Book reviews

Ancient Greece and Standards. The history and control of the materials which left their mark on Greek civilisation by George Varoufakis. *Aeolos, Athens, 1999, 89pp, 242x170mm, ISBN 960-521-071-1. No price stated.*

This book offers a non-technical account of the ancient Greeks' technological know-how and of their highly developed institutions for maintaining high standards of quality which underpinned their remarkable art and architecture. The first part traces evidence of technological progress and knowledge in ancient Greek literature with extracts from Homer, Hesiod, Aeschylus, Xenophon and others. This leads to an appreciation of the effect of technical change in general, and the development of metal technology in particular, on the evolution of ancient Greece. Its golden age was the 5th century BC, by which time precious metals had emerged as the store of economic value which facilitated the creation of 'super-powers' such as Athens and, later, Philip II's Macedonia. Also included are technical matters, for example particular terms related to metals, which are often the source of confusion even amongst experts such as engineers or archaeologists.

The book's second part tells how ancient Greeks applied a sophisticated system of quality control and certification procedures to most of their products, ranging from metals and their alloys to agricultural products. It is based on ancient inscriptions and studies of copper and iron weapons, tools and other artifacts. One example is the text on a 4th century BC stele in the museum of Eleusis which refers to a decree concerning the manufacture of bronze fittings for the erection of the columns of the Philonian Stoa. The decree comprises strict technical specifications and, therefore, constitutes one of the oldest European standards. The part of the deccree concerning the chemical composition of bronze fittings states: 'That they be produced at Marion, the alloy be made of twelve parts, eleven of copper to one of tin'. This appears to mean that they should be imported from Marion on Cyprus, a very important commercial and metallurgical centre at that time. According to another inscription, from the Hephaestion of 420 BC in the Athenian Agora, the price of copper was 35 drachmas per talent (a talent was equal to about 25kg), while the price of tin was 230 drachmas per talent, *ie* over six times that of copper. The supplier would therefore be tempted to cast a cheaper, and consequently poorer and thus more profitable copper-tin alloy. It was for this reason that the required quality was so precisely dictated and a system of quality control was put in place. Had control been relaxed, the contractor stood to make a hefty profit, maybe as much as 700 drachmas, a large sum at that time.

Justine Bayley

The Carolingian Economy by Adriaan Verhulst. *Cambridge University Press, Cambridge, 2002, 160pp, 215x139mm, ISBN 0 521 00474 8 (p/b). £13-95. Also available as ISBN 0 521 80869 3 (h/b) at £37-50.*

The publisher's blurb suggested that this survey of the Carolingian economy in its European context would provide a historical view of crafts and industrial practices to set alongside that of agricultural production. This it does, but in a fairly minimal way, as only 13 pages are devoted to manufacturing, as compared with 41 pages on agriculture and 30 pages on commerce. Metalworking is only one of the industries covered so not much is said about it, particularly as little use is made of archaeological sources of information. Most manufacturing was carried on in a rural and manorial context, a change from the preceeding Merovingian period when crafts and industries were mainly based in towns; exceptions are the artisannnal quarters that are associated with large abbeys like that at St Gall.

Previous writers have suggested that iron was a scarce commodity in the Carolingian period, a view that is not followed here. Mines for iron ore were donated to abbeys, but the only documentary proof for the existence of industrial iron-working concerns possessions of the Carolingian king. Although mining and smelting are differentiated from the fabrication of weapons and tools, it is not made clear whether the general term 'iron-working' covers one or the other or both. Iron slags have been found in nearly every rural settlement, though it is not clear if iron-working was a secondary activity of peasants or a main occupation of specialized craftsmen. It is assumed that as iron production was dispersed, most fabrication would have been carried out locally. In a few areas production clearly exceeded local needs and is thus termed 'industrial'. Surviving documents mention deliveries of iron to abbeys, either as rough ingots or as finished products, as payment of rents; the quantities are often considerable. Several abbeys had arms manufactured for the military service of their vassals; selling them to others, particularly merchants, was repeatedly forbidden – and so presumably had often occurred!

Interestingly, the only mention of precious metalworking is in the discussion of money and price movements. The economic effect of the new silver mines at Melle, near Poitiers, is mentioned, as are the numbers and distribution of mints, which are normally found in urban centres, unlike other types of manufacturing. The fineness of the silver used for coinage, and the speed and frequency of recoining are also considered, but with no discussion of who the craftsmen were who undertook this work, or what extraction or refining processes they used.

Justine Bayley

Shaft Furnaces and Beehive Kilns: A history of smelting in the Far West 1863–1900 by Lynn R Bailey. *Westernlore Press, Tucson, Arizona, 2002. $26.95.*

Modern books on smelting in the American West are rare things—and though there are plenty of local histories which mention it in passing, the only other substantial work I have seen is James Fell's *Ores to Metals, the Rocky Mountain Smelting Industry* (University of Nebraska Press, Lincoln, 1979). There was, of course, a very considerable number of contemporary works, both as books and as articles, and in newspapers, but it is difficult for a distant researcher to adequately access these. Thus this work is especially welcome, helping fill one of the most important gaps in modern metallurgical history.

My interest in mining and smelting in the American West stems from extensive travel there. I find the history of the American West is strangely neglected in Britain. Strange, because the conquest of the West, in most respects before 1900, was by English, Scottish, Welsh and Irish sons, brothers and cousins, together with other European emigrants. This is our history too! Metallurgically the end of the 19th century saw the eclipse of Swansea or 'Copperopolis' as Stephen Hughes would have it (*Copperopolis: Landscapes of the Early Industrial Period in Swansea*, RCAHMW 2000), as the major world centre for copper smelting as the technological frontier also moved west.

In 1898, Edward Dyer Peters (*Modern Copper Smelting*, Scientific Publishing, New York and London, 9th edition) had this to say (slightly paraphrased) about what he termed the *American System* of the then best blast furnace practice:

> 'Twenty five years ago the copper blast furnace was regarded as an intricate, eccentric and highly uncertain machine, erected on deep and massive foundations ... provided with one to five tuyeres of limited area, through which a gentle stream of air trickled into the interior...
> The charging was done with infinite care [sometimes] of but two hundred pounds ... iron sows were a constant menace and frequent reality ... campaigns were short and, like nations, characterised by a long period of very gradual rise ... and a protracted and painful term of decadence.'

By contrast:

> 'The present [advanced type] of American copper cupola consists of a circular or oval, water-jacketed shell or of four or more straight wrought jackets ... to form the sides and ends of a rectangle... The tuyeres are ten to twenty in number and a positive or semi-positive blower [*eg* the Rootes blower] furnishes a minimum of 7000 cubic feet of air a minute at two inches mercury (690 mm water). The molten products escape immediately into a moveable forehearth from which slag flows into large pots or a stream of water which granulates and removes it. In some works the matte is tapped and moved in ladles by crane straight into a Bessemer Converter where it is converted into 99% copper in a single operation...
>
> In short an American copper metallurgist regards a blast furnace as a simple cavity, surrounded by a fire-proof wall, in which his mission is to burn coke with the greatest attainable rapidity taking care always to supply the utmost quantity of carefully fluxed ore that the coke can melt and forcing his charge through the furnace so quickly there is no opportunity for conversion of the iron to metal... a daily duty of 100 to 160 tons of ore is attained...'

A major expectation for the present work under review is that it would show how the *American System* developed and by whom and where. In this Bailey is largely but not, in the end, entirely successful though his story is a detailed one, as will be seen from the following synopsis.

American iron, lead and copper smelting had an earlier history in the Colonies and States east of the Rocky Mountains before and after the 1776 rebellion, but in the west copper smelting began in California in 1863 at a small settlement called Copperopolis after its canvas-covered boarding-house. Ore was at first shipped via San Francisco to Swansea, but Thomas Price, a buyer for the Vivian Company in South Wales, saw his opportunity and with San Francisco capitalists, erected a small reverberatory furnace, on the Welsh pattern, with an eight ton daily capacity. Technically only marginally successful, the high cost of capital contributed most to its downfall. A year later, the Powning Brothers, originally from Cornwall, imported a hundred 'Cousin Jacks' to work mines and erected a concentrator, the first on the Pacific coast whilst others (Scottish and German) erected smelters in San Francisco itself. Their works only concentrated the proportion of copper into a 'regulus', which had to be further refined in the east or at Swansea. Copperopolis boomed, but the only other similarity with Swansea was probably the ladies ready to provide men 'with creature comforts'.

From that time the smelting industry grew rapidly. A preference emerged for the use of blast furnace reduction of both lead/silver and copper ores, in the latter case of both secondary minerals which could fairly easily be reduced to metal and pyritic ores which were usually reduced to a copper sulphide matte requiring further treatment elsewhere. Methods thus followed continental practice rather than Swansea, notably that of the Harz. Many works were very small and, like the many shallow ore deposits worked, were short-lived. Technical developments made to cope with this included easily-assembled and dissembled furnaces, contained in iron casings which, in some cases, could be made ready to work within ten hours once the parts were delivered. Furnaces were thus generally small, ten, twenty or thirty tons a day were common sizes. Massive brick structures were uncommon—problems of keeping the lining and casing cool were solved by use of water-jackets: these had been introduced by a former Vivian smelter John J Williams at Michigan, but in the west, the first was designed in 1865 by Nathaniel Haskill.

A more scientific basis to smelting also emerged in that decade and in the 1870s, notably from the efforts of Germans such as Albert Arents, but with links also to British smelting practices in Spain from which Freiberg metallurgists had developed the octagonal Piltz furnace. Key amongst the ideas Arents and colleagues developed were also those of a Russian metallurgist, Vincent von Raschette, who had been responsible for an entirely new departure, a rectangular-hearthed furnace with several tuyeres on the long sides (as many as ten and, later, more) with tap-holes at each of the narrow ends. Arents adopted these ideas, building a rectangular-hearthed furnace, but with rounded ends and later added the siphon-tap or lead well (a curved tube connecting the base of the hearth with an external sump) on lead furnaces. Increased reaction speed led to greater throughput with continuous tapping of metal and slag, removing problems of blockage which plagued other furnaces. Features in his model were depended on by most later furnaces, including one for the Francklyn Smelter in Utah in 1882, the largest works up to then, which produced some $2,000,000 of bullion (unrefined lead containing silver) in its first six months.

John and Louis Williams, sons of the Williams noted earlier, using the model of a German iron-smelting cupola, in 1881 combined existing improvements with further innovation into a simple, economical and efficient furnace, easily transported and erected, capable of continuous operation for many months at a time at some 30 tons a day ore input. It was built at the Rankin-Brayton's Pacific Iron Works at San Francisco, and was used very widely in large numbers at works such as those at Bisbee (Arizona, at the Copper Queen) and at the Comstock (Nevada, the fabulous lead/silver lode).

Service industries obviously had to develop too. Huge foundries were set up to provide furnaces and other mining-related equipment in centres such as San Francisco, Salt Lake City and Denver. The metallurgical fuel was commonly charcoal. Mountains were stripped bare of timber, for a radius of 30 and more miles around, and in one instance a 27-mile timber flume was constructed (in about a hundred days), to bring whole trees down to a mill and charcoal kilns: the timber-laden stream within raced down slopes of two or three hundred feet a mile at ten or fifteen miles an hour. Large works, however, with the development of railways, generally used coal (as coke), and water power usage for blowing cylinders quickly developed into coal- or wood-fuelled steam engines powering fans and the Roots blower.

Charcoal making in heaps and in kilns receive their own chapter. These kilns survive in a number of localities and are available for archaeological examination, lovingly preserved by the National and State Forests who would today undoubtedly bar re-introduction. There is, however, no parallel discussion of coke ovens.

As a historian, Bailey also develops the family and business relationships which made so much possible, which will certainly widen the interest in his book. Some, but not much, consideration is given to the substantial health problems of furnace operators, thus mirroring the historical reality. The end of his chosen era (1900) and the beginning of the next, is represented by the massive porphyritic copper find at Bingham Canyon—hitherto a lead/silver and gold mining locality, and the formation of three huge smelting corporations vying for its control, of which the American Smelting and Mining Company emerged the winner. It was capitalised at $65,000,000. At about the same time, with the rapidly rising world demand for copper, giant furnaces, of some 300 ton daily capacity began to be produced and the Bessemer converter, used experimentally for oxidation of impurities in copper matte as early as 1878, began to be used on a similarly large scale, notably, he cites, at Bisbee.

This is in most ways a very useful book and easy to recommend. It is solidly referenced though less happily indexed and would benefit from an introductory chapter or a glossary, defining simple smelting processes and their limitations (as between oxidized and sulphidic ores for example) and terms such as regulus, matte, bullion etc. It is possible some of the minor confusions in these respects are based on the original sources.

This reviewer's principal adverse criticism, however, is not in what he has written, but in what he has not. The very limited discussion of the mighty end-century developments is certainly the weakest part of the book. Not including coke is also an obvious flaw, but the greatest disappointment comes from the consideration of shaft furnaces in isolation, without the reverberatories which were so important at large works, notably at the end-century works at Butte (and nearby Anaconda) in Montana (Skovers, Fiege, Martin and Quivik: *Butte and Ananconda Revisited.* Butte Historical Society, 1991). It was here that the Bessemer was introduced on a commercial scale and around 1900 Butte was the largest copper producer in the world. Following a period of highly spirited 'copper wars' the major works amalgamated during the period 1899–1910 to form, from 1915, the giant Anaconda Copper Company.

Exclusion of contemporary topics such as electrolytic refining and pyritic smelting is, perhaps more excusable. The end-century saw the triumph of a technological and commercial revolution, especially in copper metallurgy: its lack of full consideration means the wonder implicit in Peters' vivid description is hardly evident here. It is a pity.

Lynn Willies