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Sustainability and Shared Value in the Interwar Swedish Copper Industry

This study of the Swedish-based mining company Boliden examines the proactive strategies it adopted to deal with the potential for severe environmental problems associated with the establishment of its large copper smelter in the 1920s. The article demonstrates how international networks, personal experience, and knowledge transfer from the U.S. copper industry help to explain the importance given to environmental issues by the Swedish industrialists. It is suggested that the main explanation for the proactive stance of the Swedish managers is that they perceived excessive pollution as working against creating a profitable and sustainable business. This case provides compelling evidence that firms pursuing an agenda focused on earning profits can still deliver environmental innovation and value to the local community, compatible with the concept of creating shared value.

The Swedish mining company that was to become known as Boliden began to operate its first copper smelter, equipped with state-of-the-art environmental technology, in 1929. From the outset of the project, Boliden was aware of the immense risks associated with both the expected emissions of arsenic and sulfur and the disposal of these substances. The smelter was therefore furnished with Europe's tallest smokestack and the latest in U.S. smoke abatement technology—the Cottrell Precipitator—as well as other technologies developed in-house by Boliden.[1] To minimize smoke damage to cropland and forests, the smelter had been located on the coastline, about thirty miles from the mine. Moreover, these investments and considerations were made before the emergence

[1] The Cottrell precipitator was one of the most important new pollution-control technologies of the early twentieth century. It could clean an array of particulate pollutants from smoke produced by a wide variety of industrial processes. See Timothy J. LeCain, "The Limits of 'Eco-Efficiency': Arsenic Pollution and the Cottrell Electrical Precipitator in the U.S. Copper Smelting Industry," *Environmental History* 5, no 3 (2000).

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of any serious pollution problems and in the absence of social protests, litigation, or regulatory pressure. As such, these proactive corporate strategies appear to conflict with the widely held view of the environmental strategies of firms during this period, which stresses that such strategies were defensive responses to external forces.[2] This prevalent view rests heavily on evidence from the United States. Our study provides a contrast by exploring such strategies in a European country—specifically, why proactive strategies were adopted by Boliden.

Business historians such as Christine Meisner Rosen have argued for nearly two decades that environmental issues have been of greater importance to business than is usually acknowledged.[3] Yet, the emergence of corporate environmental policies has remained a fairly under-researched field in business history, especially in a non-U.S. context.[4] The research that has been published identifies regulatory pressures as the primary driver behind corporate environmental strategies.[5] This is consistent with a view that companies have usually perceived purification measures as a cost only, which in turn has made regulation necessary to put pressure on companies to take action. The relationship between environmental goals and industrial competitiveness has often been thought of as a trade-off, not the least within the neoclassical paradigm. However, as Michael E. Porter and Mark R. Kramer argue in their recently introduced concept of creating shared value (CSV), corporate strategies to avoid social harms including pollution does not mean that profits are not maximized. Instead they suggest that addressing social issues can lead firms to innovate and pursue cost-saving paths. The aspiration of the CSV concept is that managers viewing the corporation as socially embedded will actively uncover the potential for value creation for all stakeholders,

[2] On defensive strategies, see, for example, Craig E. Colten and Peter N. Skinner, *The Road to Love Canal: Managing Industrial Waste before EPA* (Austin, Tex., 1996); Gerald Markowitz and David Rosner, *Deceit and Denial: The Deadly Politics of Industrial Pollution* (Berkeley, 2002); and Benjamin Ross and Steven Amter, *The Polluters: The Making of Our Chemically Altered Environment* (Oxford, 2010).

[3] For a good summary of this argument, see Christine Meisner Rosen and Christopher C. Sellers, "The Nature of the Firm: Towards an Ecocultural History of Business," *Business History Review* 73, no. 4 (1999): 577–600.

[4] For a recent overview of business historical research in the field, see Geoffrey Jones and Christina Lubinski, "Making 'Green Giants': Environmental Sustainability in the German Chemical Industry, 1950s–1980s," *Business History* 56, no. 4 (2014): 623–49.

[5] See, for example, Christine Meisner Rosen, "Businessmen Against Pollution in Late Nineteenth Century Chicago," *Business History Review* 69, no. 3 (1995): 351–97; Christine Meisner Rosen, "The Role of Pollution Regulation and Litigation in the Development of the U.S. Meat Packing Industry," *Enterprise & Society* 8, no. 2 (2007): 297–347; Frank Uekoetter, "Divergent Responses to Identical Problems: Businessmen and the Smoke Nuisance in Germany and the United States," *Business History Review* 73, no. 4 (1999): 641–76; and Hugh S. Gorman, *Redefining Efficiency: Pollution Concerns, Regulatory Mechanisms, and Technological Change in the U.S. Petroleum Industry* (Akron, Ohio, 2001).

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in order to remain competitive and secure organizational longevity.[6] Proactive business strategies should, according to Porter and Kramer, be adopted to avoid negative externalities such as pollution. As Porter and Kramer argue,

> Efforts to minimize pollution were once thought to inevitably increase business costs—and to occur only because of regulation and taxes. Today there is a growing consensus that major improvements in environmental performance can often be achieved with better technology at nominal incremental cost and can even yield net cost savings through enhanced resource utilization, process efficiency, and quality.[7]

The jury is still out as to whether, in the contemporary context, the aspiration to create shared value can become a reality. However, history can provide some useful empirical evidence. As is well known, stakeholder concepts of capitalism were widespread before the 1970s, even in the United States. Robert Strand and R. Edward Freeman have explicitly observed that the CSV model resembles many long-established practices in Scandinavian business.[8] Business history research supports this view.[9] The case of Boliden provides an opportunity to explore the mechanisms at work in depth. The proactive strategies adopted by Boliden might be related to a belief that preventing environmental damage was actually good for business because it avoided negative outcomes for the company's local stakeholders. Indeed, cooperation between companies and their stakeholders is widely seen as a long-standing practice in Nordic business.

A related stream of research has explored the historical development of corporate social responsibility (CSR). This concept has gained attention within business history, not least because of the resonance of some historical debates to contemporary debates on the role of business in society.[10] Archie Carroll et al., who examined the history of CSR in U.S. business, suggest that the reasons for firms to "do good" had to do with

[6] Michael E. Porter and Mark R. Kramer, "Creating Shared Value," *Harvard Business Review*, Jan.–Feb. 2011, 1–17.

[7] Ibid., 9.

[8] Robert Strand and R. Edward Freeman, "Scandinavian Cooperative Advantage: The Theory and Practice of Stakeholder Engagement in Scandinavia," *Journal of Business Ethics* 127, no. 1 (2015): 65–85.

[9] Susanna Fellman, Martin Jes Iversen, Hans Sjögren, and Lars Thue, *Creating Nordic Capitalism: The Business History of a Competitive Periphery* (New York, 2008).

[10] See, for example, Archie B. Carroll, "A History of Social Corporate Responsibility: Concepts and Practices," in *The Oxford Handbook of Corporate Social Responsibility*, ed. Andrew Crane, Abagail McWilliams, Dirk Matten, Jeremy Moon, and Donald S. Siegel (Oxford, 2009), 19–46; and Keetie Sluyterman, "Corporate Social Responsibility of Dutch Entrepreneurs in the Twentieth Century," *Enterprise & Society* 13, no. 2 (2013): 313–49.

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legal compliance, response to demands from various pressure groups, and actions based on self-interest.[11] In studying more broadly the history of concepts of responsibility in a global perspective, Geoffrey Jones looks beyond national characteristics and identifies four factors that seem to have driven a belief that corporations have responsibilities beyond making money for their owners. The first factor is spirituality or, essentially, religious beliefs; the second relates to self-interest, in securing legitimacy and a good reputation; and the last two factors are related to government: fear of government intervention as well as frustration over governments' incapability to deal with major social and environmental issues.[12]

Historical research into the copper industry in the nineteenth and early twentieth centuries provides several examples of a reluctant industry that has dealt with pollution issues as a cause of external pressure. Examining primarily the American experience, Donald Macmillan, Duncan Maysilles, Timothy J. LeCain, and others have shown that it was social protests, litigation, and regulation that forced the industry to undertake measures to abate emissions, including developing new technologies.[13] One of the most clearly illustrative examples from the United States is that of the Anaconda Company. Environmental destruction and the conflicts caused by the smoke from Anaconda's smelter prompted President Theodore Roosevelt to create the Anaconda Smelter Smoke Commission (1911–1920), with the directive to suggest measures that the company should undertake to address the smoke issue.[14] Lawsuits against the copper industry were simultaneously taking place in Ducktown, Tennessee, leading to the U.S. Supreme Court's first verdict in an air-pollution case, in 1907.[15] Further litigation was also going on in the copper districts of California and Utah.[16] As shown by LeCain and others, the conflicts and court cases, which eventually led to regulations, forced the U.S. copper producers to cut their emissions of sulfur and arsenic significantly. Although the pollution

[11] Archie B. Carroll, Kenneth J. Lipartito, James E. Post, and Patricia H. Werhane, *Corporate Responsibility: The American Experience* (New York, 2012).

[12] Geoffrey Jones, "Debating the Responsibility of Capitalism in Historical and Global Perspective." HBS Working Paper 14-004 (Harvard Business School, Boston, Mass., 2013).

[13] Donald MacMillan, *Smoke Wars: Anaconda Copper, Montana Air Pollution, and the Courts, 1890–1924* (Springfield, Ill., 2000); Duncan Maysilles, *Ducktown Smoke: The Fight over One of the South's Greatest Environmental Disasters* (Chapel Hill, N.C., 2011); Timothy J. LeCain, *Mass Destruction: The Men and Giant Mines That Wired America and Scarred the Planet* (New Brunswick, N.J., 2009); Fredric Lincoln Quivik, "Smoke and Tailings: An Environmental History of Copper Smelting Technologies in Montana, 1880–1930" (PhD diss., University of Pennsylvania, 1998).

[14] MacMillan, *Smoke Wars*, chap. 8; LeCain, "Limits of 'Eco-Efficiency,'" 341.

[15] Maysilles, *Ducktown Smoke*.

[16] LeCain, *Mass Destruction*, 75–76.

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problems were far from being solved, the pollution issue had emerged as an issue that constrained managerial decisions in the highly polluting copper industry.

Prior to the Boliden project, Sweden had not experienced anything resembling the severe environmental destruction that had taken place in the U.S. copper districts in the early 1900s. Nor had the comparatively small Swedish cities experienced smoke-pollution problems comparable to cities like Detroit, Pittsburgh, or London.[17] This meant that Sweden had seen no environmentally related litigations resembling those in the United States. Instead, conflicts and a political debate emerged in Sweden during the early 1900s, essentially because of a growing number of pulp and paper mills causing odors and visible water pollution.[18] In 1909, the Swedish government appointed a committee that in 1915 suggested a regulatory framework for air- and water-pollution control through a mandatory concession system.[19] In the Swedish case, though, the deep economic recession of the early 1920s came to downplay concerns over industrial pollution and the Swedish government declined the proposition, arguing that the new legislation would endanger the competitiveness of the country's industry. The legal frameworks of the interwar period were therefore built on regulations already established in the second half of the nineteenth century. The most important of these regulations was the Public Health Act of 1874, which constituted the first governmental "all-embracing" attempt to address sanitary issues, which to some degree included industrial pollution.[20] Also, a case law practice had evolved (*Imissionsrätten*) that made it possible for a private person to sue any neighbor, including a company, for damage to private property caused by "nuisances."[21]

The fact that the legislative and political pressure on air-pollution control in Sweden during the 1920s and 1930s was weak, or even nonexistent, shows that the proactive strategies were not responses to regulation as such. Essentially there was no legislation limiting smoke damage

[17] Frank Uekoetter, *The Age of Smoke: Environmental Policy in Germany and the United States, 1880–1970* (Pittsburgh, 2009); Rosen, "Businessmen Against Pollution," 351–97; Peter Brimblecombe, *The Big Smoke: A History of Air Pollution in London since Medieval Times* (London, 1987).

[18] Lars J. Lundgren, *Vattenförorening: Debatten i Sverige 1890–1921* (Lund, Sweden, 1974); Kristina Söderholm and Ann-Kristin Bergquist, "Firm Collaboration and Environmental Adaptation: The Case of the Swedish Pulp and Paper Industry, 1900–1990," *Scandinavian Economic History Review* 60, no. 2 (2012): 183–211.

[19] Söderholm and Bergquist, "Firm Collaboration," 190–91.

[20] Ibid. The law was a tool for the municipal boards, whose expertise on industrial issues was limited. Another central regulation was the Water Rights Ordinance of 1880, the first general regulation in Sweden specifically addressing water pollution.

[21] Staffan Westerlund, *Miljöskyddslagstiftning och Välfärd* [Water pollution: The debate in Sweden, 1890–1921] (Stockholm, 1971), 23.

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and holding a polluting company responsible to a supervising government body. Still, the potential damage to property, particularly forests, could potentially have been costly for Boliden. The Swedish legal framework had a long tradition and was directly linked to private property rights. Still, legal frameworks do not act. Similar regulation in the United States did not bring about a proactive strategy in the American industry. It is therefore necessary to look closer at the Boliden case to uncover all relevant aspects behind the attempts by Boliden to limit smoke damage.

Copper Smoke and Early Abatement Technologies

Even by the standards of the Industrial Revolution, the copper industry was notorious for the highly toxic nature of its emissions. Sulfides are the most plentiful copper ores on Earth, and the toxicity of the smoke from copper smelters is related to geology and the different molecular bonds in the specific ore. As indicated by the name, sulfide ores contain sulfur. In addition, the economically valuable sulfide ores also contain metals and half-metals such as gold, silver, iron, arsenic, nickel, silicon, mercury, and lead.[22] At the different stages in the refining process of these metals, compounds of sulfur, arsenic, or other toxic substances are released. In Britain, copper smoke had already emerged as a political issue by the eighteenth century.[23] In Wales, the concentration of copper smelters, especially in the area of Swansea, created environmental, legal, and technical problems worse than any smelter district had experienced before.[24] Yet, as argued by Edmund Newell, although Britain had seen many pollution-related court cases, especially in Wales, the copper smoke prompted only minor constraints to its business activities before the copper industry declined in the early twentieth century.[25]

[22] Copper ores can be divided into three major categories: primary (sulfide) ores, altered secondary (sulfide, carbonate, oxide, and silicate) ores, and native (pure metallic) copper. See Christopher J. Schmitz, "The World Copper Industry: Geology, Mining Techniques and Corporate Growth, 1870–1939," *Journal of European Economic History* 29, no. 1 (2000): 77–78.

[23] Edmund Newell, "Atmospheric Pollution and the British Copper Industry, 1690–1920," *Technology and Culture* 38, no. 3 (1997): 655–98; Mark Wilde, "Nuisance Law in Industrial Wales: Local and National Conflicts (Part One): Copper Smelting in a Pre-regulatory Era," in *Environmental Law and Policy in Wales: Responding to Local and Global Challenges*, ed. Patrick Bishop and Mark Stallworthy (Cornwall, U.K., 2013), 25–42.

[24] Bode J. Morin, *The Legacy of Copper Smelting: Industrial Heritage vs. Environmental Policy* (Knoxville, Tenn., 2013), 7.

[25] Newell, "Atmospheric Pollution," 687. See also Edmund Newell and Simon Watts, "The Environmental Impact of Industrialisation in South Wales in the Nineteenth Century: 'Copper Smoke' and the Llanelli Copper Company," *Environment and History* 2, no. 3 (1996): 309–60.

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The global demand for copper skyrocketed in the 1880s with the rapid development of electricity and electrical applications, especially in the United States.[26] After an earlier dominance by British enterprises, German and especially U.S. firms came to dominate the global copper markets until well after World War II.[27] In the 1880s, the American Butte producers, led by the Anaconda and Boston & Montana firms, emerged as the world market leaders.[28] In 1911, the world market was dominated by giant American groups such as Phelps Dodge and the United Metals Selling Co. group including Anaconda-Amalgamated; the Lake mines; the Arizona Copper Co.; Greene-Cananea; and the American Smelting and Refining Co. (ASARCO). Operations in other major copper-producing regions such as Germany, Chile, Australia, and Japan were smaller in scale than their American counterparts.[29] Consequently conflicts and litigations related to smoke from the copper smelters are found in the U.S. copper districts, in tandem with the emergence of large-scale smelting production.

Litigations in the United States from the late 1890s to the interwar period spurred technical development aimed at reducing both sulfur and arsenic emissions. One of the worst methods still in use during the early 1900s was the roasting of ore in open pits, where the ore was simply piled with logs. The ore burned for days, releasing huge clouds of arsenic oxide and sulfur dioxide (SO_2) into the air.[30] The deaths in Deer Dodge Valley of thousands of horses and cows, apparently poisoned by arsenic, spurred the first comprehensive litigation against the Anaconda Company.[31] The development of technologies and practices causing less environmental damage included roasting ores in furnaces from which the fumes were emitted though a central—and, preferably, *very* tall—smokestack. One of the first methods of lowering SO_2 emissions was to capture the sulfurous material in the copper smoke and convert it into sulfur acid.[32] The so-called Gerstenhöfer roasting furnace (sometimes known as the Gerstenhöfer calciner), which condensed the acid gas and converted it into sulfuric acid, had been

[26] Ferdinand E. Banks, *The World Copper Market: An Economic Analysis* (Cambridge, Mass., 1974), 7.

[27] Alfred D. Chandler, "The United States," in *Big Business and the Wealth of Nations*, ed. Alfred D. Chandler, Franco Amatori, and Takashi Hikino (Cambridge, U.K. and New York, 1997), 68.

[28] Christopher J. Schmitz, "The Rise of Big Business in the World Copper Industry, 1870–1930," *Economic History Review*, 2nd ser., 39, no. 3 (1986): 395.

[29] Ibid., 393. Together these corporations controlled 74 percent of the world's refining in 1921.

[30] LeCain, *Mass Destruction*, 68. In Ducktown, the heaps could burn for up to three months, causing enormous discharges of sulfur dioxide. Maysilles, *Ducktown Smoke*, 41.

[31] McMillan, *Smoke Wars*, chap. 8; LeCain, "Limits of 'Eco-Efficiency,'" 340–341.

[32] Maysilles, *Ducktown Smoke*, 153.

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introduced in Germany and Britain in the 1860s.[33] The economic impact of pollution was clearly demonstrated in the United States when about four hundred Utah farmers successfully sued ASARCO, a company that at the time was controlled by Guggenheim Brothers. One consequence of the 1906 verdict was the prohibition of smelting ores with a high sulfur content. Two smelters were shut down, while two companies continued to process high-sulfur ores, with technology borrowed from the Ducktown smelters and by installing sulfuric acid plants that removed much of the SO_2.[34] Another critical issue was arsenic. To minimize the release of arsenic particles, the smelters added a seemingly primitive technology in the form of "bag houses," a technology that was both costly and inefficient as it captured arsenic pollution in the fibers of long woolen bags.[35]

However, a more radical technology soon emerged. The electrical precipitator was invented by Frederick Cottrell after Selby Smelting & Lead Co. hired the Berkeley scientist to solve pollution problems that had forced their smelter to shut down for several months. In 1907, after extensive testing, Cottrell demonstrated the successful operation of the electric precipitator, which captured liquid sulfuric acid mist and metallic dust.[36] Cottrell was next hired by ASARCO, in 1911, to install the device in the company's smelters. He was subsequently employed by the Anaconda Company to develop a precipitator for its giant Washoe smelter in Deer Dodge Valley. The precipitator captured about 90 percent of the solids in the smoke, including 94 percent of the arsenic. The smoke abatement solution included a smokestack with a bank of twenty precipitators at its base. The smokestack was completed in 1919, and with a height of 585 feet (170 meters), it was the largest freestanding masonry structure in the world.[37] In the meantime, the pollution issue had emerged as a constraint on managerial decisions; however, it also opened up new business opportunities and prospects for advancement for entrepreneurs who realized the strategic potential of pollution-control technologies. The development of such technologies related to sulfur and arsenic emissions came to involve the production of sulfur and arsenic as commercial by-products. In short, new smoke abatement technologies had been developed and were available in the United States by the time the Boliden project was established. Yet, the transfer of such technology required both motivation and relevant engineering skills. Besides, it was not obvious that a technology developed for

[33] Newell and Watts, "Environmental Impact of Industrialization," 315.
[34] LeCain, *Mass Destruction*, 75–76.
[35] Ibid., 76.
[36] Ibid., 84–85.
[37] Ibid., 98.

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a certain type of ore could easily, and at no cost, be adapted to ores with a different composition.

The Start of Boliden and the Environmental Issue

The key person behind the Boliden project was Oscar Falkman, a mining engineer who had worked at, among other places, Carnegie Steel in Pittsburgh.[38] One of Falkman's close partners, Paul Palén, had been employed at several copper smelting plants in the United States between 1905 and 1912, including one year as a draftsman at De Lamar Copper Refining Co. in Chrome, New Jersey; a short period at the Elkhorn Silver Mining Co. in Montana; about a year at the Washoe Smelter in Anaconda; and five years as chemist and assistant smelting superintendent at Old Dominion Copper Mining & Smelting Co. in Globe, Arizona.[39] This overseas experience was far from unique among the men's peers. Around 40 percent of newly graduated Swedish engineers started their careers in the United States or in Germany.[40] The Swedish entrepreneurs Falkman and Palén, with their personal experience of the smelting industry overseas, were thus part of a network of engineers in the United States and Germany.

The history of Boliden begins in 1918, when Falkman—by then the manager of a venture capital fund, Centralgruppens Emissions AB—launched a metal ore–prospecting project in the Boliden district of Northern Sweden. The project was financed by one of Sweden's three business banks, Skandinaviska Banken, under the leadership of chief executive officer (CEO) Oscar Rydbeck.[41] Equipped with a new device for electrical prospecting and a sensitive gravity meter, Falkman and his colleagues discovered a large deposit of sulfide ore in 1924. The main ore body proved to contain a concentration of 20.2 grams of gold per metric ton—a remarkably high amount—along with a significant concentration of copper and silver. Apart from these precious metals, the ore proved also to have a rare and complicated structure of arsenic and sulfur with varying intrusions of arsenopyrite and chalcopyrite. The sulfur content was very high, accounting for 30.2 percent of the ore's

[38] Per-Olof Grönberg, *Learning and Returning: Return Migration of Swedish Engineers from the United States, 1880–1940* (Umeå, Sweden, 2003), 211.

[39] Ibid., 212.

[40] Per-Olof Grönberg, "Skorsten kallar vi det rör som mot Ryssland röken för. Om konstruktionen av Europas högsta skorsten vid Rönnskärsverken" [Smokestacks are the things that the smoke to Russia brings: On the construction of the tall smokestack at the Rönnskär Plant], *Polhem*, yearbook of the Technical Museum (Stockholm, 2005).

[41] For an overview, see Jan Glete, *Kreugerkoncernen och Boliden* [The Kreuger Group and Boliden] (Stockholm, 1975).

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content; the arsenic concentration reached 9.8 percent, while the copper concentration was around 2.5 percent.[42]

As a consequence of the postwar economic crisis of the early 1920s and the collapse of Centralgruppens Emissions AB in 1926, the project was organized as two mining companies: Västerbottens Gruv AB and Skellefteå Gruv AB. Falkman remained as the manager of both companies, and the two companies were still directly under the control of Skandinaviska Banken. A more dramatic shift in corporate structure and ownership took place in 1929 when Skandinaviska Banken sold its shares in the two companies to the Swedish industrialist and global financier Ivar Kreuger, who consolidated the two companies into one: the Boliden Mining Company (Boliden Gruv AB). With Kreuger controlling the company, Falkman remained as its CEO. For simplicity, we refer to the mining company as Boliden, even before it emerged from the consolidation in 1931.

In 1925, a small shaft had been opened at a location known as Boliden to obtain definite data on the magnitude of the ore deposit. Further operations started in 1926 with mining at different levels, as deep as 250 meters. It was not mining-related environmental risks that posed a fundamental challenge to the managers. The problem was arsenic: the ore deposit in Boliden contained so much arsenic that it had no counterpart elsewhere in the world. Initially, the ore was exported to Freiberg, Germany, and to ASARCO's Tacoma smelter, outside Seattle. However, without any refinement of the ore, these two smelters could process only the Boliden ore with the highest concentration of gold.[43] Thus, it was decided in 1926 that Boliden would build its own smelter, beginning the complicated process of developing a smelting program, including construction of Europe's highest smokestack. As Palén wrote in the *Engineering and Mining Journal* in 1932, "The unique composition of the Boliden ore—especially its high arsenic content—necessitated careful study to work out the flow-sheet."[44]

In 1926, before the site of the smelter had been chosen, Falkman and Palén embarked on a trip to the United States. Their purpose was to consult American expertise regarding the smelting program and, especially, to learn about how American companies had dealt with the sulfur and arsenic issue. In October 1926, Falkman wrote a memorandum in New York, concluding that smoke damage had been a serious

[42] Eric Wesslau, "Sweden's New Gold-Copper Enterprise," *Engineering and Mining Journal* 133, no. 7 (1932): 395. To be exact, one ton of ore contained approximately 20 grams of gold, 2.5 kilograms of copper, 300 kilograms of sulfur, and 98 kilograms of arsenic.

[43] Oscar Falkman, *Så Började Boliden* [How Boliden was started] (Stockholm, 1953), 26.

[44] Paul Palén, "Smelting at Rönnskär, Sweden," *Engineering and Mining Journal* 133, no. 6 (1932): 339.

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problem at almost every American smelter. It was, according to Falkman, impossible to predict the harmful consequences that could arise at Boliden if no actions were taken to prevent pollution.[45] During their trip, Falkman and Palén met with several engineers and metallurgists, and Falkman visited the ASARCO Tacoma smelter to learn about the smelting program there. First of all, he found, a very tall smokestack seemed to be absolutely necessary; no damage to growing crops had been reported around the smelter since the company had begun operating its 170-meter chimney. In addition, Falkman was informed that the absence of sulfuric smoke damage after 1920 was due to the installation of Cottrell precipitators.[46] Based on climate conditions in the United States, Falkman calculated that a 120-meter stack should be tall enough to avoid smoke damage in Northern Sweden, but as a precaution, he suggested that Boliden should build a smokestack even taller.[47]

The Cottrell device would make it possible for Boliden to extract sulfur and arsenic from the smoke, yet a big concern for Falkman and his colleagues was the form in which the sulfur and arsenic should be extracted. For advice, Falkman consulted the distinguished American metallurgist Louis Davidson Ricketts, who had been a member of Roosevelt's Anaconda commission. Above all, Ricketts advised Falkman not to put the construction of the smelter into the hands of American consultants, but rather to engage professionals familiar with Swedish conditions. Ricketts also recommended that Falkman should pay attention to the ongoing experiments taking place in the United States and Germany regarding the production of liquid sulfur as a by-product.[48] However, for safety reasons, Boliden would not adopt a method to produce liquid sulfur as a by-product. The Boliden managers considered liquid sulfur to be too dangerous to store and transport. Developing a process that could enable solid sulfur production was expected to take some time, and Falkman therefore suggested the company begin with a prototype plant.[49] He directed the board of directors to investigate the cost of erecting a 153-meter smokestack, and to use the Cottrell precipitator to

[45] Oscar Falkman, memorandum: "PM. A brief summary of results from a study trip to the United States," 9 Oct. 1926, Oscar Falkman Arkiv, box FI:2, Swedish National Archive, Marieberg, Stockholm (hereafter OFA).

[46] Notes by Oscar Falkman regarding his visit at Tacoma Smelting Company, 4 Sept. 1926, Rönnskär Museum, Skelleftehamn (hereafter RM). Falkman wrote that, with a sufficiently tall chimney, only highly diluted and harmless gases would eventually hit the ground. The Tacoma plant had initially emitted its flue gases through a ninety-meter chimney, which clearly had not been sufficient.

[47] Oscar Falkman, memorandum: "PM. A brief summary of results from a study trip to the United States," 9 Oct. 1926, OFA.

[48] Falkman, *Så Började Boliden*, 88–89.

[49] Oscar Falkman, memorandum: "PM. A brief summary of results from a study trip to the United States," 9 Oct. 1926, OFA.

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produce solid sulfur.[50] A solution to the arsenic problem still remained to be found.

The central challenge facing the company was to figure out a way to separate the arsenic from the flue gases in a form that was not overly hazardous. In charge of these research and development (R&D) programs at Boliden was Axel Lindblad. Indeed, Lindblad had already proposed a method in which the arsenic and approximately half the sulfur were extracted from the flue gases, in 1925.[51] Then, in the next step, the arsenic and sulfur formed a substance known as realgar (sulfur arsenic), which at first was considered harmless, but regrettably also had no commercial value.[52] The sulfur arsenic could be stored for later use in the manufacturing of arsenous acid, which was used in impregnated wood and the manufacturing of pesticides. Lindblad was granted a patent for the sulfur arsenic process in 1926. Testing was undertaken at the Metallurgische Gesellschaft in Frankfurt during the winter of 1927.[53] Also, ongoing negotiations with Metallbank were held in Frankfurt over large-scale trials of the manufacturing process.[54] The arsenic problem was more troublesome than first realized, since it proved that the sulfur arsenic was much more environmentally hazardous than first anticipated. The substance was indeed combustible and could even self-ignite, causing an inextinguishable fire that would release smoke in the form of highly toxic arsenous acid.[55] The Boliden board stated a need for purely innovative work concerning the arsenic.[56] Here, the Americans offered no transferable technical solutions.

One strategy that was considered was to export the ore with the highest arsenic content to Freiberg in Germany. Another was to mix the arsenic with concrete, achieving a building material suitable for harbors and the like; alternatively, the arsenic-concrete could be dumped in the Baltic Sea.[57] Meanwhile, the Boliden engineer Lindblad was elaborating on a new method that directly formed arsenous acid, thereby avoiding the combustible sulfur arsenic. Again, testing took place in Germany, this time in the German company Krupp's roasting

[50] The principles of the manufacturing process were so basic that patent issues were not relevant. Nor did impurities in the ores—such as, in the Boliden case, arsenic—interfere with the process.

[51] Falkman, *Så Började Boliden*, 27.

[52] Board minutes, Skellefteå Gruvaktiebolag, 8 Aug. 1927, Boliden Archive, Boliden (hereafter BA). In fact, realgar was neither harmless nor completely useless. It was used in the leather industry and as a component in firecrackers, while burning the substance creates highly toxic fumes.

[53] Ibid.

[54] Board minutes, Skellefteå Gruvaktiebolag, 2 Feb. and 9 June, 1927, BA.

[55] Falkman, *Så Började Boliden*, 27.

[56] Board minutes, Skellefteå Gruvaktiebolag, 8 Apr. 1927, BA.

[57] Board minutes, Skellefteå Gruvaktiebolag, 23–24 Sept. 1929, BA.

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furnace.[58] Briefly, the new method included the evaporation of sulfur as SO_2 from the ore, resulting in blister or raw copper. The smoke gases from the furnaces were collected in a Cottrell precipitator, which removed the arsenic and most of the particulate matter. This material was in turn refined for the production of arsenous acid and solid sulfur.[59] The method basically followed the principles used in the American smelters but was modified on the basis of Lindblad's research and the outcomes of the German trials. This method came to be known as the Rönnskär process (sometimes called the Skellefte process) and was now ready for a large-scale pilot plant, which would later become the full-scale smelter at Rönnskär.[60]

A coastal location for the smelter was chosen in 1927. The first, and most obvious, option for the managers and the board was to locate the smelter close to the mine. A location close to the mine would have meant low transportation costs because the deposit was situated quite close to the already existing state railway trunk line.[61] However, one of the basic arguments in favor of the coastal location was the low risk of smoke damage to vegetation that could be expected. In 1928, the company made a formal agreement with the city of Skellefteå to buy Rönnskär, a coastal area about fifty kilometers (thirty-one miles) from the Boliden mine. It was in this agreement that the company committed itself to "undertake measures at the smelting and purification plants" that could be reasonably called for in order to prevent, as far as possible, harmful effects from gases and waste in solid and liquid form.[62] The agreement stated that the company had no legal responsibility for any damage to vegetation on municipal land, but that the company was legally responsible for damage on private property.[63] Of its twenty-one paragraphs, only one concerned the environment. The local board of public health—which was responsible for overseeing that industrial operations were in compliance with the Public Health Act, the main

[58] Board minutes, Skellefteå Gruvaktiebolag, 6 May 1929, BA.

[59] Note that Anaconda was one of two smelters that could process the Boliden ores, and the company was subject to lawsuits at the time of Palén's first engagement there.

[60] The process occurred in the following stages: (1) crushing and bedding of ore and fluxes; (2) roasting, to eliminate arsenic and part of the sulfur; (3) removal of the arsenious oxide from the cooled roasting gases in Cottrell precipitators; (4) smelting of the calcines in reverberatory furnaces; (5) blowing of molten matte to blister copper; (6) preliminary refining of the blister and casting of anodes; (7) electrolytic refining, with recovery of gold and silver; and (8) melting, refining, and casting of the electrolytic copper for the market. Palén, "Smelting at Rönnskär," 340–41.

[61] Falkman, *Så Började Boliden*, 30.

[62] Protocol from the City Council of Skellefteå town, Appendix 1, 21 Feb. 1928, box AIa26, Municipal archive, Skellefteå (MAS).

[63] Ibid., § 9.

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regulatory tool to control air pollution—had no objections to the location of the smelting activity.[64]

Pollution-Control Technology as a Strategic Asset

The question of which technology and process were to be used was not definitively settled. While the Boliden-developed Rönnskär process was ready for a large-scale pilot plant test, the company's board members were made aware in April 1929 that the Norwegian company Orkla Grube A/S (Orkla Mining Co.), in Trondheim, had developed "some sort of method" for the roasting of copper-bearing pyrite ores.[65] Orkla was controlled by Sweden's most influential business group, the Wallenberg group (controlled by the Wallenberg family) and, at this point, competitor of Boliden's owner, Skandinaviska Banken. Orkla was keen to sell its technology to Boliden through a licensing agreement. Tests on the Boliden ore were initiated at Orkla's smelter in Oskarshamn, Sweden, with results reported to be very promising.[66] The board therefore declared that the so-called "Orkla process" was to be considered for implementation at Rönnskär, even though Orkla had revealed no details about its processing method. Falkman and some of the other Boliden managers opposed this, arguing that the Orkla process presented no significant improvement over the Rönnskär process. The Royal Institute of Technology in Stockholm was therefore engaged to evaluate both methods.[67] It was clear, however, that the Orkla process produced sulfur arsenic, which had been dismissed by Boliden's managers as being overly hazardous. On the basis of this information, the Boliden board decided to stop negotiations with Orkla.[68] A business deal was therefore declined on the basis of environmental considerations. However, the process would resurface later that year in a more complicated drama, involving American players.

In 1929, Ivar Kreuger took over Boliden. Within three years, Kreuger would become globally infamous as the greatest financial swindler of the twentieth century, but at this stage he was known worldwide for his consolidation of the fragmented match industry into Swedish Match and for

[64] In a review of all protocols of the local board of public health during the period, we found that the smelting activity was indeed never discussed—not even between 1930 and 1934, when damage started to appear.

[65] Board minutes, Skellefteå Gruvaktiebolag, 6 May, 1929, BA. Orkla's managing directors were the Swedish engineers Erik Lenander and August Nachmanson.

[66] Ibid.

[67] Ibid. The instructions for the expert to conduct the investigation had been sent on April 20, 1929 and was signed by August Nachmanson for Orkla and Oscar Falkman for Skellefteå Gruvaktiebolag AB.

[68] Ibid.

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his loans to cash-starved governments in return for match monopolies.[69] Between 1925 and 1930, Kreuger established monopolies in fourteen countries around the world. In the mid-1920s, Kreuger & Toll had started to buy large stock positions in leading Swedish industrial corporations, such as LM Ericson and SKF. He also formed the SCA group in 1929. This meant that Kreuger, backed by Skandinaviska Banken, was challenging the powerful Wallenberg business group.[70]

It was Oscar Rydbeck, the CEO of Skandinaviska Banken, who prompted Kreuger's interest in Boliden. By the late 1920s, it had become clear to Rydbeck that the Boliden mine represented not only potentially high value but also a significant risk due to the environmental and technical uncertainties associated with the Rönnskär smelter. These risks constituted an important motive for Rydbeck to sell the bank's Boliden shares.[71] Meanwhile, Boliden had attracted national and international interest, not least in the United States. Prior to Kreuger's acquisition of Boliden, the Wallenberg group had contacted Skandinaviska Banken, declaring its desire for a takeover in cooperation with the American company Guggenheim Brothers.[72] Skandinaviska Banken, however, was not interested in selling Boliden to the competing Wallenberg group, preferring to strike a deal with Kreuger.[73] The takeover started during the fall of 1929 and was completed in December of the same year. To mark the takeover, Kreuger visited both the Boliden mine and the Rönnskär smelter while attending the company's board meeting in July 1930. Figure 1 illustrates this occasion.

Yet, before the takeover was completed, Kreuger had already been in contact with international experts to arrange a valuation of the mine, including Elias Anton Cappelen Smith, director and chief metallurgist at Guggenheim Brothers, and the British consulting company Selection Trust.[74] Cappelen Smith showed no interest in collaborating with Kreuger (however, this situation would soon change). Instead, a private consulting engineer, formerly employed at the British Selection Trust, was engaged.

[69] See, for example, Frank Partnoy, *The Match King: Ivar Kreuger, the Financial Genius behind a Century of Wall Street Scandals* (New York, 2009); and Jan Glete, *Kreugerkoncernen och krisen på svensk aktiemarknad: studier om svenskt och internationellt riskkapital under mellankrigstiden* [The Kreuger Group and the crisis on the Swedish Stock Market: Studies of Swedish and international venture capital during the interwar period] (Stockholm, 1981).

[70] Håkan Lindgren, "The Kreuger Crash of 1932: In Memory of a Financial Genius, or Was He a Simple Swindler?," *Scandinavian Economic History Review* 30, no. 3 (1982): 189–206.

[71] Glete, *Kreugerkoncernen och Boliden*, 48.

[72] Ibid., 62.

[73] Ibid., 328. Indeed, it was not clear at the time whether Kreuger & Toll or Kreuger as a private individual had bought Boliden. As it turned out, it was Kreuger himself who owned the company.

[74] Ibid., 61.

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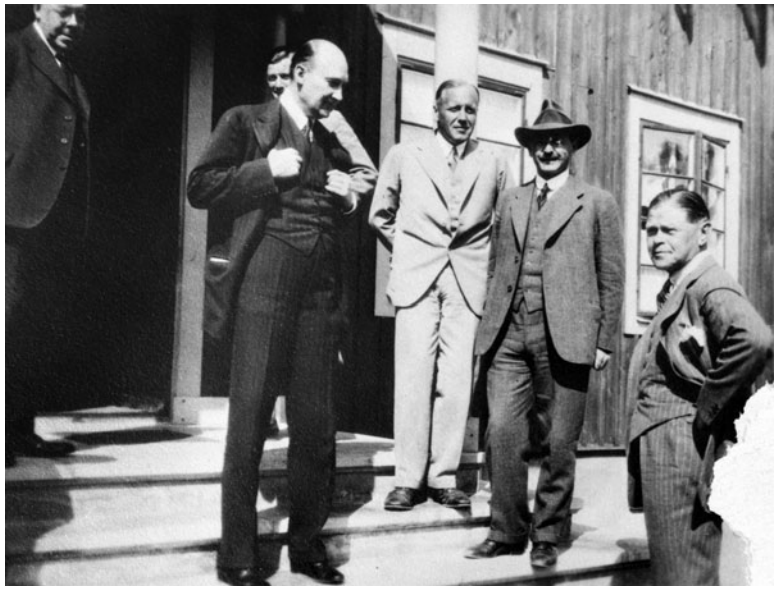


Figure 1. Ivar Kreuger visiting Boliden, 1930. Pictured are (far left) Dr. Axel Lindblad (Boliden), (left to right) Director Ivar Kreuger (Kreuger & Toll), Dr. Olof Baeckström (Boliden), manager Oscar Falkman (Boliden), Krister Littorin (Kreuger & Toll), and (behind Ivar Kreuger) manager Erik Wesslau (Boliden). (Source: Photographer unknown, photo no. SM C 00529, Boliden AB's arkiv, Bildarkivet, Skellefteå Museum.)

The consultant delivered a report on the Boliden mine in November 1930.[75] In addition to this foreign expertise, Kreuger also engaged Gunnar Magnuson, an experienced director from the pulp and paper industry, as an industrial expert at Kreuger & Toll with responsibility for Boliden.[76] Magnuson would function as Kreuger's right hand in most practical issues related to Boliden.

Concerns about environmental risks did not cease with the takeover by Kreuger—quite the opposite, in fact. Magnuson involved a professor from Centralanstaltens Kemiska Avdelning to undertake a scientific survey of the environmental impacts of the smelter smoke and to evaluate potential damage from the Rönnskär smelter at different production levels. The reason was that Kreuger wanted to increase the production capacity at the Rönnskär smelter considerably.[77] In March 1930, the

[75] Report written by Edwin G. Bloomfield, "Report on the Boliden mine, Sweden," Nov. 1929, RM.

[76] Glete, *Kreugerkoncernen och Boliden*, 61.

[77] Sven Odén to Gunnar Magnuson, 9 Dec. 1929, RM.

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report to Kreuger & Toll was delivered, citing no less than forty-one cases of smoke damage in Europe and the United States.[78] The report noted that the most serious cases of sulfur "poisoning," as recorded in the literature, concerned the Anaconda Company, around the Washoe copper smelter, and from the Tennessee Copper Co. in Ducktown. It was concluded that the damage reported in the United States was much more severe and large-scale compared to the situation in Europe.[79] The report did not include technical aspects, but only reported on damage from copper smoke. For Boliden's managers, the information was neither new nor surprising, but the report itself shows that even an internationally powerful businessman like Kreuger was interested in environmental risks.

While construction of the Rönnskär smelter was underway, Kreuger started negotiations with both the Wallenberg group and Guggenheim Brothers on implementing either the Orkla method or a method suggested by Guggenheim Brothers at Rönnskär.[80] The question of sulfur emissions had apparently been overlooked in previous reports; in short, Kreuger had learned that the volume of SO_2 emissions was lower with the Orkla method.[81] The lower volume of sulfur emissions also meant a larger sulfur production. In the spring of 1930, however, the board confirmed that the Rönnskär smelter was to employ its own method—namely, the Rönnskär method—both as a result of Falkman's fierce resistance to the Orkla method and, as Falkman put it, due to the fact that "Kreuger had, contrary to many other men, the pleasant trait to usually listen to arguments, even though the arguments were against his intentions."[82] Still, and for reasons unknown to Falkman, Kreuger kept the collaboration with Orkla alive.[83] In late March 1930, Kreuger decided that testing with the Boliden ore should be conducted at Orkla's facilities.[84] Kreuger also suggested that an Orkla-based facility

[78] The author of the report had been tasked with assessing the environmental impacts of emissions from the Rönnskär smelter, particularly sulfur dioxide (estimated levels of 25,000 tons annually).

[79] Report delivered to Kreuger & Toll from Professor Sven Odén, 1 Mar. 1930, RM.

[80] Glete, *Kreugerkoncernen och Boliden*, 97.

[81] Fredrik Carlsson to Gunnar Magnuson, 8 Feb. 1930, RM. This was later confirmed by Falkman; see Oscar Falkman to Ivar Kreuger, 26 Nov. 1930, RM.

[82] Falkman, *Så Började Boliden*, 94. This statement contrasts sharply with the supposedly psychopathic personality of Ivar Kreuger as suggested in Robert Shaplen, *Kreuger: Genius and Swindler* (New York, 1960).

[83] Glete speculates that Kreuger may have wished to maintain close ties to the Wallenbergs for an upcoming stock release. One of Kreuger's last desperate moves, in the spring of 1932, was indeed to use Boliden shares as collateral for two loans, to save his match empire. Falkman speculates vaguely on some kind of complicated, behind-the-scenes financial arrangements. See Glete, *Kreugerkoncernen och Boliden*, 99; and Falkman, *Så Började Boliden*, 42.

[84] Board minutes, Skellefteå Gruvaktiebolag, 31 Mar. 1930, BA; Gunnar Magnuson to Orkla Grube A/S, 1 Apr. 1930, RM.

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should be constructed at Rönnskär, even though the plant would soon be operational. Again, Falkman rejected these proposals on both environmental and economic grounds.[85] The issue was concluded instead with Kreuger & Toll financing a pilot furnace at Orkla's Norwegian plant.[86]

Kreuger's motives for keeping the Orkla discussions active likely had to do with a desire for gaining control of the sulfur market. Monopolies were Kreuger's specialty. In November 1929, Magnuson—Kreuger's right hand—had contacted Palmer, Flygt & Co. in London asking for information about the British market for sulfur acid.[87] Kreuger's interest in entering the sulfur market suggests that sulfur abatement technologies could be of strategic economic importance.[88] Indeed, in conversations with Magnuson, Kreuger had suggested that it would be wise if Kreuger & Toll could join forces with the Wallenberg group to exploit the Orkla method in a separate company. Kreuger would, according to this plan, own 80 percent of the shares in the new company, which would buy ores at market prices from Boliden. In this way, Kreuger planned to bring the conflicting interests together; that is, the profits from the Orkla method would be realized in the new company. Kreuger had also mentioned that he could possibly become interested in buying Orkla in the future.[89] Clearly, Kreuger considered both a friendly, cooperative strategy and a hostile takeover. Also, the Orkla method may, in Kreuger's mind, have been a means for reaching strategic ends rather than for improving on the production process at Rönnskär. Yet, companies on the sulfur market had close ties to the leading copper producers—a link that had been created by the copper smelters' initial problems with sulfuric emissions.[90] Kreuger's strategy was therefore not separate from a solution to sulfur emissions.

While discussions with Orkla were taking place, Kreuger and Guggenheim Brothers made a deal. Before Kreuger's takeover of Boliden, the Guggenheim Brothers's chief metallurgist, Cappelen Smith, had suggested that Guggenheim Brothers and Kreuger & Toll should form a joint American holding company. Kreuger was interested in Cappelen Smith's suggestion, but he believed the plan should be put on hold for a couple of years.[91] Yet, it

[85] Oscar Falkman to Ivar Kreuger, 26 Nov. 1930, RM.

[86] Author unknown, memorandum: "PM. Orkla," 10 Sept. 1930, RM.

[87] Einar Flygt to Gunnar Magnuson, 9 Dec. 1929, RM.

[88] Later, Orkla Grube A/S would also utilize the patents for the Orkla method in deals with the U.S. sulfur industry. See Trond Bergh, Harald Espeli, and Knut Sogner, *Brytningstider: storselskapet Orkla 1654–2004* (Oslo, Norway, 2004).

[89] Memorandum regarding a conversation with Ivar Kreuger: "PM. Samtal med Ivar Kreuger" (undated and unsigned but with the characteristics of Gunnar Magnuson's writing), RM.

[90] Maysilles, *Ducktown Smoke,* 177–78.

[91] Glete, *Kreugerkoncernen och Boliden*, 63.

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did not take long before Kreuger and Guggenheim Brothers agreed to jointly develop the mining industry in Boliden: a deal was made in New York in June 1930.[92] Under the deal, Guggenheim Brothers would send consulting engineers to examine and report on the nature and extent of the ore body in Boliden. Also, Guggenheim Brothers, at their own expense, would develop a metallurgical process adapted to the treatment of the Boliden ore, including a solution to the sulfur and arsenic problems. Moreover, if it could be confirmed before December 1931 that the ore body contained at least fifteen million tons of proved and probable commercial ore, Guggenheim Brothers would have the right to obtain a certain share of the company—specifically, twice the proven reserve—as well as the right to acquire 20 percent of its common shares.[93]

In July 1930, four experts from Guggenheim Brothers arrived in Northern Sweden to visit Boliden, including two Americans—Dr. R. M. Overbeck and Robert Marsh. Marsh immediately started to outline a report not only containing an estimate of ore reserves and drift calculations, but also addressing the environmental effects that could be expected from running the smelting program planned for Boliden.[94] Falkman was certainly not impressed with the presence of the Americans at the mine. In a note, he wrote that "Mr. Marsh and Mr. Overbeck are not knowledgeable in mining in a strictly narrow sense. To allow them [to] decide on the future work of the mining progress, seems to me not appropriate, and would certainly not promote the best possible results."[95]

Marsh delivered his report on Boliden in April 1931, concluding that the company was potentially facing major and critical problems. For one, it was, according to Marsh, unlikely that world demand for arsenic would increase; therefore, the company would likely be forced to store huge quantities of arsenic for years to come:

> [I]t is the universal experience of all plants handling large quantities of these poisonous materials that it seriously affects the health of the workman, regardless of any precaution which it is possible to take. For these reasons we consider it essential to remove the arsenic as an insoluble compound, thus eliminating all danger in handling, storage or disposal. . . . The roasting of 2,000 tons of Boliden ore per day would produce about 700 tons of sulphur and as much sulphur dioxide. If this were discharges [*sic*] through the Rönnskär stack, it is our firm conviction that it would result in the destruction

[92] Guggenheim Brothers to Ivar Kreuger, 10 June 1930, RM.

[93] Ibid. Further, a Swedish company would be formed that was to hold the preference shares entitled to 7 percent of the dividends and common shares entitled to surplus profits.

[94] Robert Marsh, memorandum, Apr. 1931, RM.

[95] Oscar Falkman, memorandum regarding Cappelen Smith's letter written 8 Sept. 1930, (authors' translation), 9 Sept. 1930, RM. Falkman's use of the phrase "in a strictly narrow sense" is a polite insult, suggesting amateurism.

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> of trees and agricultural crops within a radius of at least 15 kilometres. Moreover, the mixture of sulphur fumes with small quantities of white arsenic, which would be deposited on the vegetation in this area would endanger all animal life.[96]

There were two points in this report that, in Cappelen Smith's opinion, could not be emphasized "too strongly": first, the inevitable damage to forest and crops that would be caused by the huge quantities of sulfuric gases emitted by the roasting and smelting processes planned for the Rönnskär smelter; and second, the tremendous responsibility to be assumed by the company in storing huge quantities of arsenic, in the form of arsenic oxide, for many years into the future.[97] Cappelen Smith warned Kreuger that the way Boliden had designed its metallurgical process implied risks of environmental damage of almost biblical proportions. Strikingly, Cappelen Smith used environmental risk as his main argument for selling the Guggenheim process. In a note on the Guggenheim Brothers's report written by Marsh, Magnuson declared that he was not convinced of its arguments—that the information provided was incomplete and, as such, the method could not be assessed. He also argued that the arsenic (to be extracted from the smoke as suggested in the Rönnskär method) could be stored safely and that the risks with sulfur emissions would be the same with both alternatives.[98]

Falkman was similarly unimpressed by the conclusions of the Guggenheim Brothers's report. In fact, Falkman wrote to Kreuger to argue against most of the suggestions and conclusions it contained. According to Falkman, the storage of sulfur arsenic—a by-product of both the Orkla and the Guggenheim methods and, before them, the method proposed by Boliden's own engineer Lindblad in 1926—was overly dangerous. He pointed out that sulfur arsenic was ignitable and, if ignited, would create a cloud of arsenic acid that would cause "severe disasters." To dump the sulfur arsenic into the sea—an option suggested by Lindblad in 1926 was certainly too much of a risk; to illustrate this, Falkman referred to German experiences. On the other hand, he argued, arsenic acid was stable and could not develop gases.[99] Concerning workers' safety, and referring to points made by the Americans, Falkman wrote,

[96] Robert Marsh, memorandum, Apr. 1931, RM.

[97] Elias Anton Cappelen Smith to Gunnar Magnuson, memorandum, 20 Apr. 1931, RM.

[98] Gunnar Magnuson, memorandum regarding Cappelen Smith's letter sent on April 20, 1931 and his meeting with Smith in Paris (authors' translation), 12 May, 1931, RM.

[99] Oscar Falkman, memorandum regarding Cappelen Smith's memorandum written on April 19, 1931 and Cappelen Smith's letter on April 20, 1931 (authors' translation), 18 May 1931, RM.

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> As the memorandum argues, it is indisputable that the handling of arsenic materials involves certain risks for the workers. Therefore, we at Rönnskär are also focused on, as extensively as possible, mechanizing all of the arsenic transports and the like, and by doing so, we hope to keep the risks to a minimum. That the risk of exposure would completely disappear, as the memorandum asserts, if one binds the arsenic as arsenic sulfur instead of sulfuric acid, is incorrect.[100]

Falkman argued that both Guggenheim Brothers and Orkla had overlooked the unknown and potentially much more serious risks of arsenic oxide in the production of sulfur arsenic.[101] Indeed, he stated that the Guggenheim report had emphasized environmental risks over economic arguments to justify its choice of method. But he also stressed that Guggenheim Brothers had not provided further information about how their process really worked. Indeed, Falkman doubted that Guggenheim Brothers even had a process and suggested they used arguments about environmental risks instead to advance the deal with Kreuger.[102]

Palén, the Boliden chief engineer, went in the fall of 1931 to meet with Guggenheim Brothers in New York to see a demonstration of their metallurgical process. Falkman and Magnuson (the latter representing Kreuger) arrived shortly after. The Swedes got the impression that the Guggenheim process was far from being ready for production on industrial scale. The first stages of the metallurgical process were still only on laboratory scale. Furthermore, Palén reported that Guggenheim Brothers had not been doing any work on the subsequent stages, including the converter process in their laboratory. Instead, Guggenheim Brothers suggested that their converter process would be "done in the similar manner" as that used by the Tennessee Copper Co.[103] Therefore, Palén traveled to Tennessee Copper Co., in Copperhill, but was not impressed. There was a leakage of gases from the converter with a "thick cloud of sulfur smoke constantly pouring out."[104] Palén wrote that if this was the process that Guggenheim Brothers were suggesting be implemented at the Rönnskär smelter, it was certainly a questionable solution.[105] Falkman and Magnuson concluded that the advantages

[100] Ibid., 5.

[101] Ibid.

[102] Oscar Falkman, memorandum regarding the Guggenheim smelting process (authors' translation), undated, RM. In this note, Falkman thoroughly described how the Rönnskär method would treat both the sulfur danger and the arsenic danger and how the arsenic disposal would be mechanized. He emphasized again that workers would have no contact with the arsenic disposal process, besides those materials that had to be processed for sale.

[103] Paul Palén to Axel Lindblad, 21 Oct. 1931, box ERA/ca. Studieresor Ing P Palén USA, Boliden Archive, Rönnskärsverken, Skelleftehamn (hereafter BAR).

[104] Paul Palén to Axel Lindblad, 3 Nov. 1931, box ERA/ca. Studieresor Ing P Palén USA, BAR.

[105] Ibid.

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attributed to the Guggenheim process were in fact impossible to verify, as the laboratory scale experiments were never demonstrated to the Swedes.[106] Palén, however, had other important contacts; in November, he met with "old friends" at the offices of the International Precipitation Co. in New York. Indeed, this was the company founded in 1907 by Frederick Cottrell and the discussion focused on the extraction of solid sulfur.[107]

Then, in December 1931, the collaboration and the deal with Guggenheim Brothers were terminated. On December 5, Magnuson informed Cappelen Smith that Kreuger had decided not to prolong their agreement.[108] Kreuger's main argument was twofold: that the anticipated quantity of ore (fifteen million tons) had not been proven, and that Boliden had already adopted its own smelting process.[109] The possibility of a deal would not be discussed again—within only three months, Kreuger was dead. Just five days after Kreuger's death in Paris on March 12, 1932, Guggenheim Brothers sent a letter to Magnuson asking him to inform the company of whether he wished to consider the "sulfur question" further.[110] Magnuson did not pick up the thread.

In June 1932, Palén published an article in the *Engineering and Mining Journal* presenting the smelting process adopted at the Rönnskär smelter.[111] In it, he stated that one of the main problems in planning the smelter had been the removal of the large amounts of arsenic from the roaster gases because no similar operation on a large scale was known to be active elsewhere in the world. Among the most impressive structures at the Rönnskär smelter were its 153-meter-high smokestack (Figure 2) and the arsenic storage, a concrete structure (110 meters long, 40 meters wide, and 23 meters high) capable of holding about 120,000 tons of crude arsenic (Figure 3).[112]

The two buildings—symbols today of a dirty industrial past—were monuments to the engineering expertise of the early 1930s in their efforts to control pollution. The technology was not comparable with its state-of-the-art counterpart a few decades later, but it was cleaner

[106] Falkman, *Så Började Boliden*, 42–43.

[107] Paul Palén to Axel Lindblad, 3 Nov. 1931, box. ERA/ca. Studieresor Ing P Palén USA, BAR.

[108] Gunnar Magnuson to Ivar Kreuger, telegram, 12 Dec. 1931, RM.

[109] Ibid.

[110] G. Temple Bridgman (Guggenheim Brothers) to Gunnar Magnuson, 17 Mar. 1932, RM.

[111] Palén, "Smelting at Rönnskär," 340–41. According to Palén, the Boliden engineers had observed that the Cottrell precipitator worked more efficiently if the gases were cooled down to below 150 degrees Celsius, which is why the company had been struggling with improving the cooling chambers. About one-third of the arsenious oxide was recovered in the coolers, and the rest was being precipitated in the Cottrell precipitators.

[112] Ibid., 340.

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Figure 2. Construction of the Rönnskär stack, 1928. (Source: Unknown photographer, photo no. SM X 00470, Boliden AB's arkiv, Bildarkivet, Skellefteå Museum.)

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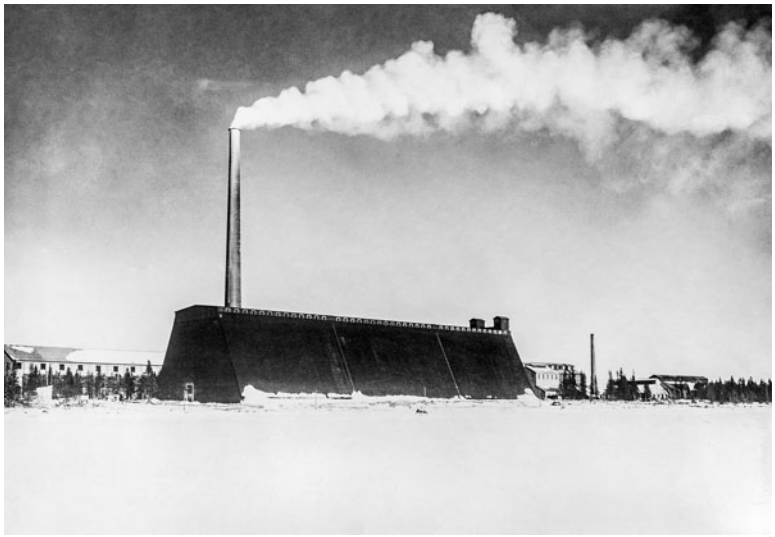


Figure 3. The arsenic storehouse, Rönnskär smelter (behind the storehouse is the Rönnskär stack), 1932. (Source: Photographer unknown, photo no. BOL 4480, Boliden AB's arkiv, Bildarkivet, Skellefteå Museum.)

than the technology used in Anaconda, Salt Lake City, and Ducktown three decades earlier.

Proactive Strategies and the Creation of Shared Value with the Local Community

Despite the Boliden managers having incorporated a proactive strategy to prevent smoke damage right from the planning stages of the project, the surrounding environment was soon affected by SO_2 emissions. Initially, only relatively low-sulfur ore was processed at the plant, but in 1935 the company started to treat ore with substantially higher sulfur content. Between 1931 and 1940, annual SO_2 emissions increased from 4,000 tons to around 100,000 tons. Complaints from farmers and forest landowners began to increase around 1934.[113] As mentioned, the company preferred a process that produced solid sulfur to one producing sulfur acid, due to the risks of storing and transporting sulfur acid. A pilot plant to produce solid sulfur was ready in

[113] In 1936 the company asked the regional office of the Skogsvårdsstyrelsen (Swedish Forest Agency) for assistance. It is worth noting that the company had paid compensation for damaged crops and trees before 1932.

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1931, but the production program was not operationalized as the board believed the profit opportunities were too uncertain. However, in 1933, Falkman clearly declared to the board that the need to construct a full-scale sulfur plant was urgent, regardless of whether the sulfur production was profitable or not. He argued that the smoke damage to the area would otherwise lead to major compensation claims—and probably to intervention by the authorities.[114] The board approved the investment, and the sulfur plant for extraction of solid sulfur was finally ready in 1935.

The proactive strategy adopted by Boliden managers contributed to the avoidance of more serious smoke damage. The company's managers made persistent efforts to find technical solutions where arsenic-related risks were prevalent at least until the mid-1930s. Relying on environmental arguments, Falkman and the other managers fought fiercely against Kreuger's plan to adopt the Guggenheim smelting process. The reason for Krueger's eventual compliance with the position of Boliden's managers was, according to Falkman, that Kreuger accepted their arguments.[115] Ultimately, it was not a question of downplaying profit maximization out of the goodness of either Falkman's or Kreuger's heart, but a proactive strategy aimed at avoiding conflicts that would have interfered with Falkman's ambition to build a long-lasting, profitable business. Avoiding excessive pollution was seen as a reasonable and even necessary step in establishing a modern mining industry, which is in line with Michael E. Porter and Mark R. Kramer's concept of shared-value creation: that causing social harm can (and does) create internal costs for a company.[116] Falkman, with his farsighted perspective in building the business, stressed that Boliden should provide safe employment and give something back to the region in which it worked. These CSV-related ideas were not restricted to the working environment and emissions. One way Falkman could achieve his paternalistic ideal—which had deep historical roots in Swedish manufacturing—was to engage the London-based architect Tage William-Olsson to create a model community in the town of Boliden, which bears the same name as the company. Quality housing, pleasant gardens, and clean water, among other things, were designed to create a comfortable environment for the workers.[117] Other exponents of CSV included the building of a school for children, meeting houses for laborers and their families, and facilities for independent church activities.[118] The company also started a fund for mitigating

[114] Falkman, *Så Började Boliden*, 88–89.
[115] Ibid., 43.
[116] Porter and Kramer, "Creating Shared Value," 5.
[117] Grönberg, *Learning and Returning*, 210–11.
[118] Board minutes, Skellefteå Gruvaktiebolag, 8 Apr. 1927 and 21 Nov. 1929, BA.

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the anticipated social costs associated with the mine's eventual depletion.[119] Falkman believed that such investments would not only improve the bottom line but also act as a step toward good working relations and high productivity.[120] The same belief can be seen in the company's integration of technology that would purify the smelter smoke. Yet, the rate of workplace accidents and injuries was high during the initial operation of the Rönnskär smelter. During 1931 and 1932, 30 percent of the workers experienced some kind of accident.[121] Falkman saw to it that a public medical clinic, with one doctor, was established at the Rönnskär smelter in 1931.[122]

Over the following decades, the general knowledge of ecosystems and health issues evolved, uncovering critical and increasingly complex environmental concerns. In addition to arsenic and sulfur, emissions of mercury, cadmium, lead, and copper were added to the spectrum of potential problems at the Rönnskär smelter. During the 1960s, there was a growing awareness that a major gap existed in general knowledge of both the scope and the effects of emissions from Swedish industry. In contrast to the interwar period, the 1970s and 1980s saw a period of strong legal pressure on the company to redefine long-term investment strategies and related R&D. In terms of environmental investments, the company has devoted resources to in-house R&D and worked proactively against regulation until the present.[123] Unlike the Anaconda Company and Tennessee Copper Co., the Rönnskär smelter is still in operation and in fact is one of the most efficient smelters in the world, specializing in recycling complex materials such as electronic scrap.

Conclusion

In this article we have explored why the Swedish mining company Boliden adopted proactive environmental strategies when it started operations during the interwar period. Clearly, investing in environmental technology was seen as a source of competitive advantage. Without this investment the company could not utilize the gold and would have polluted the surrounding environment to a much larger extent. These proactive strategies adopted by the company represent a shared value

[119] Oscar Falkman, memorandum Dec. 1934, box F1:2, OFA.

[120] Grönberg, *Learning and Returning*, 210–11.

[121] Falkman, *Så Började Boliden*, 84 ff.

[122] While the municipality of Skellefteå declined to finance such a service, the Swedish Medical Board (Medicinalstyrelsen) agreed to do so. Board minutes, § 5, 21 July 1931, BA.

[123] Ann-Kristin Bergquist, "Dilemmas of Going Green: Company Strategies in the Swedish Mining Company Boliden, 1960–2000," in *Green Capitalism? Exploring the Crossroads of Environmental and Business History*, ed. Hartmut Berghoff and Adam Rome (Pennsylvania University Press, forthcoming).

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argument: good for business and good for the environment. Indeed, as argued by Porter and Kramer, the "health" of the communities around a company is closely intertwined with the competiveness of that firm. From an environmental perspective, this means that Boliden, within the limits of best available technology, but also by developing its own methods, tried to internalize the social costs of pollution. Values were therefore shared with the local community, as the environmental costs were not fully externalized to landowners and other stakeholders. Since the company also undertook other CSV-compatible measures, it is clear that environmental concerns were part of a broader value system, including both social responsibility and respect for the property of others. In short, excessive pollution was perceived as bad for the chances of a long-lasting, profitable, and sustainable business.

Boliden's managers made efforts to prevent damage from smoke; in addition, we found that solutions to the smoke problems were related to other strategic decisions. It seems, for instance, that Kreuger realized that the sulfur-abating technologies were a means by which to enter, and possibly even control, the cartelized sulfur market. The interrelation between environmental issues and the production of sulfur may also explain the interest in environmental technologies by both Guggenheim Brothers and Orkla. From this perspective, it is important to recognize that efforts were being made to identify and further develop technologies that would satisfy both economic and environmental needs simultaneously, an argument already suggested by Timothy J. LeCain and Hugh Gorman.[124] The commercialization of both sulfur and arsenic was an issue of high priority in terms of economies of scope. Concerns about smoke damage became integrated with what we normally recognize as traditional business motives. The blurring of boundaries between different motives makes it difficult to determine where environmental issues end and other business interests begin. This fundamental entanglement is, however, central to the analysis and distinguishes the Boliden case as an example of CSV rather than of CSR. While CSR is about taking responsibility as value is created in a production process, CSV is about creating value through a production process that is inseparable from the value creation outside the company. This is not simply consumer surpluses or wage creation, but processes that can be understood in terms of positive externalities or avoidance of negative externalities. In the case of environmental issues, CSV is probably most often associated with the avoidance of negative externalities but can be distinguished from CSR by the fact that such avoidance is indispensable for value creation within the company. For instance, it is clear that

[124] LeCain, "The Limits of 'Eco-Efficiency'"; Gorman, *Redefining Efficiency*.

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Boliden tried to achieve profitability in both the sulfur and the arsenic business. No clear trade-off existed between investing in abatement technology and profits in the way Boliden's managers and engineers handled these two issues. The technology was simultaneously a production process and a means of reaching environmental goals. Clearly, the motive for integrating pollution-control technology can be seen as a way to efficiently exploit economies of both scale and scope, in Alfred D. Chandler's terms. Controlling the toxic copper smoke allowed a larger-scale production than would have otherwise been possible, considering potential damage, while simultaneously producing sulfur and arsenic as by-products of the copper- and gold-making process.

The Boliden case also exemplifies the possibilities offered by global learning. Managers at the company had witnessed environmental problems in the United States and learned from their experience. This is not discussed by Porter and Kramer, but it helps us to understand further why Boliden came to the conclusion that environmental technologies could be a competitive advantage. The company never questioned whether smoke damage should be avoided or not; rather, the question —and the challenge—was about *how* to prevent a situation similar to that of certain copper districts in the United States. The American copper industry was on the front line of the struggle with toxic copper smoke, and the Swedish entrepreneurs learned, transferred that knowledge and technology, and developed them further for adaptation to the Swedish geophysical, climatological, and institutional context. The importance of knowledge about local conditions for adaptation of the technology was stressed by one of the American consultants, Louis Davidson Ricketts. Straightforward technological transfer from the United States was not an option.

The government was not explicitly involved in Boliden's search for, and development of, technology to prevent smoke damage, nor in its sending top engineers on trips to the United States seeking consulting expertise. As shown by the works of McCain, Maysilles, and others, extensive social protests, lawsuits, and court cases forced American copper companies to take action. Boliden's managers and engineers were fully aware of this, allowing the situation to not be repeated in the Swedish case. Rather, extensive smoke damage, related protests by farmers and ranchers, and litigations in the United States functioned as a warning. Although the Swedish managers faced the threat of government intervention if they caused smoke damage to the degree experienced in the United States, this does not appear to have been a prevailing motivation. Also, in response to the company's convincing report on the successful development of smoke abatement technologies, the municipal government had no objections.

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Finally, national institutions were important, but not in the way that is usually assumed when environmental issues are discussed. It was not government policies per se but rather the Swedish concept of property rights that mattered the most. Norms among Swedish business leaders had long been formed by paternalistic ideals, and Falkman asserted his vision of building a modern and lasting industrial community. Conflicts with forest landowners, forestry companies, and farmers were perceived as working against these ideals. The Boliden managers' respect for private property probably mattered more for the environmental-related strategies than a compassion for nature. Running a business at the expense of forest landowners and farmers stood in contrast to the notion of respect for private property because it implied "doing bad" to the local community. Needless to say—and thus Boliden's managers did not explicitly say it—you cannot destroy what belongs to someone else. It may be that the heritage of this stance in Scandinavia is a historical social structure characterized by a large proportion of self-owning smallholder farmers and a weak aristocracy. Besides, the Swedish nuisances legislation did open for processes against companies in cases when property had been damaged. In this respect, at least, Sweden's experience resembled that of the United States.

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