
**Lothar von Falkenhausen**

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Donald Wagner’s painstakingly researched book is a valiant and pioneering attempt to provide a long-needed comprehensive account of early siderurgy in China. Incorporating the analysis of textual sources as well as the study of material relics, it is an important contribution to interdisciplinary scholarship, though one may well hesitate to accept the study in its entirety.

Addressing only the earliest stages of iron production in China, the first five chapters of the book focus on the pre-Han era, a period from which few iron objects have been preserved. Chapter 1, “Introductory Orientations: The Bronze Age in China” (pp. 1-49), presents an overview of early Chinese history and archaeology down to the founding of the Empire. The author points to the heterogeneous nature of the Chinese sources and questions the accuracy of orthodox Chinese historiography, emphasizing instead the importance of local, non-“Chinese” cultures. The chapter also introduces the major steps in the development of bronze casting technology and mining, which paved the way for iron production. Entering the long-standing debate on the possible use of bronze for purposes of economic production in ancient China, the author examines the scanty repertoire of early Chinese bronze tools; he finds that virtually all of them were associated with crafts or mining, and that there is no evidence for the use of bronze implements in agriculture, at least in the central regions of northern and southern China. Bronze was thus, according to Wagner, fundamentally different from iron in that it probably remained, throughout Chinese antiquity, a symbolically charged material of prestige.

In Chapter 2, “The Earliest Evidence of the Use of Iron in China” (pp. 50-96), Wagner surveys materials datable to the Springs and Autumnns period or later, quite properly excluding from consideration some blades of meteoric iron in weapons from the middle Shang dynasty, isolated curiosities that bear no relevance to the rise of iron production. The author begins by scrutinizing
textual evidence and analyzing the etymology of various Chinese words connected to iron. There follows a presentation of the earliest iron objects so far recovered archaeologically, with lengthy (and often seemingly pointless) discussion of their contexts of excavation.

Most of the objects presented in this chapter come from locales along the Yangzi river and date to after ca. 500 B.C., leading the author to hypothesize that the geographical origins of Chinese iron technology were in the southeastern state of Wu during the Late Springs and Autumns period. This idea is elaborated in the following chapter, entitled “The State of Wu and the Discovery of Iron” (pp. 97-146). Here Wagner delves into a long and often interesting account of Wu history and archaeology—to my knowledge the most extensive such treatment so far in a Western language, and thus useful even though one might argue that it is out of place in the present book. He shows the non-Zhou underpinnings of Wu culture, paying particular attention to its distinctive bronze industry and to the role of metallurgy in legendary accounts regarding the Wu state, which was renowned for its excellent bronze weapons. Moreover, Wagner notes that Wu peasants used bronze tools of local derivation, which seem to be typologically ancestral to later agricultural tools made of iron. Unfortunately for Wagner’s theory, such iron tools have only been found in other areas, but so far not in Wu. The chapter concludes with a hypothetical reconstruction of how local bronze founders might have started experimenting with iron, which was a common trace element in copper ore. It has since been shown that mid-Eastern Zhou bronzes from this area contain trace elements of iron,¹ which may manifest themselves as iron corrosion on the surface; we have also learned a great deal more about ancient copper mining sites along the Lower Yangzi during the time contemporary with the Zhou dynasty,² and during even earlier periods.³

Wagner is himself aware that his “working assumption” of a Wu origin of Chinese iron technology rests on somewhat shaky grounds—as would any theory based largely on circumstantial reasoning. Conscientiously enough, he presents (pp. 91-95) some finds that would suggest a greater time depth of iron use in the northwestern region than anywhere further south: several tools from the enormous tomb of a ruler of Qin (possibly Jing Gong, r. 576-537 B.C.) at Nanzhihui, Fengxiang (Shaanxi), and an iron dagger with a bronze handle from an Early Springs and Autumns period (eighth century B.C.) Qin tomb at Jingjiazhuang, Lingtai (Gansu), which Wagner, without any good reason (such as analysis data), shrugs off as a likely instance of meteoric iron use. In fact, besides the objects noted by Wagner, other early objects have come to the fore in northwestern China since the book was written. They include more than

¹See Wenwu no. 9 (1990), pp. 37-47.
twenty iron objects from a Middle Springs and Autumns period Qin tomb at Yimencun, Baoji (Shaanxi), including an iron sword with an elaborate inlaid gold handle,4 and an iron dagger with a jade-encrusted bronze handle from a newly excavated large tomb at the necropolis of the rulers of Guo at Shangcunling, Sanmenxia (Henan),5 which some scholars date to as early as Western Zhou times (the terminus ante quem, at any rate, is the annihilation of Guo in 655 B.C.). The reports allude to the existence of other, as yet unpublished evidence from the same region.

In all these early contexts, iron is used as a material of prestige, associated with individuals of the highest ranks and used for ritual display and conspicuous consumption. This suggests cultural-processual parallels to early iron use in West Asia, where, as is well known, iron was at first employed for making ornamental trinkets. Given that the use of iron in West Asia goes back to a much earlier time than in China, the discovery of early evidence of iron use along the western fringes of the Zhou cultural sphere inevitable raises the possibility of a transasiatic connection. Like all diffusion issues, this problem is extremely difficult to tackle—not only because it touches on political taboos, but also for general methodological reasons, as Wagner shows in his discussion of bronze technology (pp. 28-33).

The evidence for early iron use in Qin and adjacent areas does not, of course, automatically invalidate Wagner’s “working assumption” in its entirety; for there is no inherent reason why iron technology should not have been independently developed in the southeast, along the lines suggested by Wagner (i.e., as a utilitarian material without strong symbolic connotations attached). However, historical evidence presented by Wagner in his Chapter 5 does suggest that Qin was fairly early in developing, during the Warring States period, a state-supervised iron industry geared to the mass production of tools and weapons; and it appears quite unlikely, pace Wagner, that the technological knowledge enabling this development was diffused from the Lower Yangzi area. What triggered the reversal in the cultural position of iron from a precious to a utilitarian material remains to be elucidated by future research.

The massive Chapter 4, “A Survey of Early Iron Artifacts” (pp. 147-245), enumerates and describes pre-Han archaeological finds of iron objects from all parts of China, ordered in part typologically, partly according to site. Most items are illustrated, and the captions provide important information in addition to that given in the text. The reader thus obtains a fair idea of the range of objects made of iron in Warring States times—weapons, production tools, belt hooks, and such accessories as manacles, shackles, and leg-irons. At the end of the chapter, Wagner speculates about the cultural significance of regionally different distributions of iron objects, e.g., swords and belt hooks in the Qin and

4Baoji wenwu no. 2 (1992), p. 19; the sword is depicted on the back cover.
Chu areas, suggesting, among other things, that the widespread use of iron swords after the third century B.C. may have been promoted under the influence of Qin. Disappointingly, in spite of the historical thrust suggested by Chapter 1, Wagner does not discuss how the large-scale adoption of iron during the Warring States period may have contributed to the tremendous social and political changes of those times.

Instead, Chapter 5, "Ironworks and Ironmasters in the Third Century B.C." (pp. 247-56), speculates about the social circumstances of iron production. Using written sources, mostly from the third century B.C., it describes the geographic distribution of iron sources, the organization of production under "ironmasters," the iron workshops, and the technology of iron production. This discussion is by necessity somewhat skimpy as no actual pre-Han iron manufacturing sites have yet been identified, and our knowledge of early Chinese mining is entirely based on the remains of copper mines. Under present circumstances, the best evidence on the details of iron production is to be obtained from the scientific analysis of the microstructures of surviving iron objects.

The results of such analysis are presented in the following two chapters—"Metallographic Studies 1: Wrought Iron and Steel Artifacts" (pp. 267-334) and "Metallographic Studies 2: Cast Iron Artifacts" (pp. 335-404). Here the author suddenly extends the time span of coverage through the fourth century A.D., without, however, providing the kind of background information given in chapters 1 through 5 for the preceding period. In his richly illustrated presentation, Wagner mainly comments on studies of excavated artifacts undertaken by Chinese scholars. To accompany his own discussion, he provides careful translations of thirty-nine original reports (pp. 461-484)—a heroic effort deserving the greatest praise: for these terminologically unassailable renderings can help the neophyte to understand the Chinese scholarly idiom in this difficult field, and they will undoubtedly serve as standards in future translation work. Reviewing the data in the light of general metallurgical theory and through comparison with the history of siderurgical technology in the West, Wagner succeeds in staking out some of the basic technical parameters within which the ancient Chinese iron smiths and iron casters worked.

Wagner finds that white cast iron and wrought iron are approximately coeval in southeastern China, and that weapons were generally made of wrought iron (often laboriously refined to steel), whereas tools and implements were of cast iron. White cast iron, though cheap, was difficult to cast and too brittle to be useful in many functions; but great improvements came with the invention, in the third century B.C., of malleable cast iron, i.e., white cast iron that had been heat-treated after casting, thus lowering its carbon content and increasing its elasticity. This development spurred the mass-production of cast-iron agricultural tools and weapons.

In his "Concluding Remarks" (pp. 405-411), the author summarizes the results of the metallographic chapters. He points out that the large-scale
organization of the Late Warring States period iron-casting industry was facilitated by cultural habits developed in many centuries of bronze casting experience. Iron manufacture in large, state-controlled workshops might, according to Wagner, have led to the development of the blast furnace, which can operate efficiently only with a large volume of production. In such a situation, firewood is likely to have been a more restricted commodity than the ubiquitous iron ore. Wagner speculates that the industry was organized in "iron plantations" exploiting large tracts of forests for charcoal, and that it was in order to quell politically unorthodox tendencies emanating from these operations that the Han government imposed a state monopoly on the iron industry in 117 B.C. Indulging in further historical speculation, Wagner then compares the different "technological choices" made by ironworkers in ancient China and ancient Greece in terms of their overall historical impact.

There follows an extensive Danish abstract (pp. 413-426). As is proper for a handbook, the bibliography (pp. 485-552) is very comprehensive, containing works on sinology, Chinese archaeology, the principles of siderurgy, and the history of science in addition to specialized works on the book's subject. Both the bibliography and the extensive index (pp. 553-573) are amply supplied with Chinese characters, as is the main text of the book.

Part of a prestigious series, this volume aims to make the state of scholarship in the author's field accessible to the wider scholarly community. In this respect, Wagner scores but a mixed success. In contrast to the fairly straightforward archaeological chapters, the extremely technical language used throughout most of the two technical chapters makes this part of the book virtually impenetrable, even to a reader possessing an elementary foreknowledge of siderurgy. The author is quite aware that readers will not understand his analysis (cf. pp. 267, 336), and yet has not solved this problem.

In spite of such criticism, this is a very useful book: reliable as a source of material and accurate terminology, and valuable for its attempt to give some amount of synthesis to what remains an extremely incomplete and badly reported-on database. This book confirms the author's competence as the leading Western specialist on iron technology in ancient China. We may look forward to his forthcoming volume in Joseph Needham's Science and Civilization in China, where he will hopefully present his research on the much more voluminous materials on Han and later iron production.

In spite of the volume's many illustrations on glossy paper, its price can only be called outrageous.