"Just Now the 'Merican expert is the Prominent Man": American mining engineers and the Australian mining industry 1880s-1910s *

By JEREMY MOUAT
University of Alberta

The nineteenth-century gold rushes transformed mining, just as they transformed those places where they occurred. As Elliot West noted – speaking of America although his comments apply equally to Australia, New Zealand, or Canada – 'every rush set loose the transforming energy of a new urban industrial America into the country around it. A mining camp was like an artillery shell lobbed into the outback'.[1] Mining flourished in the decades that followed the gold rushes, particularly in the western United States. The individuals associated with those mines came to be regarded as especially competent, and by the late nineteenth century they had emerged as a distinct occupational group, American mining engineers. Soon they could be found on virtually every mining field around the world. Their sudden rise to prominence seems a fascinating – if neglected – chapter in the growing globalization of the world's resource industries.[2] A number of these men were recruited to operate Australian mines, and the following pages examine their role in New South Wales, Western Australia and Victoria during the late nineteenth and early twentieth centuries.

American mining engineers attained a dominant position in the world's mining industry in a remarkably short time and when the industry itself was undergoing profound change. These individuals not only controlled much of the industry, they also participated in professional organizations and supported a range of technical journals. They created an epistemic community which, like the mining industry in which they worked, extended to every corner of the world. The phrase 'epistemic community' has a specific meaning within the social sciences: 'Epistemic communities can ... be defined as a group of [people] sharing a common goal of knowledge creation and a common framework allowing the shared understanding of this trend'.[3] This may seem a somewhat cumbersome and overly theoretical way to describe American mining engineers and their activities, but it provides a way to understand the rapid growth and growing ubiquity of the technical literature of the mining engineering profession. Periodicals such as the New York-based *Engineering and Mining Journal* regularly ran

articles on innovations developed on mining fields in countries thousands of miles apart, articles which then could spark lively discussions in the correspondence pages among geographically-dispersed practitioners. Those conversations illustrate the workings of the engineers' epistemic community.[4]

If the growing prominence of the American mining engineer was in evidence by the 1880s, it was at that point still a relatively recent phenomenon. In mid nineteenth century, North Americans deferred to European expertise in mining and metallurgy. In the wake of the gold rushes, for example, ambitious young men from the United States flocked to European mining schools, notably at Freiburg in Germany, since they had little opportunity to study mining in their own country.[5] Despite this, hard rock mining soon became a predominantly North American industry, largely because the processes and technology that functioned adequately in such European mining regions as Cornwall or Germany did not transfer successfully to North America's mining frontier. The relative inadequacy of European methods in the American West meant that it became a region where rapid innovation and technological change was the norm, thus giving western mining its distinctive characteristics. Thus James Douglas, a prominent North American mining engineer, argued in 1899 that 'Where [American mining engineers] differed from their brethren abroad was in their inoculation by the spirit of adaptiveness which is so strong a feature of the national character'.[6]

More generally, the rise of the American mining engineer coincided with the mining industry's rapid development and expansion, as it became an industrial activity based on intensive mechanization and economies of scale. The period saw the introduction of new mining and metallurgical methods as well as readily available venture capital, which together helped to launch new mines all over the world: mineral production soared and mining stocks enjoyed periods of intense speculative activity. Yet in many ways the catalyst for this expansion was the industry's dramatic growth in western America, and western mining became the norm against which mining practices around the world were judged (even though much of the venture capital was British, and few of the key innovations were of American origin).

It is useful to situate the rise of American engineering within a broader international context, especially that of the shifting fortunes of the US and the UK. The dramatic eclipse of Swansea's smelting industry, coupled with the equally dramatic rise of American copper smelting, was a telling example of this shift. From the 1880s through to the First World War, British authorities routinely lamented their failure to

maintain their technological lead, a general complaint that often pointed to the specific example of the dominance of American mining engineers in South Africa. The analysis offered by the authors of a book published in the UK in 1916 was typical:

> In [mining engineering] as in other industries the lead in up-to-date methods was given by America. The mechanical processes of mining in this country have failed to give many new ideas to the world, and modern methods have been mostly developed abroad. ... In the development of our gold mines in South Africa, the majority of the engineers were American and the machinery of American design. In smelting the same thing obtains. For many years this country held the premier position in copper smelting, and ore was imported in large bulk to Swansea and elsewhere for treatment. Gradually other countries began to break away and to establish their own plant. The English smelters pinned their faith to old methods, and "best selected" was their standard. America, followed by other countries, developed electrolytic refining, originally an English idea...[7]

The presence of American mining engineers in Australia reflected a broader trend, the general expansion of American engineering expertise.

The growing significance of American engineering was not confined to mining. The railways were another industry where British authorities becoming increasingly anxious about American engineering competition. This was witnessed firsthand in Australia, when in 1886 an American firm won the contract to build the Hawkesbury River Bridge in New South Wales, after an international competition.[8] The success of the American tender provoked Jeremiah Head, President of the (British) Institution of Mechanical Engineers, to discuss the issue in his address that year. His comments in turn attracted the attention of the editor of the *Engineering and Mining Journal*, on the other side of the Atlantic, in New York. The editor commented that

> There is no doubt that Mr. Head has really touched the key-note to the superiority of our American engineering practice, which is pre-eminent in its adaptability to the surrounding circumstances, irrespective of precedents that may have been established under other and varying conditions.[9]

Notwithstanding the self-congratulatory nature of the comment, most authorities agreed that significant shifts were taking place and that American engineering was indeed proving to be superior. The success of the American bid can be explained by the pace and scale of railway building in America, as well as that country's high labour costs, circumstances that encouraged American engineering shops to prefabricate materials in ways in which the British were not inclined (or compelled) to do.[10]

The example of the Hawkesbury River bridge is relevant here because a similar

set of circumstances helps to explain the appeal of American mining engineers to those in charge of the large mining companies in the Australian colonies, first on the Barrier in New South Wales. In the late 1880s, the directors of the Broken Hill Proprietary [BHP] had begun to appreciate both the wealth and the extent of their mine's ore body, and realised too that efficient mining and metallurgical operations would require considerable engineering skill. It is worth bearing in mind that the directors were men with virtually no experience in mining, and well aware of their limitations when it came to mining operations. To obtain the services of the best available experts for running their property, they turned to the western US, and it was from there that they recruited their senior officials. 'Just now', noted an Adelaide journalist in his report on Broken Hill in early 1888, 'the "'Merican expert" is the prominent man'.[11]

In 1886, the same year that the Hawkesbury Bridge contract had been awarded to an American firm, one of the BHP directors, W.R. Wilson, was dispatched to the U.S.[12] He visited mines, inspected equipment and interviewed a candidate for the job of metallurgist at Broken Hill. H.H. Schlapp, the prospective employee, was formerly superintendent of the Pueblo smelter in Colorado 'and Mr. Wilson thoroughly satisfied himself ... that Mr. Schlapp's qualifications were of the very highest order'.[13] The Directors engaged another mining man with American experience to make 'an outside general report' on the mine, which was appended to the Directors' Report of 1886.[14] In early 1887, the job of General Manager was offered to a third 'Merican expert', W.H. Patton. He was Superintendent of the Consolidated Virginia Silver Mining Company, one of the largest mines on the famous Comstock lode. 'This gentleman', the directors proudly told BHP shareholders,

> holds a premier position in the silver mining world of America, and has had a long experience in the mining of large silver lodes, which will be of the utmost value and importance in relation to your large property. … He has had under his control very large milling and amalgamating plants, and is fully conversant with all their operations. Your Directors therefore regarded the possession of his experience and advice in regard to these processes of ore reduction as of the highest importance, and as alone justifying the appointment.[15]

Not until the 1920s did an Australian hold the position of General Manager at BHP.[16]

It is tempting to speculate that had Broken Hill been developed ten or twenty years earlier, BHP directors may have turned to Cornwall as the logical place to recruit expert staff. As it was, the emergence of the Comstock as the world's premier silver

mining region doubtless goes a long way towards explaining the directors' choice. In both places, mining took place on a very large scale.

In places on the BHP claim, the lode was a hundred feet wide. One of the first geologists to inspect Broken Hill described it as 'the most extraordinary and largest lode I have ever seen'.[17] Mining such a massive ore body created problems, since it entailed the removal of enough underground material to jeopardize stability at the surface. The first American managers at BHP introduced mining methods to deal with such problems. Patton inaugurated the square-set method of mine timbering in an effort to prevent subsidence and cave-ins from hampering mining operations.[18] Even square sets, however, did not prevent earth movement and the occasional disastrous cave in. Patton's successor as General Manager, John Howell, another American, introduced an alternative solution to the problem. In 1891 he began extracting ore from the surface by means of an open cut, which eventually extended almost a mile along the line of lode and 300 feet deep.[19] The open cut was not only efficient, allowing the recovery of virtually the entire ore body that it exposed, but also relieved pressure on deeper underground workings and meant that a significant amount of timber could be retrieved from the underground workings that it exposed.

Some of the same BHP directors were also key actors in the development of the Mt Lyell mine in Tasmania. After BHP's American metallurgist gave them an encouraging assessment of the mine's ore, they decided to purchase the property.[20] It was clear that operating the mine profitably was going to call for considerable metallurgical skill, and so once again they turned to the US to recruit a suitable engineer. The man they hired, Edward Peters, was North America's leading expert on copper smelting, and had recently built the smelter for the Canadian Copper Company in Sudbury, Ontario.[21] In late 1892 Peters accepted their lucrative offer to assist with setting up mining and smelting operations at Mt Lyell. He spent five months at the mine, proving its worth as a producer as well as the viability of smelting its ore. Robert Sticht, a second American and someone who, like Peters, had extensive smelting experience in the western US, subsequently took charge of Mt Lyell's metallurgical operations. He was soon the mine's general manager, continuing in that position after the Mt Lyell and North Lyell companies amalgamated in 1903.[22] By then, according to Geoffrey Blainey, Sticht was widely regarded as 'the greatest figure in the huge Australian mining industry of that day'.[23]

At the same time that Mt Lyell achieved prominence as a leading copper

producer, the golden wealth of Western Australia was also attracting a good deal of attention, particularly from speculative investors on London's Stock Exchange. News of the dramatic gold finds in Kalgoorlie had reached England in 1894. Almost immediately City financiers – hoping for a second South Africa – formed companies to acquire and operate mines there.[24] London promoters launched nearly 50 mining companies in the autumn of 1894, compared to 18 in the first eight months of the year. The momentum grew throughout 1895 and continued into 1896. By the end of that year, close to 800 West Australian mining companies had been floated in London.[25]

The following year, a young American mining engineer, Herbert Hoover, arrived in the colony. Hoover's career in Western Australia differed in some significant ways from the other American mining engineers discussed thus far. Unlike those others, who were recruited directly by Australian mining interests, Hoover was employed by a London engineering firm, Bewick, Moreing and Company. The firm's activities were largely directed by C.A. Moreing, one of the key players in London's speculative boom in Westralian mines of the mid-1890s.[26] Thus Hoover's initial career in Australia was linked to the strategies of a British firm, who hired him as a mine scout.[27] He was subsequently placed in charge of a mine he had recommended for purchase, the Sons of Gwalia mine, where he soon established his abilities as a mine manager.[28] Hoover introduced various changes at the mine – increasing the miners' working hours, reducing staffing levels underground, and recruiting Italian labour – that would become typical of the Western Australian properties managed by Bewick, Moreing.[29] Hoover worked hard to reduce the mine's working costs, a concern typical of mining engineers and managers throughout the American west. In Western Australia, however, it was more of a novelty. Managers there were under a great deal of pressure to ship ore – and the higher grade the better – in order to bolster share prices, as a consequence of the prevailing boom conditions. In this context, antagonizing working miners was unwise, since a strike-bound mine was not likely to prove attractive to investors. Even Bewick, Moreing became nervous when it learned of Hoover's plans to use Italian labor:

> We note that you are endeavouring to introduce Italian labor into the mines as far as possible, and Mr. Hooper would suggest that this be done judiciously so as not to supersede other labor altogether, otherwise the Labor Union may give you trouble and precipitate strikes.[30]

Despite such misgivings, the London office certainly appreciated Hoover's work in Western Australia. Moreing later remembered Hoover as 'one of my engineers in my

staff in Western Australia, a young man at that time [1898] who had very greatly distinguished himself there'.[31]

In early 1899 Moreing picked Hoover for an assignment in China, where he spent the next two years. Hoover's time in China enabled him shortly afterwards to become a full partner in Bewick, Moreing and Company. He then returned to Australia, where he assumed overall control of the firm's extensive mining interests.

Once back in Western Australia, Hoover pursued a policy of ruthless efficiency, one which he had first charted at the Sons of Gwalia several years earlier. Now, however, he was a figure of far greater authority and could act with considerable autonomy. One of his first moves was to import a number of American mine managers, to whom he entrusted many of the mines operated by Bewick, Moreing. His reputation as a leading engineer was also gaining wide currency. In early 1903, for example, *The Economist* described 'the great improvement' in the management of West Australian mines as 'almost startling'. Its 'Special Mining Commissioner' (J.H. Curle) felt that

> Bewick, Moreing, and Co. have played an important part in the recent development of West Australian mines, and by the introduction of some of the ablest American mine managers and the sound handling of the mines under their charge, have helped to raise the industry to a materially higher plane. ... Personally, I look on Mr. Hoover as a most valuable factor in the mining industry today.[32]

The following year marked the peak of Bewick, Moreing's influence in Western Australia, however, as in 1904 it suffered a series of setbacks. Several groups in Australia challenged the company's dominant position on the goldfields, although the reverses of 1904 were not only a result of this opposition. Not unlike characters in a classical tragedy, Hoover's and Moreing's confidence and pride encouraged them to over-extend themselves.[33] Under their direction, Bewick, Moreing & Company assumed the responsibility for managing two more leading mines in Western Australia – the Golden Horseshoe and the Great Boulder Perseverance – but the firm promised the corporate owners of the two properties more than it could deliver. The subsequent embarrassments damaged Bewick, Moreing's reputation although it continued to operate in West Australia for many years.[34]

The pattern of Hoover's mining activities now changed. Increasingly he aligned himself with the financier, Francis Govett, and acted as a consultant and adviser for those London-based companies in which Govett was interested. Companies under their

influence – notably the Lake View Consols and later, the Oroya Brownhill – began to invest heavily in other mining properties around the world. Thus companies that had originally been formed to operate individual mines became complex multi-national entities, with holdings in numerous regions around the world.[35] One of the more successful of their ventures was in Broken Hill, where they participated in the launch of the Zinc Corporation. However, they were not acting alone: in addition to Hoover and Govett, key figures included W.S. Robinson, his brother Lionel Robinson, William Clark, and W.L. Baillieu.[36] Hoover's role in all this was largely as a financier and promoter. It is hard to assess what contribution he made as an engineer, but if he did act in this capacity, it was as a very minor player.[37]

Hoover played a larger role in attempting to turn a profit from the Loddon Valley's auriferous 'deep leads', in Victoria. The alluvial gravels of the Loddon Valley had earlier attracted Whitaker Wright's attention and he had formed three companies ostensibly aimed at working them (although they could well have been organised for speculative purposes).[38] Like other of Wright's companies, they suffered a dramatic decline when Wright's mining empire collapsed in 1900-1901. Hoover evidently hoped that a reconstructed and re-capitalized company might prove successful. An advertisement in *The Times* of London in May 1903 advised readers of the formation of a new company, the London and Globe Deep Leads Assets, Ltd. The company was being formed, explained the advertisement,

> to acquire the interests ... in about 11,000 acres of mining rights, situated in the well-known Deep Leads of Victoria, Australia, by the provision of further working capital ... to render remunerative the large sums which have been already spent on the development and equipment of the properties ... These interests consist chiefly of valuable assets of the London and Globe Corporation [sic] and the British American [sic] Corporation, which have been disposed of by the Official Receiver for the benefit of the creditors of the first-named company, at a fraction of the price at which they formerly stood.[39]

Shortly afterward, Hoover arranged to have a senior official with the US Geological Survey come to Victoria and report on the deep leads.[40] The editorial pages of the Melbourne *Age* featured an optimistic piece about the project in December 1903, noting Hoover's involvement; a little over six months later, the New York-based *Engineering and Mining Journal* carried an article on the deep leads, adding approvingly that Bewick, Moreing's representatives 'are importing an American "push" into the work

which is much appreciated'.[41] However, even American push proved unequal to the task: the project carried on for some years, but ended in failure.[42]

As these various examples suggest, American mining engineers played prominent roles on various mining fields in Australia from the late 1880s to the early 1900s, as they did in other regions – in South America, South Africa, and elsewhere. And that raises the question of its significance: What meaning should one attach to the presence of American engineers in Australia?

Any answer to that question ought to pay attention not only to the Australian context into which these American engineers were recruited, but also to those conditions in the US that helped nurture engineering expertise. After all, the actions of BHP directors in seeking out senior American staff for their mine seem fairly straightforward. The fact that these were American mining engineers was likely of little immediate concern; the point was to take advantage of individuals who could introduce 'best practices' at the mine and mill.[43] And as Nathan Rosenberg has argued, technology during the nineteenth century tended to move in step with the movement of trained personnel: 'Where the transfer of technology involved places geographically distant from one another, the reliance upon the migration of trained personnel (at least temporarily) was very strong'.[44] But why were these American engineers willing to travel such distances? To judge by their behaviour, like their employers they were driven chiefly by economic motives. Their overseas employment was typically of limited duration, and they were well rewarded for their work.[45]

However other factors deserve to be noted. Contemporary observers saw the ascendancy of American mining engineers as a reflection of the technological lead of the United States, underlining the growing pre-eminence of American technology and American business methods. The fact that this coincided with increasing American economic strength and political resolve internationally was hardly fortuitous. In 1906, no less a figure than the American Secretary of State drew attention to the fact that America was no longer a debtor nation, but was accruing a pool of capital that needed to be re-directed abroad, to find foreign markets. Despite its origins in anti-trust rhetoric, the Federal Reserve was created seven years later to assist and encourage the internationalisation of American financing.[46] The presence of American mining engineers in Australia and elsewhere is also part of that larger story. After all, these men travelled the world both as Americans and as engineers, as one of their colleagues noted in the *Engineering & Mining Journal* in 1910:

> The American mining engineer in foreign lands formerly recognized the sad fact his Government did not give him adequate protection. ... there has been a decided improvement in the policy of protection to the American citizen abroad and the engineer from the United States feels that the day is at hand when he will be as much respected as the citizens of ancient Rome whose declaration, *civis Romanus sum*, was sufficient to get him justice in every part of the world.[47]

The American mining engineers who came to Australia were not simply individuals pursuing economic advantage. Their presence also reflected the complex relationships between national identity, commercial interests, and the increasingly connected world of the twentieth century.

Acknowledgements

- An earlier version of this paper was presented at the annual conference of the Australian Mining History Association, held in Kadina, South Australia, in July 2006. The paper is based in part on research carried out at the American Heritage Center at the University of Wyoming and I am grateful to the university for awarding me a Bernard L. Majewski Fellowship which made that research possible. I would also like to acknowledge the support of the Social Sciences and Humanities Research Council of Canada
-

Endnotes

1 Elliott West, in his revised edition of Rodman Wilson Paul's classic *Mining Frontiers of the Far West, 1848-1880*, Albuquerque: University of New Mexico Press, 2001, p. 231. I have examined the Australian, New Zealand and BC gold rushes in comparative perspective; see Mouat, 'After California: Later Gold Rushes of the Pacific Basin', in Kenneth N. Owens (ed.), *Riches For All: The California Gold Rush and the World*, University of Nebraska Press, Lincoln Nebraska, 2002, pp. 264-95.

2 Although this phenomenon has not attracted a great deal of scholarly notice, see the chapter, 'No Spot upon the Globe Is Too Remote', in Clark C. Spence, *Mining Engineers & the American West: The Lace-Boot Brigade, 1849-1933*, Yale UP, New Haven, 1970, and Jessica Teisch, 'Engineering progress: Californians and the making of a global economy (India, South Africa, Palestine, Australia)', PhD thesis, University of California, Berkeley, 2001. Note also Elaine Katz, 'The Contributions of American Mining Engineers and Technologies to the Witwatersrand Gold Mining Industry, 1890-1910', *Mining History Journal*, no. 13, 2006, pp. 12-30.

3 This definition is from Patrick Cohendet, Frederic Creplet, Olivier Dupouët, 'Organisational innovation, communities of practice and epistemic communities: the case of Linux', in Alan Kirman and Jean-Benoît Zimmermann (eds), *Economics with Heterogenous Interacting Agents*, Springer, Berlin, 2001, pp. 307-08.

4 Evidence of this can be found not just in the articles that appeared in the *Engineering and Mining Journal* and the *Mining and Scientific Press* but also in their subsequent re-publication in book form. See for example the following: T.A. Rickard (ed.), *Ore Deposits, a Discussion Re-Published from the Engineering and Mining Journal*, New York, May 1903; *The Engineering and Mining Journal,* 1903; T.A. Rickard (ed.), *The Sampling and Estimation of Ore in a Mine,* New York: Engineering and Mining Journal, 1904 (a republication of papers and consequent discussion, from the *Engineering and Mining Journal*); T.A. Rickard (ed.), *Pyrite Smelting*, New York; *Engineering and Mining Journal*, *1905* (This volume is a reprint of the discussion on Pyrite smelting which ran through various issues of the *Engineering and Mining Journal* between October 1903, and February 1905 – Preface); T.A. Rickard (ed.), *The Economics of Mining*, New York; *Engineering and Mining Journal 1905* (a revised edition appeared in 1907); T.A. Rickard (ed.), *Recent Cyanide Practice*, Mining and Scientific Press, San Francisco, 1907 (this book gives, in convenient form, a compilation of the series of articles on cyanidation as they have appeared in the pages of the *Mining & Scientific Press* between January 1906 and October 1907); T.A. Rickard (ed.), *The Flotation Process*: Mining & Scientific Press, San Francisco,

1916 (articles reprinted from the *Mining and Scientific Press*); T.A. Rickard & Oliver C Ralston (eds), *Concentration by Flotation*, John Wiley & Sons, New York, 1921 (a compilation of articles appearing in the *Mining and Scientific Press* during the years 1915 to 1920). Rickard noted that some of these books 'sold like hot cakes' (Rickard, 'A Chapter in Journalism', *Mining and Scientific Press*, vol. 120, 22 May 1920, p. 756). Rickard's prominence in these developments merits a separate article.

5 See esp. J.C. Bartlett, 'American Students of Mining in Germany', *Transactions of the American Institute of Mining Engineers*, vol. 5, 1876-77, pp. 431-47, and R.H. Richards, 'American Mining Schools', *Transactions of the American Institute of Mining Engineers*, vol. 15, 1886-87, pp. 309-40, 809-19 but esp. pp. 336-37. Bartlett argued that American students had few alternatives but to attend German schools, while Richards claimed that in the ten years following Bartlett's article American mining education had come of age.

6 James Douglas, 'The Characteristics and Conditions of the Technical Progress of the Nineteenth Century', *Transactions of the American Institute of Mining Engineers*, vol. 29, 1899, p. 665. See also Rodman Wilson Paul, 'Colorado as a Pioneer of Science in the Mining West', *Mississippi Valley Historical Review*, vol. 47, 1960-1961, pp. 34-50, and Spence, *Mining Engineers & the American West, passim.*

7 Herbert Branston Gray and Samuel Turner, *Eclipse or Empire?,* Nisbet & Co., London, 1916, pp. 208-09. For other examples, see *American Engineering Competition; being a series of articles resulting from an investigation made by "The Times", London*, Harper & Bros., New York and London, 1901; A.S.E. Ackermann, *Coal-cutting By Machinery in America*, The Colliery Guardian Company Ltd., London, 1902; Sydney J. Chapman, *Work and Wages*, Longmans, Green, and Co., London, 1904, especially 'Part I, Foreign Competition'; and Arthur Shadwell, *Industrial Efficiency: A Comparative Study of Industrial Life in England, Germany and America*, Longmans, Green, London, 2nd edition, 1909.

8 For accounts of the awarding of the Hawkesbury bridge contract and the subsequent construction of the bridge, see Charles Ormsby Burge, 'The Hawkesbury River Bridge, New South Wales', *Minutes of Proceedings of the Institution of Civil Engineers*, vol. 101, 1889-1890, pp. 2-12 & Discussion, pp. 38-72; E.K. Morse, 'Erecting the Hawkesbury Bridge, 1887-1889: Reminiscences of a Thrilling Construction Job in Australia', *Civil Engineering*, vol. 8, no. 10, October 1938, pp. 682-84; and David Burke, *Making the Railways*, State Library of New South Wales Press & the State Rail Authority of New South Wales, Sydney, 1995, pp. 91-106. Robert Lee also describes the controversial issues surrounding the bridge's construction, but his account borders on the hagiographical - see his *Colonial Engineer: John Whitton 1819-1898 and the Building of Australia's Railways,* UNSW Press, Sydney, 2000.

9 Untitled, *Engineering and Mining Journal*, vol. 42, no. 10, 4 September 1886, p. 164. Head's speech is reported in 'The Institution of Mechanical Engineers', *The Times*, 18 August 1886, p. 7.

10 I am relying here partly on the insightful analysis provided in Thomas Curtis Clarke, 'European and American Bridge-building practice', *Engineering Magazine,* vol. 24, April 1901, pp. 43-58. The argument about high labour costs is elaborated in H.J. Habakkuk, *American and British Technology in the Nineteenth Century: The Search for Labour-saving Inventions,* Cambridge UP, Cambridge, 1967; cf. Mira Wilkins, *The Emergence of Multinational Enterprise: American Business Abroad from the Colonial Era to 1914*, Harvard UP, Cambridge, Mass, 1970. The controversy over the Hawkesbury Bridge was eclipsed by the outcry in Britain a dozen years later, when an American firm won the contract to build the Atbara railway bridge in the Sudan. For an introduction to this latter controversy, see Jeffrey W. Cody, *Exporting American Architecture 1870-2000*, Routledge, London, 2003, pp. 9-14.

11 'A Special Correspondent', *The Barrier Silver and Tin Fields in 1888*, W.K. Thomas & Co., Adelaide, 1888, p. 62. R.H.B. Kearns names seven Americans employed in senior positions by Broken Hill mining companies during the first years; two others (William Harper and Zebina Lane, a Canadian) should be added to the list, see Kearns, *Broken Hill: A Pictorial History,* Investigator Press, Hawthorndene, South Australia, 1982, p. 53. Cf. Brian Kennedy, *Silver, Sin, and Sixpenny Ale: A Social History of Broken Hill*, Melbourne, 1978, p. 33, & Geoffrey Blainey, *The Rush That Never Ended: A History of Australian Mining*, Melbourne UP, Melbourne, 3rd edition, 1978, pp. 154-55.

12 Directors' Report, Broken Hill Proprietary Co. Ltd., 30 November 1886, p. 8. Bridges' account in *From Silver To Steel: The Romance of The Broken Hill Proprietary*, George Robertson & Co., Melbourne, 1920, p. 145, is taken literally from this report. See also Blainey, *The Rush that Never Ended*, pp. 154-55, and for detail on Wilson, see Blainey, *The Rise of Broken Hill,* Macmillan of Australia, Melbourne, 1968, pp. 39-40.

13 Directors' Report, Broken Hill Proprietary Co. Ltd., 30 November 1886, p. 8.

14 The man, John Provis, concluded 'that the mine is destined to rank among the foremost of the leading silver mines of the world', see Directors' Report, Broken Hill Proprietary Co. Ltd., 30 November 1886, p. 38. Again, Bridges lifted his account on pp. 143-4, directly from this report.

15 Directors' Report, Broken Hill Proprietary Co. Ltd., 31 May 1887, p. 8. Blainey states that Patton was offered an annual salary of £4,000, 'the most expensive manager hitherto hired by an Australian mining company', see *The Rise of Broken Hill*, p. 25; cf. Blainey, *The Steel Master: A Life of Essington Lewis*, Macmillan, Melbourne, 1971, pp. 60-61. Otis Young describes developments on the Comstock Lode and the 'Con Virginia' in *Western Mining: An informal account of precious metals prospecting, placering, lode mining and milling on the American frontier from Spanish times to 1893*, Oklahoma University Press, Norman, 1970, pp. 234-66; milling operations at Patton's former workplace are particularly well-described. By the 1880s, when Patton left Nevada for Broken Hill, the field was in decline.

16 Blainey, *The Steel Master*, p. 64.

17 Norman Taylor in September 1884, quoted in Bridges, *From Silver To Steel,* p. 81. E.C. Andrews, *The Geology of the Broken Hill District,* Memoirs of the Geological Survey of New South Wales, Department of Mines, Sydney, 1922, p. 138, gave the width as 100 feet. As the lode went deeper, it became wider; for example, in 1903 according to Edwin K. Beaumont, 'Silver-Lead Ore Mining and the Various Systems of Stoping and Timbering Employed in Broken Hill, New South Wales', *Transactions of the Australasian Institute of Mining Engineers,* vol. 9, 1903, p. 126, its width in the Central Mine was 270 feet.

18 For the development of square-sets, see Young, *Western Mining*, pp. 242-46. P.H. Warren in Andrews, *The Geology of the Broken Hill District,* pp. 201-206 gives an excellent account, with illustrations, of timbering methods at Broken Hill. See also O.H. Woodward, *A Review of the Broken Hill Lead-Silver-Zinc Industry*, (edited by K.P.W. Parsons), West Publishing Corporation, Sydney, 2nd edition, 1965, pp. 56-7; BHP Directors' Report, 30 November 1887, pp. 13, 21, and Directors' Report, 31 May 1888, p. 14. The *Proceedings of the Australasian Institute of Mining Engineers*, New Series, no. 10, 1913, contains probably the most detailed description. That issue includes five papers on 'Some Features of Broken Hill Mining', see pp. 129-80. An important earlier account was written by Edwin K. Beaumont, 'Silver-Lead Ore Mining and the Various Systems of Stoping and Timbering Employed in Broken Hill, New South Wales', *Transactions of the Australasian Institute of Mining Engineers*, vol. 9, 1903, pp. 117-44.

19 See BHP Directors' Report, 30 November 1892, p. 16, & the remarks of Howell at the Fifteenth Half-Yearly Meeting of BHP, 25 January 1893, Melbourne, p. 6 of published transcript; also Bridges, *From Silver To Steel*, pp. 174-78; Kearns, *Broken Hill: A Pictorial History*, p. 53 and Blainey, *The Rise of Broken Hill*, pp. 102-04. Blainey mistakenly describes the open cut as a glory hole. 'The line of lode' is a distinctive Broken Hill phrase, as is the ore body to which it refers.

20 Geoffrey Blainey, *The Peaks of Lyell*, Melbourne UP, Melbourne, 3rd edition 1967, pp. 57-58. Much of the detail in this section is based on information gleaned from Blainey's study.

21 See 'Canadian Copper Company', *Engineering and Mining Journal*, vol. 46, no. 21, 24 November 1888, p. 444, which describes the Sudbury smelter then under construction. The article points out that 'Dr. Peters, well known to all readers of the JOURNAL, and who doubtless is the ablest copper metallurgist on this continent, is the general manager.' Peters' book, *Modern American Methods of Copper Smelting*, Scientific Publishing Company, New York, 1887, was widely regarded as a definitive text, and by 1905 it had gone into 13 consecutive editions. For details of Peters' career, see 'Biographical Notice of Edward Dyer Peters', *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 60, 1918-1919, pp. 735-40. On his recruitment to work at Mt Lyell, see Blainey, *The Peaks of Lyell*, pp. 59-61.

22 For details of Sticht's career at Mt Lyell, see Blainey, *The Peaks of Lyell,* pp. 74-75, 161, 262-64, and *passim*. A third American, L.C. Trent, played a lead role in operations at North Lyell, although he was dismissed in 1902, a victim of the complex machinations that consumed the company prior to its amalgamation with Mt Lyell - see Blainey, *ibid.,* pp. 132, 145-50.

23 *Ibid.*, p. 161.

24 For accounts of the discovery of Coolgardie & Kalgoorlie, see Blainey, *The Rush That Never Ended*, pp. 177-207; Blainey, *The Golden Mile*, Allen & Unwin, St. Leonards, NSW, 1993; R.M. Gibbs, 'The Real Poseidon: South Australians and the Golden Mile in the 1890s', *Journal of the Historical Society of South Australia,* vol. IV, 1978, pp. 3-32; and G. Spencer Compton, 'Searching Eastwards for Gold in Western Australia, 1887-1896', *Royal Australian Historical Society, Journal and Proceedings*, vol. 43, 1957, pp. 13-44. For the London boom, see Alan Lougheed, 'The London Stock Exchange boom in Kalgoorlie shares, 1895-1901', *Australian Economic History Review*, vol. XXXV, no. 1, March 1995, pp. 83-102, as well as J.W. McCarty, 'British Investment in Western Australian Gold Mining, 1894-1914', *University Studies in History*, vol. IV, no. 1, 1961-1962, pp. 7-23, and John Bastin, 'The West Australian Gold Fields, 1892-1900: The Investors and their Grievances', *Historical Studies Australia and New Zealand,* vol. 6, no. 23, November 1954, pp. 282-89. For a succinct overview of Western Australia's development during the period, see R.T. Appleyard, 'Western Australia: Economic and Demographic Growth, 1850-1914', in C.T. Stannage (ed.), *A New History of Western Australia,* University of Western

Australia Press, Nedlands, WA, 1981, pp. 211-36.

25 The figures for West Australian mining companies floated in 1894 are given in *The Mining Journal and Investor's Review* (Perth), vol. 1, no. 9, 13 December 1895, p. 213. J.W. McCarty, 'British Investment in Overseas Mining, 1880-1914', PhD thesis, Cambridge University, 1961, p. 13, gives the figure of 780 West Australia mining companies launched in London by the end of 1896, while the list of Western Australian companies for 1894-1896 given in Edward Ashmead, *Twenty-Five Years of Mining, 1880-1904: A Retrospective Review*, The Mining Journal, London, 1909, p. 125, totals 789 companies.

26 For a description of Moreing's role in the Kalgoorlie boom, see Ian Phimister & Jeremy Mouat, 'Mining, Engineers and Risk Management: British Overseas Investment, 1894-1914', *South African Historical Journal*, vol. 49, November 2003, pp. 7-8. For a brief biography, see Gill Burke, 'Charles Algernon Moreing', in David J. Jeremy (ed.), *Dictionary of Business Biography*, vol. 4 - MC-R, Butterworths, London, 1985, pp. 311-14.

27 For a good example of Hoover's activities at this time, see his report, 'Reconnaissance Trip for the London & Western Australian Exploration Co. Ltd.', dated 12 October 1897; a copy of the report is in Pre-Commerce Subject file – 'Mining – Australia', Box 50, Pre-Commerce Papers, Herbert Hoover Presidential Library, West Branch, Iowa [hereafter HHPL]. See also Ronald H. Limbaugh, 'Pragmatic Professional: Herbert Hoover's Formative Years as a Mining Engineer, 1895 – 1908', *Mining History Journal,* 11, 2004, pp. 43 - 58; Richard Hartley, 'Bewick Moreing in Western Australian Gold Mining 1897-1904: Management Policies & Goldfields Responses', *Labour History*, no. 65, November 1993, pp. 1-18; Richard Hartley, 'Bewick Moreing's Involvement in Western Australian Gold Mining 1894-1910', unpublished paper presented to the Third International Mining History Conference, Colorado School of Mines, 8 June 1994, and George H. Nash, *The Life of Herbert Hoover: The Engineer, 1874-1914*, W. W. Norton & Co., New York, 1983, pp. 57-58.

28 For details of Hoover's role in the purchase of the Sons of Gwalia, see Nash, *The Life of Herbert Hoover*, pp. 63-67, & Hartley, 'Bewick Moreing in Western Australian Gold Mining 1897-1904', p. 2.

29 Hartley identifies the three notable policies that Hoover introduced at the Sons of Gwalia: 'firstly an emphasis on the reduction of mine working costs which became increasingly important as higher grade ores became scarcer; secondly an insistence on the systematic mining of payable ore rather than selectively mining the richest lodes[;] and thirdly, a more aggressive attitude to labour relations than was prevalent elsewhere in the goldfields and, in particular, the employment of Italian miners' – see Hartley, 'Bewick Moreing's Involvement in Western Australian Gold Mining 1894-1910', p. 2; cf. the comments in Hartley's earlier article, 'Bewick Moreing in Western Australian Gold Mining 1897-1904', pp. 2-10, and Nash, *The Life of Herbert Hoover: The Engineer, 1874-1914,* pp. 84-86.

30 Extract from London Office Letter of 6th May 1898, included in letter from Bewick, Moreing & Co. Coolgardie office to H.C. Hoover, The Sons of Gwalia mine, Mount Leonora, dated 28 July 1898, p. 2, in vol. 1, Correspondence (Inward and Outward), 'Sons of Gwalia' Limited Papers, MN 270, Acc No. 1614A, J. S. Battye Library of West Australian History, Perth, Western Australia. On Hoover's use of Italian labor, note esp. Hartley's comments, 'Bewick Moreing in Western Australian Gold Mining 1897-1904', pp. 3-8.

31 Evidence of C.A. Moreing, 3 February 1905, from the printed report of proceedings in the case, *Chang Yen-Mao v. C.A. Moreing and Others*, in the High Court (Chancery Division). A copy of the proceedings survives in the E.J. Nathan Papers (MSS. Eng. hist. c. 456), held at the Bodleian Library, Oxford University.

32 J.H. Curle, 'Special Mining Commissioner', 'Gold mining investments – VI', *The Economist***,** 10 January 1903, p. 57.

33 As argued in Hartley's, 'Bewick Moreing in Western Australian Gold Mining 1897-1904', p. 13, 'The blows that had been the main cause of the turning point in Bewick, Moreing's fortunes had in fact ... been ones that Moreing and Hoover had inflicted upon themselves in London'.

34 This analysis owes much to the painstaking scholarship of Richard Hartley. In addition to his works cited above, see his dissertation, 'A History of Technological Change in Kalgoorlie Gold Metallurgy 1895-1915', PhD thesis, Murdoch University, Western Australia, 1998; note also the comments in Ronald H. Limbaugh, ' "There is a game against us": W.J. Loring's Troubled Years as Bewick-Moreing Company's General Manager and Partner in Western Australia, 1905-1912', *Journal of Australasian Mining History,* vol. 2, September 2004, pp. 90-114, and Phimister & Mouat, 'Mining, Engineers and Risk Management', pp. 4-8.

35 Patrick Bertola describes this process in his dissertation, 'Kalgoorlie, Gold and the World Economy, 1893-1972', PhD thesis, Curtin University of Technology, WA, 1993 - see esp. 'Chapter 2, The Establishment of the Gold Mining Industry in Kalgoorlie: 1893-1918'. Cf. Peter Richardson, 'Collins House Financiers: W.L. Baillieu, Lionel Robinson and Francis Govett', in R.T. Appleyard and C.B.

Schedvin (eds.), *Australian Financiers: Biographical Essays*, The Macmillan Company of Australia, 1988, South Melbourne.

36 For a useful discussion of these individuals and their relationships, see Richardson, 'Collins House Financiers', pp. 226-53, as well as the recent article by Gilbert M. Ralph, 'The Broken Hill - Collins House Connections: Mining Personalities', *Journal of Australasian Mining History*, vol. 2, September 2004, pp. 198-221. Also useful is W.S. Robinson (edited by Geoffrey Blainey), *If I Remember Rightly: The Memoirs of W. S. Robinson 1876-1963,* F.W. Cheshire, Melbourne, 1967.

37 The Zinc Corporation's early years were crisis-driven, as it frantically adopted and then rejected a series of different flotation processes, before finally settling on the Minerals Separation process. Govett is widely credited with keeping the company going through these early years and I have found no evidence to suggest that Hoover's engineering abilities played any role, other than perhaps in allaying the anxieties of nervous investors. A manager at one of the other Broken Hill plants later recalled that 'The Zinc Corporation was in "some state," and varied both process and management about once per month ... It must have taken excellent and influential finance to save the Zinc Corporation from entire collapse' - see Charles S. Galbraith, 'Flotation in Australia', *Mining and Scientific Press,* 17 July 1915, p. 84. Galbraith was manager of the De Bavay's Treatment Company's plant in Broken Hill during 1907. See also the comments in John Kennett, 'The Collins House Group', PhD thesis, Monash University, 1980, pp. 25-28, and Diane Menghetti, 'Invention and Innovation in the Australian Non-Ferrous Mining Industry: Whose Technology?', *Australian Economic History Review*, vol. 45, no. 2, July 2005, pp. 212-14.

38 The three were Victorian Gold Estates, Loddon Valley Goldfields, and Moorlort Goldfields.

39 'The London and Globe Deep Leads Assets, Ltd.', *The Times*, 29 May 1903, p. 11.

40 See Waldemar Lindgren to Hoover, 16 June 1903, and Lindgren to Hoover, 19 June 1903, both in 'Mining - Correspondence - Lindgren, Waldemar, 1897-1914', Box 49 - Pre-Commerce Subject file, HHPL.

41 See *The Age,* 17 December 1903, and 'Melbourne', *Engineering and Mining Journal,* vol. 78, no. 2, 14 July 1904, p. 75.

42 For accounts indicating the project's fate, see 'Deep Leads of Victoria', *The Statist*, 29 May 1909, pp. 1154-55, and 'Loddon Deep Leads: Directors Rebuffed', *The Argus*, 15 April 1912, p. 14. Through 1906 and 1907 *The Statist* had published a series of optimistic reports on the deep leads, articles likely intended to boost investor confidence; clippings of many of these survive in the University of Melbourne Archives; see Box 6, file 121, W.S. Robinson Papers, 101/70. Note also the optimistic assessment of the deep leads by J.H. Curle, 'Present Status of the Gold Mining Industry', *Mining and Scientific Press*, vol. 95, no. 5, 3 August 1907, p. 149.

43 I agree with Menghetti's sensible advice to avoid ascribing nationality to technology - see Diane Menghetti, 'Invention and Innovation in the Australian Non-Ferrous Mining Industry', pp. 204-19.

44 Nathan Rosenberg, 'Economic Development and the Transfer of Technology: Some Historical Perspectives', *Technology and Culture*, vol. 11, no. 4, July 1970, pp. 550-75, at p. 553.

45 Harold Titcomb, a mining engineer who worked for the Guggenheims, Chester Beatty, and other notables of the mining industry, recalled that the early 1900s were 'about the last of the golden age for mining engineers and investors. There was no income tax whatever in the U.S.A. and if you made money, you had it unless you wasted it, lost it or spent it. Every individual had a good chance if he proved worthy of that. From the Denver office were sent out expeditions to nearly all the Western states, Mexico, Central and South America', see –'Outline of Some of the More Important Mine Examinations Made for A. Chester Beatty, John Hays Hammond and the Guggenheim Exploration Company, 1901-1906, by Harold A. Titcomb, Farmington, Maine', typescript, dated 8 October 1953, in Harold A. Titcomb Papers, 1870-1975, Accession number 2220, Box 22, Folder 10, American Heritage Center, University of Wyoming.

46 For a fuller discussion of these issues, see Nathan J. Citino, 'The Global Frontier: Comparative History and the Frontier-Borderlands Approach in American Foreign Relations', *Diplomatic History*, vol. 25, Fall 2001, pp. 677-93; Emily Rosenberg, *Financial Missionaries to the World: The Politics and Culture of Dollar Diplomacy 1900-1930*, Harvard UP, Cambridge, Mass., 1999; Thomas F. O'Brien, *The Revolutionary Mission: American Enterprise in Latin America, 1900-1945,* Cambridge UP, Cambridge, 1998; and Gray Brechin, *Imperial San Francisco: Urban Power, Earthly Ruin*, University of California Press, Berkeley, 1999.

47 T. Lane Carter, 'The Gold Mining Industry in Nicaragua', *Engineering & Mining Journal*, 17 December 1910, p. 1204. Carter's own career illustrates the peripatetic nature of the American mining engineer. He had worked in southern Africa and Central America, before returning to the US where he died at a relatively young age in a mining accident. For details, see his obituary in the *Bulletin of the American Institute of Mining Engineers*, no. 76, April 1913, pp. xxxii-xxxiv.