REVIEWS

Peter Golas, *Science and Civilisation in China.* Vol. 5: *Chemistry and Chemical Technology.* Part XIII: *Mining*. Cambridge: Cambridge University Press, 1999. xxvi + 538 pp., 127 ills., 15 maps, 14 tables.

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Peter Golas's volume for *Science and Civilisation in China* gives us for the first time a real history of mining in China. He provides the necessary technical detail with very clear explanations, and he makes great efforts to place the technical development in its full historical context. Peter Golas is thus a worthy disciple of our master Joseph Needham, whose insistence on 'brass tacks', and on taking up the whole of a subject in a big book, seems to me the most valuable part of his legacy.

The sources for the study of mining in China change with the period. Archaeological excavations give a fine view of Han and pre-Han mining, but Chinese archaeologists have shown very little interest in later developments. From the late Han through the Tang there is very little relevant material of any sort. For the Song and Yuan we have a few interesting written sources, throwing some light on the economic and social context of mining but with very little information on the techniques. From the Ming the written record becomes richer, and we begin to learn more about mining techniques, especially in the *Tian gong kai wu* _an gon of 1637 and the *Diannan kuangchang tulüe* _annan kuan of ca. 1845. For the 19th and 20th centuries there are numerous eyewitness accounts by Western and Western-trained mining engineers. Finally, Golas has himself visited a number of mines in south China which still today use traditional techniques.

Our view is thus inevitably patchy. We know a great deal about the techniques used by miners at (among others) the great copper mine at Tonglüshan ??? in Daye, Hubei, in the Warring States and Han, but nothing about how they lived or who organised their work. We know more about the organisation of Song mining, but virtually nothing about its technology. We know a little of both for the Ming and Qing, but what we know immediately raises more difficult questions. The only way to proceed is to interpret the

sources for a period in the light of what is known for earlier and later periods: not an ideal situation, but Golas is fully aware of the pitfalls in his path, and he has produced an account which seems methodologically solid. I have a few reservations on the use of modern eyewitness accounts, and will return to these further below.

The techniques of mining may perhaps be roughly divided into three categories: prospecting and exploration; everything that goes on inside the mine; and ore dressing. Outside these categories are placer mining and the copper precipitation process. All of these matters are of course impressively covered and well explained, but in less than half of the book (pp. 203–386). The rest, what makes this book unique and wonderful, covers the *context* in which these techniques were developed and practised: the geology of ore deposits in China (pp. 41–57), the products of Chinese mining (pp. 58–202), labour and capital (pp. 387–415), and the role of the State (pp. 416–428).

With all this before us we can begin to see *technological choices* as effects and as causes in history on an equal footing with other historical factors in constant interaction. China's ore deposits are most often small and irregular; this was perhaps the reason for the generally small scale of mines. This may in turn have been an important factor in a seemingly general lack of investment capital in the mining industry, or perhaps State policies hindered large-scale investment. Both deposit size and available capital influenced the techniques chosen for any particular mine; these techniques influenced labour relations; or was the influence of labour relations on the choice of techniques more important? The processes which followed on after mining and ore-dressing, in particular the techniques of smelting ores to metals, must also have interacted with mining techniques: particular smelting techniques set requirements for mining and ore dressing, while the limitations in these techniques set requirements for smelting processes.

The sections on 'Major non-ferrous metals' and 'Iron' (pp. 58–150, 150–173) anticipate future volumes of *SCC* and may in some particulars be corrected by them. It is nevertheless important to have this material as part of the story of mining, and Golas's treatment, for example, of the earliest use of copper and bronze in China (pp. 58–78) brings geology and mining technique very usefully into the discussion of this vexed question. Surveys of the geology of native copper, mixed ores (copper–arsenic, copper–tin), and sulphide ores in China are all relevant here.

An example of the ways in which techniques set requirements for other techniques can be seen at the Tonglüshan copper-mine site. Techniques for mining hard rock seem not to have been available here at this early time; fire-setting, for example, seems not to have been much used, and tools were generally of bronze or wrought or cast iron rather than steel. Therefore the early mining activities at Tonglüshan were restricted to a contact zone in which the rock is friable and easy to mine with primitive implements. But the friability of the rock meant that mining in this zone required extensive timbering, and the

timbering methods here were developed, over the centuries through the Han, to a high level of sophistication. Elsewhere, and at later times, many mines used less timbering; the rock in these places must have been harder and the techniques for cutting into rock more developed.

In the friable copper ore at Tonglüshan the sulphur had been leached out by rainwater over geological time. The resulting oxide ore was much easier to smelt than sulphur ores, and copper-smelting near the mine used a relatively simple blast-furnace process. In places where only sulphide ores of copper were available, a more elaborate multi-stage process would have been necessary.

The chapter 'The shortage of capital' (pp. 410–415) states one of the conundrums of Chinese economic history: Chinese mining seems normally to have been on a small scale, and there has always been difficulty in obtaining the necessary investment for mines. This in spite of the fact that there has not been a *general* shortage of private investment capital; institutions existed for pooling capital in sophisticated partnership arrangements. Golas discusses various explanations and suggests that the most important factor was that the risks involved in mining investment, which he discusses in detail, generally outweighed the possible returns.

There is more to be said on this question. First, we should distinguish between the scale of the individual *mine* and the scale of the *enterprise* as a whole. In many places it is the local geology alone which determines that mines will be small (p. 57). If deposits are small and quickly worked out, then large investment, for example in drainage, ventilation, or mechanised haulage, is not economical, even in cases where such investment would make more of the deposit available for exploitation. This may have been the case in the iron mines of Guangdong. In Shanxi, on the other hand, the enormous deposit of coal underlying the greater part of the province would have lent itself to large-scale mining, but simply digging a vertical shaft to the coal layers was so straightforward (pp. 163, 200 fn. 694) that large-scale mines were apparently seldom attempted here before modern times – as far as we know.

Chinese mining and smelting *enterprises*, on the other hand, have sometimes been very large. In Guangdong, in the late Ming and early Qing, large firms played a significant role in iron production: iron was mined, smelted in numerous blast furnaces in the mountains, and transported down the great rivers of the province to Foshan, where it was fabricated into products and traded throughout China and Southeast Asia.[1] According to *Guangdong xinyu* uangdo,[2] (by Qu Dajun (by Q, 1630–96) the labour force of such a firm was at least 300 households, including 200 miners, and transportation was provided

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[1] See e.g. Xu Dixin & Wu Chengming (eds.), *Chinese Capitalism, 1522–1840*, tr. by C. A. Curwen et al., London: Macmillan, 2000, pp. 93–110, 249–264.

[2] Typeset ed., repr. Hong Kong: Zhonghua Shuju, 1974, ch. 15, pp. 408–410; tr. Donald B. Wagner, *The Traditional Chinese Iron Industry and Its Modern Fate*, Richmond, Surrey: Curzon Press, 1997, pp. 65–67.

by 200 oxen and 50 river vessels. Even allowing for exaggeration, these were large-scale enterprises which could easily discount the risks involved in investing in any one mine.

But here is where the unavoidable reliance on recent travellers' accounts can lead into methodological muddle. Qu Daxin's account was written before foreign trade sent the Guangdong iron industry into a steep decline, and no modern-trained observer ever saw that industry in its prime. For Shanxi, on the other hand, we have numerous modern descriptions of traditional mining practices, but seemingly none at all before the late 19th century, when foreign competition had sent profits down to near-zero at the same time that foreign trade was introducing other, more profitable, investment opportunities.

Accounts of Chinese mining by knowledgeable modern observers are unreliable guides to earlier practice. In the nature of the case, all such accounts refer to an industry operating in economic conditions fundamentally changed by contact with the modern West. Decreased profits, higher returns on alternative investments, and a surfeit of cheap labour due to generally troubled times meant that the most economically rational technologies were usually small-scale and labour-intensive. Several modern observers have noticed signs in poverty-stricken mining districts of the former prosperity of their 'glory days' (pp. 40 fn. 130, 393 fn. 48). What technologies were used back then is often simply unknowable, but Golas does give us some examples of what seem to be larger-scale mines in which, at some past time, significant investment was made (pp. 16, 283, 335 fn. 266, 315 fig. 81, 340, 342, 348, 393 fn. 48).

It may well be that future work, especially in the archaeology of mining in more recent centuries, will give us an alternate view of the technology and context of Chinese mining. In the meantime, Peter Golas's book gives us a clear view of the available evidence and an opportunity to argue about these questions in a more informed manner than has ever been possible before.