ore bodies. The sulphur contents, while not providing definitive evidence, suggest that at least some of the cast irons were smelted using coal or coke rather than charcoal. Where it was possible to tell, specifically for the white and mottled irons, the objects had been cast using the piece mould process. This work increases appreciably the corpus of analytical results for Chinese iron of this time period.

Introduction

Cast iron, the carbon-rich liquid product of iron smelting furnaces, is often thought of as a relatively recent material in comparison with wrought iron, its lower-carbon ferrous cousin whose first appearance dates from at least as far back as the mid-second millennium BC. In a Western context this is probably justified although sporadic finds of cast iron, possibly discards, have been found at a few early sites (see, eg. Burton Brown 1950) including some early bloomery iron smelting sites. It is now believed that in Medieval Europe there is likely to have been a gradual development that culminated in the stuckofen and ultimately, c 1000 AD, in the blast furnace (see, eg Pleiner 2000). For the most part, the cast iron (pig iron) product of early European blast furnaces was intended for conversion into wrought iron by a fining process, with the manufacture of cast objects a secondary and significantly later development. However in China liquid iron was being produced from blast furnaces very much earlier, certainly no later than the mid-first millennium BC and possibly as early as the 9th century BC (see eg Wagner 1993, Han Rubin 1996, Craddock 2003). Although it appears likely that some pig iron was being converted into wrought iron from early times, there is no question that functional castings were also being produced, so that by no later than the third century BC the casting of iron objects was a major industry in China (Bronson 1999). The rapid development of such an industry was undoubtedly aided by China’s long experience with the production of high quality bronze castings, which dates back to the first half of the second millennium BC. This expertise could be readily applied to cast iron, which melts at temperatures not far above that of bronze.

Chinese iron castings were made for ceremonial and utilitarian purposes. Examples include agricultural implements (hoes, spades, plough-shares), weaponry (spear heads, daggers), salt evaporation pans, coinage, hardware (fittings, locks), tools (axes, hammers, saws), stoves, cooking vessels (pots, cauldrons, woks), lamps, bells, ornaments and structural segments of pagodas (see, eg Hartwell 1962, 1966, Rostoker et al 1983, 1984, Wagner 1993, 2000, Bronson 1999, Craddock et al 2003, Wayman and Wang 2003, Chen Jianli et al 2003, Wagner unpublished manuscript). A major application was for statuary, which ranged from tiny objects to monumental statues weighing tens of thousands of kilograms. The present contribution deals with small