

Made in America: Progressive Mining Engineers and the Origins of the South African State

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The gold-field of the Witwatersrand is an astrobleme, a star-wound. It was formed two billion years ago by the largest, and the oldest, meteorite to strike our planet. What remains of the crater produced by the planet-bending energy of this collision has a diameter of some 250 kilometres. It is centred on the granite Vredefort dome, which was sucked out of the earth's crust by the reactive force of the meteorite impact. Along the outer rim lie the extraordinary rocks of the Witwatersrand basin.¹ There are a many volcanic and granite breaks in the continuity of the gold-bearing rock, but along much of the circumference of the crater are South Africa's deep-level gold mines.

The Witwatersrand rock layer averages seven kilometres in thickness and it is about a billion years older than the meteorite crater. The rock that houses the three main gold-bearing reefs was formed by processes of deposition on top of the archaic rock that encased our planet more than 3 billion years ago. Other rocks, some sedimentary and some volcanic in origin, covered the Witwatersrand layer about 500 million years after it was formed. About another 500 million years later, the meteorite slammed into the centre of the Witwatersrand system, changing the character of the gold-bearing rock, tilting the layer like an upturned dinner-plate, and covering it with yet more rock. After the collision, the gold bearing reefs of the Witwatersrand system were securely embedded in the crust, uniquely protected from the geological forces that moulded our planet.²

There are three narrow reefs (called the Main Reef, the Main Reef Leader and the South Reef) that contain significant amounts of gold within the Witwatersrand system. The actual origin of the enormous quantities of gold (and uranium) in these reefs is still a mystery. But there is a consensus that the gold was deposited intermittently on to the bottom of a primordial delta and that the weight of the overlying rock, volcanic energy and the energy of the meteorite impact transformed the three persistent layers containing deposited gold into the characteristic conglomerate reef. This conglomerate rock is called *banket*, the Afrikaans term for the Dutch delicacy of almonds baked in brown sugar. The word captures both the texture of the white quartz pebbles embedded in their grey quartzite cement, and the sweetness of the microscopic grains of gold that they contain.³

This peculiar geography has given the Witwatersrand gold field economic features that are unusual, probably unique. The gold-bearing reefs of the basin are singularly

¹ R L Gibson and W U Reimold, "The Significance of the Vredefort Dome for the Thermal and Structural Evolution of the Witwatersrand Basin, South Africa," *Mineralogy and Petrology* 66 (1999): 15-6.

² L J Robb and F M Meyer, "The Witwatersrand Basin, South Africa: Geological Framework and Mineralization Processes," *Ore Geology Reviews* 10, no. 2 (1995): 70-78., R V Kubicek, *Economic Imperialism in Theory and Practice: The Case of South African Gold Mining Finance 1886-1914* (Durham: Duke University Press, 1979), 40., C Biccard Jeppe, *Gold Mining on the Witwatersrand Two Volumes* (Johannesburg: Transvaal Chamber of Mines: Johannesburg: Transvaal Chamber of Mines, 1946), 48.

³ Robb and Meyer, "The Witwatersrand Basin, South Africa: Geological Framework and Mineralization Processes," 78., Jeppe, *Gold Mining on the Witwatersrand Two Volumes*, 46-8.

persistent in both their lateral and vertical extent—the gold field extends in an interrupted line from the towns to the far east of Johannesburg to the central Free State Province, some 400 kilometres in all. And while the actual amounts of gold present in each sample of rock are very small, they remain roughly consistent to very great depths. There is, in other words, a predictability about the presence and scale of gold on the Witwatersrand field that is unique.⁴

Over the last century, some 50,000 tons of gold have been removed from these mines. That represents about a third of all the gold mined in human history. And yet, today, at least as much gold remains in the rocks of the basin as has been removed. After a century of intensive exploitation, the gold reserves of the Witwatersrand are still more extensive than the total known reserves of all the other gold producing countries. But the gold is not now, nor has it ever been, easily won. The deepest of the mines are today extracting gold nearly four thousand meters below the surface where the rock temperature itself is 62 degrees Celsius.

The combination of the unmatched persistence of gold on the Rand, and the extraordinary technical difficulty of recovering it, has had clearly observable political effects in South Africa. After the initial outcrop rocks of the central 'Rand had been processed, deep-level mining on the Witwatersrand bore no resemblance to the placer mining of California where individual miners were able to use the flow of water to process the alluvial gold that had been deposited into river beds, or the shallow mines of western Australia. "Nothing," an Australian miner explained in 1851, "can have a more levelling effect on society than the power of digging gold, for it can be done, for a time at least, without any capital but that of health and strength."⁵ The reverse was true on the Witwatersrand. Without very expensive plant and years of unremunerative underground development there was no way to access the vast reserves of gold. The success of these mines also required a particular kind of state.

Like American railroad construction, mining in South Africa had a ravenous appetite for capital. After the first decade of mining, investment on the 'Rand totaled a hundred million pounds sterling, or nearly half a billion dollars.⁶ (Using 2006 values, the mines of the 'Rand had absorbed about one hundred billion dollars.) This is well known. Ever since J A Hobson observed that "nowhere in the world has there existed in so concentrated a form of capitalism as that represented by the financial power of the mining houses" much has been written about it.⁷ The personalities of the leading Randlords—Cecil Rhodes, Alfred Beit,

⁴ Jeppe, *Gold Mining on the Witwatersrand Two Volumes*, 57-66.

⁵ B Kennedy, *A Tale of Two Cities: Johannesburg and Broken Hill 1885-1925* (Johannesburg: Donker, 1984), 91.

⁶ S Herbert Frankel, *Investment and the Return to Equity Capital in the South African Gold Mining Industry, 1887--1965* (Cambridge MA: Harvard University Press, 1967), 21. These are 1913 values.

⁷ J. A. Hobson, *The Evolution of Modern Capitalism : A Study of Machine Production*, New and rev. ed. (London: W. Scott, 1906), 267. Shula Marks and Stanley Trapido, "Lord Milner and the South African State," *History Workshop Journal* 8 (1979)., Kubicek, *Economic Imperialism in Theory and Practice: The Case of South African Gold Mining Finance 1886-1914.*, Elaine N Katz, "Outcrop and Deep Level Mining in South Africa before the Anglo-Boer War: Re-Examining the Blainey Thesis," *The Economic History Review* 48, no. 2 (1995). Robert Turrell and Jean Jacques Van-Helten, "The Investment Group: The Missing Link in British Overseas Expansion before 1914?," *The Economic History Review* 40, no. 2 (1987), Robert Vicat Turrell, "Review Article: 'Finance... The Governor of the Imperial Engine': Hobson and the Case of Rothschild and Rhodes," *Journal of Southern African Studies* 13, no. 3 (1987)., Donald Denoon, "Capital and Capitalists in the Transvaal in the 1890s and 1900s," *Historical Journal* 23, no. 1 (1980). Russell Ally, *Gold & Empire: The Bank of England and South Africa's Gold Producers, 1886--1926* (Johannesburg: Witwatersrand University Press, 1994), John Lang, *Bullion Johannesburg: Men, Mines and the Challenge of Conflict* (Johannesburg: Jonathan Ball: Johannesburg: Jonathan Ball, 1986), Charles

Julius Wernher, Hermann Eckstein, J B Robinson, Barney Barnato, Solly Joel and Ernest Oppenheimer—have featured prominently in these studies.⁸ Very much less is known about the managers who actually made the decisions about how to raise and spend this capital.

In the first half-century of gold mining in South Africa, three very large companies dominated the industry, and all of them were formed by American mining engineers. The companies were Rhodes' Consolidated Gold Fields, Wernher-Beit-Eckstein's Rand Mines, and Oppenheimer's Anglo-American. In each case, and under different circumstances, it was a prominent American mining engineer who identified the source of the deep-level gold reserves, designed the plan for harvesting them, and, most importantly, acquired the financial backing of the major international merchant banks. The Randlords (all of whom earned their money and their expertise in the diamond industry) were certainly the main beneficiaries of South African gold mining, but they were not the principal agents. That task was accomplished by a group of progressive mining engineers, who fashioned modern American corporations in South Africa (long before they were present in Britain) out of the different mining companies. It was these engineers who drew the blueprint of the 20th century South African state and laid the foundations of corporate capitalism, the most defining feature of the contemporary South African economy.⁹ That, in a paragraph, is the story. But first we must consider another question: what motivated them to mine the gold in the first place?

The meaning of gold in the 1890s

The Witwatersrand deep-level goldfields were born just in the nick of time; they arrived, and it was not an accident, to save the international gold standard. American engineers were the managers of the new deep-level gold mining corporations, but the key investors, in each case, were the two banks that controlled the trans-Atlantic gold standard, N M Rothschild in London and J P Morgan and Company in New York. For these two banks deep-level gold mining, like government or railway bonds, was a predictably profitable investment, but they had another, much more urgent, motivation to encourage large-scale exploitation of the reserves of the Witwatersrand. In the 1890s, the international gold standard suffered crisis after crisis as the US economy grew more quickly than the global

van Onselen, *Studies in the Social and Economic History of the Witwatersrand, 1886-1914: Volume 1 New Babylon* (Johannesburg: Ravan Press, 1982).

⁸ See especially A P Cartwright, *Corner House: The Early History of Johannesburg* (Cape Town, Purnell: Cape Town, Purnell, 1965), A P Cartwright, *Gold Paved the Way: The Story of the Goldfields Group of Companies* (London, Macmillan: London, Macmillan, 1977), A P Cartwright, *Golden Age: The Story of the Industrialization of South Africa and the Part Played in It by the Corner* (Johannesburg, Purnell: Johannesburg, Purnell, 1968), Theodore Gregory, *Ernest Oppenheimer and the Economic Development of Southern Africa* (Oxford: Oxford University Press Oxford: Oxford University Press, 1962), A Hocking, *Oppenheimer and Son* (Johannesburg: McGraw Hill, 1973), S Jackson, *The Great Barnato* (Cape Town, Penguin: Cape Town, Penguin, 1990), Stanhope Joel and Lloyd Mayer, *Age of Diamonds: The Story of Solomon Barnato Joel* (London: Muller, 1958), Kubicsek, *Economic Imperialism in Theory and Practice: The Case of South African Gold Mining Finance 1886-1914*, Robert I. Rotberg, *The Founder: Cecil Rhodes and the Pursuit of Power* (New York: Oxford University Press, 1988), Edgar Wallace, *Solomon B. Joel, John Bull. [Analytical Entry]* (London: Odhams Press, 1922), Geoffrey Wheatcroft, *The Randlords*, 1st American ed. (New York: Atheneum, 1986). Chandler observed something very similar for US History Alfred Dupont Jnr Chandler, *Visible Hand: The Managerial Revolution in American Business*. (Cambridge, Mass: Belknap Press: Cambridge University Press, 1977), 491.

⁹ Marks and Trapido, "Lord Milner and the South African State," especially 61-4. and Elaine N Katz, "Revisiting the Origins of the Industrial Colour Bar in the Witwatersrand Gold Mining Industry, 1891-1899," *Journal of Southern African Studies* 25, no. 1 (1999). have both explored aspects of this process.

supply of bullion could accommodate. The members of the Gold Standard Defence Association urgently required the South African gold to overcome the chronic shortages of bullion in the US, and the demands of those on both sides of the Atlantic arguing for the inclusion of silver as a monetary standard.¹⁰

In the last quarter of the nineteenth century the international capital markets were based, for the first and the only time in history, on an almost pure form of the gold standard. In the 1870s Bismarck used the indemnity from the Franco-Prussian War to establish a gold-dominated mark, the United States withdrew the greenback bills that had been printed to finance the Civil War, and Russia and Japan introduced the principle of gold conversion for their currencies.¹¹ By the time of the discovery of the Witwatersrand goldfields all the major trading countries had moved onto a formal gold standard that allowed individual citizens to convert bills into gold, removed all restrictions on the international movement of bullion, and established a fixed price for gold in each national currency.

For its advocates the gold standard was the only reliable mechanism for limiting the inflationary effects of printed (or silver) money. It maintained stable international currency exchange levels and encouraged international trade and foreign investment. For the merchant banks in particular, gold had the key ability to protect the relative value of the large international loans that they extended to governments and companies. Most importantly the gold standard offered protection from popular demands to inflate the money supply. A nineteenth century aphorism explained it succinctly: "We have gold, because we can't trust governments."¹²

The City of London was the hub of the international gold standard system, and the main reserve centre for the global capital markets after the major French banks fled the invading German armies in 1871. New York, by the 1890s, was a competing centre for the raising and investing capital. American gold reserves already absorbed 15% of the total gold supply.¹³ Protecting the gold flows between London and New York was one of the preoccupations of JP Morgan and the Rothschilds. After the passing of the Sherman Silver Purchase Act of 1890, the 1893 Baring Crisis (which saw Argentinean debtors defaulting on extravagant British loans), and the growing volume of the American Populists' call to coin silver, investors in London began to withdraw from New York, taking their gold with them. These physical shipments of bullion created severe local shortages of gold, undermining the convertibility of American assets, and threatening the value of the bonds marketed by the merchant banks. In 1895 the two banks persuaded the Democratic President, Grover Cleveland, to issue a special \$65 million US government bond to buy back 3.5 million ounces of the gold that was leaking out of New York.¹⁴ This temporarily eased the gold crisis, but it did little to reduce the danger of an outright Populist victory over the monetary

¹⁰ Interest in the introduction of silver money was not limited to the American side of the Atlantic. The British cabinet also saw merit in the argument, but the City banks certainly did not. Y Cassis, "Bankers in English Society in the Late Nineteenth Century," *Economic History Review* 38, no. 2 (1985): 210. Barry J Eichengreen, *Golden Fetters: The Gold Standard and the Great Depression, 1919-1931* (New York: Oxford University Press, 1992), 54-5.; Ron Chernow, *The House of Morgan: An American Banking Dynasty and the Rise of Modern Finance*, 1st Grove press pbk. ed. (New York: Grove press, 1990), 71-78.; Ally, *Gold & Empire*, 16.

¹¹ Barry Eichengreen, ed., *Gold Standard in Theory and History* (London: Methuen, 1985), 5.

¹² Bruce R Dalgaard, *South Africa's Impact on Britain's Return to Gold, 1925* (New York: Arno Press, 1981), 55.

¹³ Jose Harris, *Private Lives, Public Spirit: Britain 1870-1914. (the Penguin Social History of Britain)* (Harmondsworth: Penguin, 1993), 18. Robert H. Wiebe, *The Search for Order, 1877-1920*, [1st ed., *The Making of America* (New York: Hill and Wang, 1967), 24-5. Eichengreen, *Golden Fetters*, 39, 54-5. For the strategic significance of the London gold market to Britain see Marks and Trapido, "Lord Milner and the South African State," 56-8.

¹⁴ Chernow, *House of Morgan*, 71-5. Wiebe, *Search for Order*, 94, 99.

standard. More than anything else it was Populism that threatened the gold standard system, and the global financial markets in the 1890s.¹⁵

A year later the 1896 Presidential election marked the high-water mark of the Populist challenge to the international gold standard. For the Populist movement the deflationary effects of the withdrawal of the Greenback were the deliberate result of a banking conspiracy, designed by Rothschild in London and implemented by Morgan. They believed, Hofstadter observed, “that those who lived by lending money wanted as high a premium as possible be put on their commodity by increasing its scarcity.”¹⁶ The issues that prompted rural discontent in the South and the West were many and varied: the collapse of the boom market in farm land, the dissolution of rural isolation that coincided with the railroad trusts, the power and sudden local influence of capricious financial markets, the corruption of federal and city government, the unseemly wealth of the new plutocrats. All seemed to hinge on the unnatural, destructive power of gold.¹⁷

In 1896 the Populists abandoned the project of building a third national political party, but they succeeded in making the gold standard the single issue of the election. The Democratic convention rejected Cleveland, the incumbent president, in favour of the leading free-silver advocate William Jennings Bryan. His acceptance speech distilled the vast reform platform of the populist movement to a single issue: the dismantling of the gold standard. “You shall not press upon the brow of labor this crown of thorns,” he concluded famously, “you shall not crucify mankind upon a cross of gold.” When the People’s Party endorsed Bryan the populist movement, as Hofstadter observed, “committed suicide.”¹⁸

Bryan’s opponents in the Republican Party attributed as many noble spiritual qualities to the gold standard as he saw evil ones. For the wealthy and the respectable, Robert Wiebe observed, “gold was the shield of a civilized life; in fact it represented a fixed scheme of things in which all values, epitomized by the intrinsic worth of their dollars, would never change.” J P Morgan, worked hard and spent lavishly to defeat the bimetalists in the election of 1896, bankrolling the Republican Party activists and the McKinley campaign on the specific condition that they would protect the gold standard. In this new politics by cheque-writing he was joined by many of the wealthiest Americans and ushered in to national politics an entirely new kind of political-order. In the presidential campaign, Marc Hanna’s Republican Party was able to out-spend the Democrats by twenty to one, giving McKinley the largest election victory since Reconstruction.¹⁹ Morgan and his allies were rewarded when the new president passed the Gold Standard Act in 1900.

The deflationary period that started with the withdrawal of paper money in 1879 came to an end in the late-1890s, notwithstanding McKinley’s legal commitment to gold, and prices began to increase rapidly. It was this inflationary trend that drew the venom out of rural populism in the United States: corn, wheat and cotton all doubled in value over the next decade.²⁰ And these price increases, in turn, reflected the dramatic expansion of the global supply of new gold, almost half of it coming from the Witwatersrand mines. In 1887 the Witwatersrand had produced little more than one ton of gold; a decade later it was producing 120 tons, or more than a quarter of total world production. Or, as Hennen Jennings, the leading American engineer on the ‘Rand in the late 1890s (many of the others

¹⁵ Eichengreen, *Golden Fetters*, 39.

¹⁶ Richard Hofstadter, *The Age of Reform: From Bryan to Fdr* (New York: Alfred A Knopf, 1956), 74.

¹⁷ *Ibid.*, 56, Wiebe, *Search for Order*, 47.

¹⁸ Hofstadter, *Age of Reform*, 107.

¹⁹ Wiebe, *Search for Order*, 104. Chernow, *House of Morgan*, 77.

²⁰ Hofstadter, *Age of Reform*, 110.

were in prison), put it: “In 1887 the total gold output of the world was about \$107,000,000, while for 1914 the output of the Rand alone was in the neighborhood of \$165,000,000, and of the world, \$455,000,000.”²¹

Corporate Capitalism

The engineers who arrived on the Witwatersrand were the bearers of the new form of industrial organisation that had revolutionized the American economy in the previous half-century. American businesses, as Alfred Chandler’s famous study of the corporation shows, underwent revolutionary reorganisation in the middle of the 19th century. Up to the 1840s capitalism was a merchant enterprise, and the typical merchant capitalist conducted business “in much the same manner as it had been done in fourteenth century Venice or Florence.”²² In the decades that followed American businesses changed very rapidly. The primary agents of this transformation, as Chandler shows, were the railroad companies and the financial markets that invested in them. If mining companies in the United States played any role at all in the development of the corporation (aside from providing the iron and anthracite required by the new heavy industries), it was as the stubborn opponents of the new forms of industrial efficiency.²³ In South Africa, American mining engineers constructed businesses that were modelled on the new corporations, with one key difference: the South African companies were organised exclusively around gold production, and the engineers failed in their efforts to encourage the development of consumer capitalism.

In the US, the development of the corporation had its roots in the expansion of domestic agriculture. The abolition of the Corn Laws in Britain in 1846, and the growth of immigrant-peopled cities on the East Coast, created a bull market for American farm products which, in turn, rewarded the mechanisation of agriculture. (The machines here were mowers, threshers and seeders, not tractors.) In the 1860s the United States abandoned the free-trade policies fitted to an economy based on slave-labour and the export of commodities, and began to foster domestic industrialisation. The new Republican policy worked directly through the use of federal tariffs on manufactured goods, and generous federal subsidies for the continental railroads; and indirectly through the Homestead and Pre-emption Acts, which effectively offered farmers in the West free land.²⁴ It was this growing continental economy, and the market for commodities and machinery, that fed the expanding railroad companies, which, in turn, encouraged new financiers to invest in them.

The most important difference between the corporation and the entrepreneurial firms of the early 19th century was the separation of ownership and management. This distinction was particularly acute in the railroad business, where the amounts of capital required were simply unprecedented and beyond the investment capacity of even the wealthiest individuals. These enterprises found a source of capital after the establishment of the bond markets in New York in the 1850s. An almost endless string of American railroad bonds, marketed by a small but powerful group of New York bankers, attracted European investors looking to escape the turmoil of the 1848 Revolution. German, French and British

²¹ T. A. Rickard, *Interviews with Mining Engineers* (San Francisco: Mining and Scientific Press, 1922), 245. Ally, *Gold & Empire*, 13, Eichengreen, *Golden Fetters*, 54-5.

²² Chandler, *Visible Hand*, 37.

²³ Ibid., 242, Carter Goodrich, *The Miner's Freedom, a Study of the Working Life in a Changing Industry* (Boston: Marshall Jones company, 1925).

²⁴ James Livingston, *Pragmatism and the Political Economy of Cultural Revolution, 1850-1940, Cultural Studies of the United States* (Chapel Hill: University of North Carolina Press, 1994), 25-33.

investors invested over a billion dollars in these markets before 1860, and by the 1880s the figure for British investors alone had reached two billion dollars. It was these railroad bonds that established both the instruments and the volumes of the modern stock market; henceforth to serve as the oracle of corporate capitalism.²⁵

By virtue of their geographical scale, the speed of the trains, the varieties of cargo, and the complexity of line connections, American railroads confronted managerial problems that were vastly more difficult than any previous enterprise. In the first instance, the scale of operations required a separation of local and central authority; decisions about traffic on the rails had to be “controlled from a single headquarters if only to prevent accidents.”²⁶ This divisional separation of management, and the hierarchy that followed it of line, middle and top managers, established the basic managerial structure of the modern corporation by the 1850s.

The railroad corporations also adopted a string of administrative reforms that changed the character of the overall economy. Most famously, standardization (and the meticulous cooperative discussions that produces it) became a survival imperative. In the 1880s the companies agreed, after much tortuous negotiation, on a single rail gauge across the entire system, a set of nationally demarcated time zones, legally stipulated equipment specifications, and a state-sanctioned accounting system. Of course, English economic historians would hasten to point out that serious effort to establish standardization predates the 1880s by about half a century, but the problems of time and place that confronted the American railroads were unprecedented, and they have equipped standards-making ever since with global ambitions.²⁷ Amongst the most revolutionary consequences of this process were the precision of freight-handling and the standardization of paperwork that underpinned the efficiencies of a new kind of market. “By the 1870s the fast-freight lines were guaranteeing the accuracy of the quantity listed on the waybill,” Chandler observed: “With such guarantees those bills quickly achieved the status of negotiable commercial paper and became used as a regular medium of exchange.”²⁸

An immediate benefit of this standardization process was the production of system-wide statistics that by the 1860s had become the primary tool of corporate management. Under continuous pressure from absent bondholders to improve profitability, managers gathered statistics on every aspect of railroad operations in their pursuit of efficiencies. By the 1870s statistics had become the control language of the corporation, and every division of the railroad enterprise was being measured against a new basic unit of operating cost: the ton-mile—the cost of moving a single ton of cargo along a mile of track.²⁹ Statistically derived per unit costs was the special preoccupation of the American engineers on the Witwatersrand: their basic unit was cost per ton of ore crushed, but they were concerned, also, given the variations in the amount of gold present in the rock, with the yields per ton of ore at each mine. In their efforts to lower these costs, they gathered data voraciously on contributing expenses—like the cost, per African worker, of the faulty recruitment system. But their central complaint, by the late 1890s, was the inflated cost per ton-mile of transport

²⁵ Chandler, *Visible Hand*, 87-91. Wiebe, *Search for Order*, 24-5.

²⁶ Chandler, *Visible Hand*, 81.

²⁷ *Ibid.*, 116, D Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe From* (Cambridge: Cambridge University Press, 1969), 107. Geoffrey Bowker and Susan Leigh Starr, *Sorting Things Out: Classification and Its Consequences*. (Cambridge, MA: MIT Press, 1999).

²⁸ Chandler, *Visible Hand*, 129.

²⁹ *Ibid.*, 109, 16.

on the Netherlands-South African Railway (NZASM), a railroad company that seemed deliberately to violate every rule of the American corporation.³⁰

Unlike the NZASM (which operated as a state-protected monopoly), American railroad companies were caught between ferocious competition and the power of the bankers who sold their bonds.³¹ By the 1870s the financial stakes were very high, and the pressure to find a solution to the problem of route competition intense. The systemic remedy to the problem of competition was a massive expansion in the territory of railroad operations and, by logical extension, the scale (the number of customers) and scope (the number of products) of corporate business. Between 1868 and 1871 the Pennsylvania Railroad (the first of the new systems) grew from a regional road with 500 miles of track, to a continental network of nearly 6000 miles; the company bought mining and steel companies as well as competing railroads in the effort to defend its carrying capacity. In the process the Pennsylvania set a new standard for the raising of capital, issuing \$87 million in bonds over the five year period: “No other private enterprise in the United States had ever raised so much capital so quickly.”³²

After J P Morgan took control of the bond issues of the Pennsylvania Railroad, in 1871, he became the architect of the movement towards the incorporation of American.³³ It was Morgan more than any other individual who redesigned American businesses in the last quarter of the 19th century, solving the problem of competition (and surplus production) by constructing massive, vertically integrated, corporations: the large railroad systems, General Electric, AT&T, US Steel.³⁴ Soon after the turn of the century, this view of competition, and the move to incorporation had become hegemonic; by 1905 hundreds of new corporations employed over seventy percent of the workforce and absorbed over 80 percent of the capital.³⁵ Corporate capitalism was firmly established in the United States by the first decade of the twentieth century.

The Science of Mining

Engineers played key roles in the emergence of the American corporation. In the nineteenth century, the men Chandler describes as the “pioneers of modern management”--the individuals who invented the key instruments of railroad management--were all civil engineers who had learned their management practice as railroad and bridge builders.³⁶ David Noble has traced an even more intimate bond between the modern corporation and engineering. The engineer, Noble shows, sought to “present himself as ‘technology’ itself,” and, in doing so, he merged himself with the corporation “for that too was technology, as much a part of him as he was of it.”³⁷ The relationship between the modern corporation and the engineering professions is clearly an intimate and affectionate one.

³⁰ See Leggett’s testimony in Witwatersrand Chamber of Mines, *The Mining Industry, Evidence and Report of the Industrial Commission of Enquiry, with an Appendix* (Johannesburg: Chamber of Mines, 1897), 241-51.

³¹ Chandler, *Visible Hand*, 148.

³² *Ibid.*, 151-3, 55.

³³ *Ibid.*, 155. Wiebe, *Search for Order*, 186.

³⁴ Chandler, *Visible Hand*, 426, 202, David F Noble, *America by Design: Science, Technology and the Rise of Corporate Capitalism* (Oxford: Oxford University Press Oxford: Oxford University Press, 1977), 9-12, Wiebe, *Search for Order*, 187. Chernow, *House of Morgan*, 83-86.

³⁵ Livingston, *Pragmatism and the Political Economy of Cultural Revolution, 1850-1940*, 99.

³⁶ Chandler, *Visible Hand*, 95.

³⁷ Noble, *America by Design: Science, Technology and the Rise of Corporate Capitalism*, 44.

Mining engineers have been given only bit-parts in this story. For Chandler, mining “involved little more than having small teams of men doing much the same thing in different parts of the mine.”³⁸ And in Noble’s study mining engineers attracted barely a sentence; they were small in number, bad at professionalisation, and more interested in making money than they were in building scientific corporations. Even those who have made a specialisation of mining history have dismissed American mining as conservative and imitative. There is some truth to this assessment; mining did not lend itself to Taylor’s factory system with much ease. This resistance was most eloquently captured by Goodrich’s 1925 study of the *Miner’s Freedom*, which emphasized the physical isolation of mine work and the enduring importance of violence underground.³⁹

Yet all of these studies have ignored the fact that the most ambitious mining projects were located outside of the United States, and many drew upon American engineers. Progressive mining engineers, much more than the other professional engineers, were missionaries of American corporate methods outside of the United States. With the single exception of Herbert Hoover, who managed gold mines in western Australia and coal mines in China, all the dominant figures of this international mining fraternity found their way to the Witwatersrand in the 1890s.⁴⁰ (Hoover visited Johannesburg but never worked there.) The expertise that they carried with them was well fitted to the development of the new mining corporations.

With few exceptions these engineers were the bearers of a professional status that derived, in part, from specialist university training: the architect of the Gold Fields corporation, John Hays Hammond, trained in mining engineering at the special school at Freiberg; Hennen Jennings, the Rand Mines consulting engineer, studied science at Harvard; Gardner Williams, manager of the De Beers’ Kimberley mines, studied at the University of California. But some of the dominant engineers had no university education at all: Hamilton Smith and Henry C Perkins, the deans of the American engineers, had started mining directly after leaving school.

Even those who had no university education brought a familiarity with science to the work of mining that was absent on the Rand. “Although largely self-educated, his scholarly book on hydraulics,” Hennen Jennings observed of Hamilton Smith “showed that he was a master in theoretical mathematics.”⁴¹ Their training and interest in metallurgy and geology set them apart from the local managers, like Merriman, Philips, Eckstein, Fitzpatrick and, later, Oppenheimer, who had no university training; what little the local men knew about gold mining they had learned from transport riding or sorting diamonds.⁴² Some of this identification with science was, no doubt, unmerited, but the engineers wore the mantle of the widespread adoption of applied science in American industries and universities in the 1880s. “It was the American universities that took engineering away from rule-of-thumb

³⁸ Chandler, *Visible Hand*, 242.

³⁹ Roger Burt, “Innovation or Imitation? Technological Dependency in the American Nonferrous Mining Industry,” *Technology and Culture* 41 (2000), Goodrich, *The Miner’s Freedom, a Study of the Working Life in a Changing Industry*, Noble, *America by Design: Science, Technology and the Rise of Corporate Capitalism*, 36.

⁴⁰ Clark C. Spence, *Mining Engineers & the American West; the Lace-Boot Brigade, 1849-1933*, *Yale Western Americana Series*, 22 (New Haven; Yale University Press, 1970), 23.

⁴¹ Rickard, *Interviews with Mining Engineers*, 226.

⁴² Phyllis Lewsen, *John X Merriman: Paradoxical South African Statesmen* (New Haven: Yale University Press: New Haven: Yale University Press University Press, 1982), 12-3, 31-41. Andrew Duminy and Bill Guest, *Interfering in Politics: A Biography of Sir Percy Fitzpatrick* (Johannesburg: Lowry Publishers, 1987). Maryna Fraser and Alan Jeeves, *All That Glittered: Selected Correspondence of Lionel Phillips, 1890-1924* (Cape Town: Oxford University Press, 1977), 4.

surveyors, mechanics, and Cornish foremen,” Hoover remarked late in his life, “and lifted it into the realm of application of science.”⁴³

Another key part of the American engineers’ work was their status as expert commentators, both within the companies that employed them and, far more importantly, in the public domain that informed the stock markets. This expert testimony had a long history in the United States, where consulting engineers had, for decades, routinely investigated the investment potential of thousands of individual mines on behalf of merchant banks in New York. The peculiar “apex” mining law in the US, which granted underground mineral rights to the owner of the land on which reef outcrops appeared, added to the expert practice of the mining engineers: they were continuously called to appear as scientific authorities in disputes between property owners over the continuity of reef. The frequency, and importance, of this “experting” work, encouraged American engineers “keep abreast of the latest scientific writing and to think in broad terms.”⁴⁴

Like American methods in general, the mining engineers arrived on the Rand as the bearers of the new ideology of efficiency. According to Hoover the management of mine labour could be summed up by that one word.⁴⁵ In the reports written in the Transvaal, as much as in their professional journals, the engineers made no specific mention of Taylor, or his systems, but they certainly sought to impose the components of scientific management; Jennings explained to the Mining Industry Commission in 1897, “contracts, piece-work, bonus-systems and uniformity in accounts should be encouraged.”⁴⁶ Following the earlier innovations of the railroad companies, the engineers insisted that a key part of the search for efficiency was the compilation of detailed, and standardized, financial reports on every aspect of the workings of mines. And it was these uniform accounts that allowed the generation of the vast store of statistical information that has subsequently become the keystone of mine management in South Africa. This, perhaps more than anything else, was the special contribution of engineers like Jennings and Leggett, who worked to gather and standardize the first industry wide statistics.⁴⁷

The engineers on the Rand were selected because of their mastery of the technologies of mining. Officials and mining advocates in the late 1890s habitually used the phrase the “most perfect machinery” to describe the technical conditions on the goldfields, and they had in mind the thousands of stamp mills, hoists, rock-drills, flotation systems and electrical plant that were purchased by the American engineers over the previous decade. The great bulk of this heavy equipment was purchased from American manufacturers: electric mine shaft hoists from General Electric, rock-drills from Ingersoll-Sergeant, and stamp-mills from producers across the continent. (American exports to South Africa were valued at \$16 million in 1899, and \$30 million in 1903).⁴⁸

⁴³ Edwin T. Layton, *The Revolt of the Engineers; Social Responsibility and the American Engineering Profession* (Cleveland; Press of Case Western Reserve University, 1971), 3. Hoover cited in Spence, *Mining Engineers & the American West; the Lace-Boot Brigade, 1849-1933*, 15-6.

⁴⁴ Spence, *Mining Engineers & the American West; the Lace-Boot Brigade, 1849-1933*, 196-200, 27.

⁴⁵ *Ibid.*, 168.

⁴⁶ Chamber of Mines, *The Mining Industry, Evidence and Report of the Industrial Commission of Enquiry, with an Appendix*.

⁴⁷ *Ibid.*, 195-225, Rickard, *Interviews with Mining Engineers*, 248.

⁴⁸ Thomas J. Noer, *Briton, Boer, and Yankee : The United States and South Africa, 1870-1914* (Kent, Ohio: Kent State University Press, 1978), 73, .

Effects and Consequences

We can trace the political results of the work on the Witwatersrand of these mining engineers in three areas: the establishment of the great mining corporations, the shaping of South African law, especially after 1902, and the fashioning of an Anglo-American progressive consensus that the South African Republic had lost its right of sovereignty because of its inefficiency and corruption. In each case, the story of the work of the progressive engineers is much longer than I have time to tell now; bullet points must suffice.

It was in the 1890s that the system of partnerships that had dominated Kimberley and the diamond trade gave way to the formation of mining corporations. Unlike the partnerships of Werner, Beit Company or Porges and Company, these businesses were legally immortal, they were run by professional, salaried managers, and they quickly developed an autonomous economic interest that often ran counter to the interests of their founding shareholders. It is this corporate autonomy, which was usually closely focused on the building of profitable businesses inside South Africa, that accounts for the relative insignificance of the major Randlords efforts to withdraw their assets from South Africa after 1907. It also implies that historians should turn away from descriptions of the interests of capital, or fractions of capital, to an attention to the specific intellectual and economic preoccupations of these corporations and the professional managers who guided them.

A striking feature of the legal order that the Milner administration implemented in the Transvaal between October 1900 and May 1901 was a preoccupation with three laws of the old Republic: the Gold Law, Liquor Law and the Pass Law. It was in the effort effectively to police these three pillars of the South African state that Sir Edward Henry, later the Commissioner of the Metropolitan Police, established a centralized Criminal Investigation Department and regional police stations. The long term consequences of this policing architecture are still being felt in South Africa today, but what has not been remembered is that the three laws were drafted by the mining industry after 1897, on the specific advice of the American mining engineers.

In the last years of the 1890s, the basis of what the Colonial Office called the "Case against the Transvaal" turned increasingly to the inefficiencies and corruption charges that were posed by the leading figures of the mining industry. In this argument, Chamberlain and Milner deployed a political philosophy that was derived from the politics of the progressive movement in America. (Chamberlain's enthusiasm for the theorists of the progressive era, and Milner's interest in city reform can be properly demonstrated.) This suggests that we should understand the South African War not, as Searle has suggested, as the precipitating event of the English crisis of national efficiency, but rather as the culmination of an Anglo-American political movement of progressive reform.

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The Progressive Miners of America (PMA, renamed the Progressive Mine Workers of America, PMWA, in 1938) was a coal miners' union organized in 1932 in downstate Illinois. It was formed in response to a 1932 contract proposal negotiated by United Mine Workers President John L. Lewis, which reduced wages from a previous rate of \$6.10 per day to \$5.00 per day. The union was dissolved in 1999, after decades of discontent by members. YouTube Encyclopedic. American Progressives, like their counterparts in the Green Sections of Not-America, sought government solutions to social problems. But many Progressives wanted actual policy made by experts who knew what was best for the people, not the people themselves. Carver was the only African-American in the United States with an advanced degree in scientific agriculture. Carver joined the faculty in 1896 where he remained for the rest of his life as both a teacher and researcher. He was the head of the Institute's Agricultural Experiment Station. The daughter of the first African-American motorman to work for the New York City subway system and a domestic worker mother who saved her money for her children's education, Patricia was born in 1942 in Harlem, New York. Patricia's interest in science became evident at an early age and her mother bought her a chemistry set. South Africa's mining industry is increasingly making use of innovative and cutting-edge technologies to run more efficient operations... The report "The state of digital transformation in the South African mining industry" was compiled with the aim of gaining an understanding of how the mining industry visualises the impact of the Fourth Industrial Revolution (4IR) on its people, processes and technologies; how they perceive the evolution of 4IR on their businesses in the years to come; and what steps they.