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July 24-28, 2000

Colorado School of Mines

Golden, Colorado

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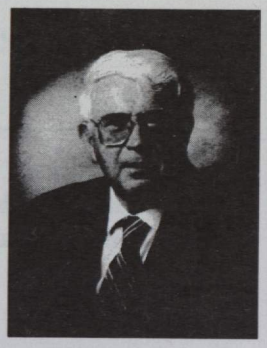


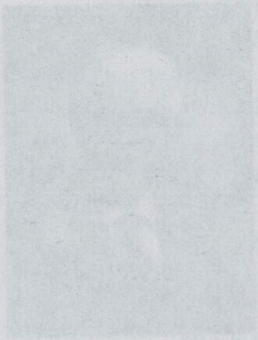
The Colorado School of Mines' community was deeply saddened by the death of Russell L. Wood (E.M., '49) on April 29, 2001. Born in New York in 1927, Mr. Wood was 73. He is survived by his wife of 43 years, Lyn, and their four children. Russ was involved with the School for more than half a century as a concerned alumnus, dedicated Board of Trustee member, benefactor, and friend.

In 1961 Mr. Wood was an engineer with New Jersey Zinc Company, ultimately becoming the company's Senior Vice President. In 1975 he started Gold Fields Mining Company where he served as President and CEO until 1979. For the next five years Mr. Wood was President of the Copper Range Company. He and two partners acquired the company in 1985, which they then sold in 1989. He then served as President and Chief Executive Officer of Asamera Minerals, Inc. until 1992.

Mr. Wood was a devoted alumnus of the CSM. He was appointed to the Colorado School of Mines Board of Trustees in 1981 and served until 1997. He was President of the Board for six of those years. CSM honored Mr. Wood on the following occassions: in 1981 with the Distinguished Achievement Medal; in 1993 with the Melville F. Coolbaugh Memorial Award; in 1996 with the Trustees Emeriti Honor Award; and in 1997 with an Honorary Doctor of Engineering Degree.

Mr. Wood was equally devoted to the mining industry. He served as director of the Colorado Mining Association and was elected as Honorary Member in 1991. He also was a founder of the National Mining Hall of Fame and Museum in Leadville, Colorado.

Beginning in 1994, Mr. Wood and his wife Lyn made a series of gifts to establish the Russell L. and Lyn Wood Mining History Archive at the Colorado School of Mines' Arthur Lakes Library, one of the largest mining history collections in the Rocky Mountain region. Mr. and Mrs. Wood have supported the Library and the School in many ways throughout the years including sponsorship of the 5th Symposium. His death is the loss of a friend, an advisor, and a person who would always make you smile.



The Colorado Fuel & Iron Company's Industrial Empire: Nature, Workers, and the Transformation of Western Landscapes, 1870-1915

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Abstract

This paper examines some of the ways in which the Colorado Fuel & Iron Company transformed the landscape of the American West in the late-nineteenth and early-twentieth centuries. In contrast to existing scholarship that focuses on corporate history or labor-management disputes (particularly the 1913-'14 coal miners' strike and the Ludlow Massacre), this paper argues that the history of CF&I's industrial West, from the company's conceptualization through the 1913-'14 strike, is best understood as the product of three intersecting entities: workers, the company, and the environment. [1]

Introduction

Picture two scenes separated by less than fifty years' time. First image: The year is 1913, and the setting is just over a hundred miles south of Golden, Colorado. Above the flat shortgrass prairies loom the blast furnaces, converters, and smokestacks of the Colorado Fuel & Iron Company's Minnequa steelworks, the only integrated steel mill west of the Missouri River. Inside the buildings and around the yards, more than 5,000 men deploy some of the world's most sophisticated machinery to transform coke, lime, and iron ore into pig iron and steel, then craft rails, nails, bolts, rods, and a host of other important products out of these metals. While dwarfed by its counterparts in the eastern U.S. and Europe, CF&I's plant nonetheless presents an impressive sight, a bustling hive of activity operating twenty-four hours a day, every day of the year. Its appetite for raw materials is voracious and incessant. Over the steel rails connecting the various buildings with one another and with the outside world flows a nearly constant stream of freight cars rumbling in from the far-flung reaches of the American West: ore from southern Wyoming, southern New Mexico, and the Colorado Rockies; lime from quarries southwest of town; coke from the mines and ovens of southern and western Colorado; coal from Canon City and Walsenburg to power the plant's electric machinery. These resources streaming into the Pueblo works represent just some of the work of the 10,000 men laboring in CF&I's extractive divisions. Invisible on the surface but just as essential is another material flowing into the Minnequa works: water, diverted from the San Carlos and Arkansas Rivers, stored in a series of reservoirs southwest of town and Sugarloaf Reservoir near Leadville. Black clouds billow out the smokestacks of the plant, attaching to Pueblo the nickname "Pittsburgh of the West." It is a moniker that townspeople bear with pride, for it signals employment and prosperity. Meanwhile, pipes discharge a polluted stew of wastes into the river downstream, far from the homes of plant managers and foremen but all too close to the sprawling shantytowns inhabited by immigrant laborers. Wielding immense political power on the local and state levels, exercising near-feudal dominion over its company towns, extracting profits from the earth's crust and its workers' labors, CF&I constitutes a vast industrial empire whose only counterparts in the American West are the copper kingdoms of Anaconda to the north and Phelps-Dodge to the southwest.

Now flash back to the 1860s, before there was a CF&I, before any of its predecessor corporations existed, and before the arrival of railroads spurred the industrial transformation of Colorado. Little by little, Native Americans are losing ground to Anglo and Hispano settlers. Pueblo is but a small frontier town, linked by wagon road and cattle trail to the surrounding countryside. Metal mining constitutes the lifeblood of the territory, yet the greatest bonanzas—the San Juans, Leadville, Aspen, Cripple Creek, Creede—lay ahead. Wood, plentiful but dear, is the fuel of choice. Human activities are wreaking ever-greater havoc on the region's ecology: beaver populations are decimated; the herds of bison that once blackened the prairies and mountain parks are dwindling with alarming alacrity; the forests around population centers no longer seem inexhaustible; and mining and processing wastes befoul once-pristine mountain streams. [2] The difficulty and expense of wagon freighting from the Missouri River or the railheads pushing west across the Great Plains renders iron, steel, and the goods manufactured out of them extremely expensive. A peripheral frontier, the region is only tenuously connected to the great centers of industry and capital such as New York and Pennsylvania. There is little hint of just how tied its future will be to these places; little clue of the destiny of smokestacks, steelworks, coal mines, large corporations, and labor disputes it will share with them.

Images of two quite different landscapes have been presented: the first, a mature industrial core; the second, a developing frontier, separated by only forty-five years' time. This paper is an exploration of the transformations these two images bring to mind, and suggests probable explanations for just how these changes came about. The focus will be on the relationship between CF&I and the natural world. How did CF&I transform, destroy, and reconfigure the complex webs of interrelationships we call ecosystems? In turn, how did the hard materialities of nature constrain, channel, and catalyze the actions of the company and the people—owners, managers, and laborers—who comprised it? Finally (and unfortunately only briefly explored herein), what role did workers play as agents or victims of these transformations?

William Jackson Palmer's Vision of an Industrial West

No man shaped the southern Colorado landscape in so many ways as William Jackson Palmer. [3] Though only thirty years old in 1867 when he first set foot in the territory at the command of the Kansas Pacific Railroad Survey, Palmer had amassed an impressive résumé that combined technical proficiency, fluency in modern business management, and real talent as a leader of men. He was a practical engineer trained in Pennsylvania's railroads and coal mines and conversant in the most up-to-date mining, iron-making, and transportation technologies in America and Europe. [4] He had served as private secretary to one of the greatest railroad tycoons of the era, J. Edgar Thomson, and had learned from his boss and co-workers such as Andrew Carnegie how to organize a large firm into functional divisions controlled by managerial hierarchies. [5] When the slave-holding southern states seceded from the Union in 1861, the abolitionist Palmer ignored the pacific dictates of his Quaker faith and took up arms as commander of the famed Anderson Cavalry troop; a highly-respected commander, he advanced up the ranks to brevet general by the war's completion. After northern economic might overwhelmed the rebellion, Palmer's friends in industry turned their attention westward. When they needed an able Treasurer for the Kansas Pacific in its ill-fated effort to build the first transcontinental railroad, the versatile young Palmer was the natural choice. [6] After two years of office duty, Palmer was dispatched in late summer, 1867 to assume command of a party surveying routes and examining resources between western Kansas and the Pacific Coast. As he set foot in Colorado for the first time, Palmer brought to bear all his considerable skill as an engineer, businessman, and leader.

However, a more intangible quality would prove just as important. Palmer, in short, possessed an unusual capacity to view the region not only for what it was, but also for what it could become. He possessed an imagination active enough to conjure up ideas of railroad systems, steel works, and coke ovens out of dry, chaste prairies and forbidding mountains. As he traveled across the landscape on the railroad survey, Palmer began to envision what the West could become. Over the next three years as he continued working for the KP in Colorado, his vision crystallized into a plan of action.

Palmer likely thought of this process as "projecting," a word commonly associated with entrepreneurial endeavors in the mid-nineteenth century. On its most basic level, projecting meant planning or scheming,

but it also connoted presenting for consideration or action, impelling forward, regarding as having some form of reality outside the mind, and casting an image upon a background. [7] Palmer had few equals as a projector; many decades later he would be remembered as "a man of creative intellect, of commanding genius" who possessed "the fertile imagination of a poet." [8] He saw the possibilities latent in both the West's sublime scenery, and its rich resources: precious metals; good coal; fine timber; irrigable soils; fresh air; and clean water.

Building the Vision: The D&RG and CC&I

All that was needed to actualize the region's potential was a railroad, but one quite different from any that had yet been built. First of all, Palmer's railroad would run north and south, from Denver through southern Colorado to the Rio Grande Valley, then to El Paso, and finally through the Sierra Madre to Mexico City. Second, it would master this difficult route through the mountain spine of North America using the latest technology, a narrow gauge of three feet recently pioneered in Britain and embraced by India and Russia for its ease of construction and nimbleness in rugged terrain. [9] And third, this railroad would actively encourage diversified local traffic rather than long hauls from hinterland to metropolis. [10] The management of this new railroad, Palmer imagined, would be novel, too; it would, he wrote, "be all under one's own control with one's friends...the most fitting men should be chosen for the different positions and all would work heartily and unitedly towards the common end.... [A] host of good fellows from my regiment should occupy the various positions of inspectors, agents, clerks, conductors..., etc. for which they might be fitted." A profit-sharing system would be established so that all "should feel as if it were their own business and that they were adding to their store and growing more prosperous along with the Road. They should feel as though it were their own Road and not some stranger soulless corporation.... It would be quite a little family and everybody should be looked after to see that there was no distress among the workmen and their families...and there never would be any strikes or hard feelings among the labourers towards the capitalists, for they would all be capitalists themselves in a small way...." [11] By early 1870, Palmer was ready to enact this vision of a benevolent but paternalistic narrow gauge railroad that would connect Denver and Mexico City and develop viable local economies all along the way. Such an enterprise, Palmer was confident, would have a transformative, even alchemical effect; it would, in short, industrialize the frontier.

A rail line, which Palmer dubbed the Denver & Rio Grande, or D&RG for short, soon linked southern Colorado with Denver; prosperous new settlements such as Colorado Springs developed along the new road. Palmer and his associates parlayed their insider knowledge of planned routes into considerable profits by acquiring large holdings of the finest agricultural, timber, and mining lands at rock-bottom prices, then developing town sites, selling lots, and starting logging and mining subsidiaries. After some heady initial successes, however, Palmer's D&RG seemed to encounter obstacles at every turn. His business and vision were crippled by the following developments: capital evaporated in the 1873 Panic, halting construction of the line at South Pueblo; the Santa Fé line literally cut the D&RG off at Raton Pass, forestalling its growth southward; the arrival of deep-pocketed competitors forced the D&RG to carve out a niche business as primarily a mountain road; and natural forces—floods, locust infestations, snow blockades, and so forth, also impeded the D&RG's growth.

However, by 1880 national economic recovery and the Leadville bonanza's rejuvenating impact on the Colorado economy allowed the D&RG to embark on a building spree that extended its tracks through every major river valley in the southern and central Colorado Rockies and to the edges of Santa Fe, New Mexico and Salt Lake City, Utah. Just as important as this horizontal expansion, Palmer accelerated efforts to backwardly integrate, consolidating several subsidiaries into the Colorado Coal & Iron Company and building the first steelworks west of the Missouri at South Pueblo. With the founding of CC&I, Palmer's seemingly pie-in-the-sky idea of an industrial West began to bear fruit.

CC&I and the Natural World

From its very beginnings, Palmer's CC&I had a complicated relationship with the natural world. On one hand, the company absolutely depended on the bounty of nature, from the fossilized solar energy of coal

deposits to the quenching properties of water at the coke ovens to the slagging capacity of limestone in the blast furnaces. On the other hand, the company's actions inevitably altered the environments around all of its facilities, from the dangerous new underground environments miners created through their toil to the toxic fumes given off in coke production to the soot that rained down on farmers' fields from the smokestacks of the Pueblo plant.

Nature shaped CC&I's business in myriad ways. Post-Cretaceous volcanism, for instance, metamorphosed Colorado's lignite into the full range of commercially desirable coal. As the only company in the West, and probably the United States, to mine steam, domestic, and anthracite coals and produce coke, CC&I found markets from Montana to Mexico and Nebraska to Nevada. The state's low-grade, titanium-rich iron ores, in contrast, presented a constant headache at the blast furnaces. [12] Or consider the manner in which the intersection of seasons and markets shaped work life in the coal regions: the domestic fuel mines of the Cañon City field shutting down during spring and early summer; the high anthracite mines of western Colorado operating only during the snow-free months; and the steam and coking coal mines running almost continuously. [13] Powerful as it was becoming, CC&I nonetheless remained beholden to the natural world and the possibilities and limitations it presented.

In turn, CC&I—as a consumer and marketer of raw materials and as a producer of finished products, pollution, and waste—reshaped the region's landscape and ecology in ways so numerous that only the most obvious may be addressed in this short space. CC&I coal became the primary domestic, steam, and smelting fuel across much of the region, causing a rapid expansion of mining operations and consequent environmental impacts such as surface subsidence above mines, as well as air pollution problems in some of the places CC&I coal was burned. To give another example, the new iron and steel facilities demanded ore, limestone, and immense amounts of water. Wary of depending on others for his supply of these essentials, and perhaps distrusting market mechanisms to provide for their rapid development, Palmer again backwardly integrated, this time into iron-mining, lime-quarrying, and reservoir-building, all of which led CC&I to alter Colorado's environment in ways large and small. Furthermore, wherever CC&I did business, it attracted workers and service industries, contributing to rapid population growth that put increasing pressure on many natural systems; water supplies in this arid region became strained and polluted, game and fish populations dwindled as more hunters and anglers arrived, burgeoning agricultural markets brought the plow to virgin soil, and on and on. Through its day-to-day business, this single firm was beginning to change large tracts of the Mountain West in crucial ways.

However, no firm is an island, and by the 1890's CC&I faced trouble on a couple of fronts. Firstly, its iron and steel operations suffered from poor ore supplies, high costs, and the cyclical nature of demand for rails and rail products. The Pueblo plant produced only intermittently, and barely survived the nineteenth century even with massive subsidies from fuel sales. Secondly, the company found it difficult to keep coal output growing apace with the rapid development of the region, and competitors soon entered the fray. William J. Palmer, despite his visionary tendencies, was fundamentally a solid man of affairs who recognized CC&I's weaknesses and knew when to join hands with his opponent rather than risk a fight he might not win. When the opportunity arose to merge with his main rival, the Colorado Fuel Company, Palmer did not hesitate to accept. In 1892, the two companies combined to form Colorado Fuel & Iron. John C. Osgood, president of the Colorado Fuel Company, became president of the merged corporation. Palmer was now out of the picture for good, but he left the new corporation a complex legacy of wonderful achievements, dashed hopes, and unintended consequences.

Osgood and the New CF&I: Plant Expansion, Paternalism, and Nature

Osgood, a New Yorker who learned the ins and outs of the coal trade as a young man in Iowa, took the helm of a giant-in-the making. [14] The combined corporation operated coal mines in six counties, dominating fuel markets from the mountain mining camps to the Front Range urban corridor to the treeless fuel-starved plains. But just one year after the merger, the U.S. demonetized silver and the country was plunged into the deepest depression in decades. CF&I's consumers, from the smelters who burned its coke to the railroads

who used its rails to the households who depended on its coal, cut back on their consumption of CF&I's products. As the company's growth slowed, Osgood searched for a magic solution that would place the firm on stronger footing.

The plan he developed resembled something Palmer might have dreamed up, and indeed it constituted the logical extension of what Palmer had begun at CC&I. Osgood sought to rectify three main problems. Firstly, the collapse of silver mining and the success of former consumers such as Phelps-Dodge at backwardly integrating to supply their own fuel meant that the highly profitable market for coke was in jeopardy. Secondly, CF&I's iron ore supplies in Colorado, already unsatisfactory, were approaching exhaustion. [15] Finally, the steel plant's small size, outdated design, and dependence on cyclical rail markets meant that the company's largest single piece of working capital ran only spasmodically and produced so inefficiently that the company found it difficult to compete with eastern steel makers despite the high costs the latter faced in shipping their product one or two thousand miles to western markets. [16] CF&I, in Osgood's view, had two choices: either get out of steel making, or commit itself to the business with added vigor.

Given his unyielding character, it is not surprising that Osgood chose to transform CF&I into a large steel maker. He dispatched the company geologist to examine every significant iron ore deposit available in the West. [17] He began to plan a massive expansion of the Pueblo steel works that would internalize coke consumption, lower costs through economies of scale and streamlined production. Product lines were diversified to include more non-railroad items like barbed wire and pipe. Through this process Osgood insured continuous operation to maximize the efficiency of working capital and skilled labor.

The search for iron was successful as CF&I secured rich deposits in Wyoming, New Mexico, and Utah. The company also increased its reserves of coking coal and acquired large supplies of timber for mine props and railroad ties by purchasing the Colorado portion of the Maxwell Land Grant. Expanding the steelworks, however, required much more money than Osgood could easily raise. Though pushing ahead with expansion meant amassing large debts, issuing new stock, and jeopardizing his control over the company, Osgood was resolute that CF&I had to grow to survive. Shortly after most of the expansion work had been completed, however, two of the era's most opportunistic financial families, the Rockefellers and the Goulds, circled in like vultures to snatch control over CF&I from Osgood. Now, ultimate power over the enterprise rested not in Colorado, but at the nerve center of the Rockefeller empire in mid-town Manhattan, New York.

However, whether power lay in Denver or New York changes in CF&I's operations exacted consequent transformations in western landscapes. The company opened its first open pit mine at Sunrise, Wyoming, using techniques and laborers imported from Minnesota's Mesabi Range, as well as glory-hole methods developed to meet the deposit's particular characteristics. [18] Coal mines and coke ovens snaked their way deeper into the southern Colorado foothills, spewing benzene and other toxins, taxing the region's most essential resource, water, voraciously consuming timber reserves for mine ties, and slowly but inexorably subverting local Hispanic subsistence agriculture. [19] The Pueblo works consumed 30-40,000 gallons of water for each ton of finished steel produced, leading CF&I to acquire rich riparian habitat along the Upper Arkansas River and flood it beneath the Sugarloaf Dam. [20] In these and many other ways, CF&I's building boom, rather than distancing the firm from nature, actually reinforced the firm's dependence on the natural world and greatly exacerbated the toll corporate activities levied upon it.

CF&I sought to create a landscape that was productive, profitable, and efficient, but just as importantly it endeavored to produce spaces through which it could exert power over its massive workforce. CF&I wanted not only to manage the land, but also to reconfigure the landscape in such a way as to increase the company's control over its workers. Periodically hampered by miners' strikes and the extreme mobility of the poorly-paid, largely unskilled, immigrant and migrant laborers it relied upon, CF&I embraced paternalistic welfare capitalism as a means of co-opting worker discontent and demobilizing migrants into a more stable and efficient workforce. [21] The company could have achieved the same ends by conceding to worker demands for higher wages, shorter hours, better conditions, and unionization; instead, it largely avoided

work-based solutions and invested large sums on company houses, clubhouse buildings, medical facilities, and company stores. Its motivations for so doing were occasionally innocent, sometimes benevolent, and always self-interested. The company had once allowed workers to erect their own dwellings; now in older camps it replaced these vernacular houses with comfortable but homogenous cottages whose reasonable rents were counterbalanced by a lease provision permitting rapid eviction if the tenant left CF&I's employ. [22] More ominous were the large fences the company placed around its camps, with guards stationed at the gates to prohibit any unwanted visitors from entering, be they suspected union agitators, Lebanese peddlers underselling the company store, Democratic candidates stumping for county and state offices, or officials from state regulatory agencies. Neat rows of company cottages, heavily-guarded enclosures, and the other structures CF&I paternalism produced joined waste heaps, belching coke ovens, smoking stacks, gaping iron mines, denuded hillsides, flooded riparian zones, and so forth as material manifestations of CF&I's industrial empire.

The word "empire" is used advisedly to suggest CF&I's scope; its dominance, its centralized hierarchical structure, its quasi-state status, and the polyglot peoples—white Americans, Hispanics, and African Americans, as well as immigrants from Mexico, Asia, and Europe—who populated its large domain. Yet human beings, and indeed the natural world, too, proved more difficult to manage than the company ever imagined. CF&I, like imperial Rome, soon discovered that the Barbarians were, so to speak, at the gates. Flash floods, warm winters, dust storms, water shortages, and dust explosions caused at least in part by southern Colorado's arid climate and chemically dry coal assailed the company during the 1900's and 1910's. At the same time, workers preserved their mobility, clandestinely set fire to company structures, astutely turned CF&I's paternalist policies on their head, and in these and many other ways, began to forge the bonds of mutual assistance, solidarity, and resistance that would lay the groundwork for unionization and the bloody struggles of 1913 and '14.

Conclusions

In the 1860s, William J. Palmer had imagined an industrial West. He envisioned a place where coal mines, coke ovens, steelworks, and railroads could co-exist happily with sublime nature, where labor would be honorable, justly compensated, and content. It was, indeed, a "stupendous conception," but a deeply flawed one as well. By 1913, CF&I's 15,000 employees, including the thousands of coal miners who went on strike in September of that year, inhabited a much more complicated, much less utopian landscape. In under forty years, CF&I had turned a frontier into its antithesis, an industrial landscape where the steel-framed skyscrapers of great cities, the cozy hearths of homes humble and grandiose, and the seemingly miraculous clatter of steam engines literally driving commerce and industry to new heights came at a considerable cost to the well-being of workers and the environment.

One can interpret CF&I's intertwined cultural and environmental legacies in several ways; thus there are many possible morals to this story. The first is this: be careful what you wish for, because you just might get it. Second, no easy lines can be drawn in the sand to separate the cultural from the natural. Because mining is integrally dependent on nature, and because it inevitably affects nature in ways good and bad, the relationship between mining and the environment constitutes just as crucial a facet of mining's cultural heritage as the diffusion of scientific ideas, the development of new technologies, or the literary, artistic, and material productions of mining peoples. Third and finally, the history of this great state, like that of the rest of the American West, was made not only by cowboys, Indians, desperados, and placer miners, but also by whole swaths of humanity—coal miners, business executives, steelworkers, and lime quarrymen, Italians, Mexicans, African Americans, Koreans, and Slovenians—whose hard, often obscure, but nonetheless important lives as Coloradoans and westerners fit only poorly within the formulaic plot-lines of Hollywood's West.

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1 This paper presents preliminary findings from the author's PhD dissertation, "The Road to Ludlow: Work, Environment, and the Industrialization of Southern Colorado, 1870-1914." This project has been made possible by the generous support of the U. S. Environmental Protection Agency through STAR Graduate Fellowship U-91560901-1.

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17 These explorations "were so thorough that no additional important iron deposits have since been reported in Colorado," a company official reported in the 1930s. "Iron Mining in Colorado," folder 118, CF&I Papers, Uncatalogued MSS.

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20 30-40,000 gallons is an estimate for a modern steel plant in the early 1970s. Thomas J. Centi, "A Survey of Wastewater Treatment Techniques for Steel Mill Effluents," in Julian Szekely, ed., *The Steel Industry and the Environment* (New York: Marcel Dekker, 1973), 170. It is unclear whether the Pueblo plant would have consumed water more or less efficiently than later steel works.

21 The best source on CF&I town-building is *Camp and Plant*. My approach here follows Don Mitchell, *Lie of the Land: Migrant Workers and the California Landscape* (Minneapolis: University of Minnesota Press, 1996).

22 *Camp and Plant* frequently printed photos showing the contrast between the poor houses workers built for themselves and the good houses the company built for them. E.g., *Camp and Plant* 1 (4 January, 1902), 49 and 1 (8 March, 1902), 198-199.

The Relations of the Geologische Reichsanstalt (Imperial Geological Survey) to Mining Activities in the Austrian Monarchy: a Contribution to the Research Project "History of Geology in Austria" of the Austrian Science Fund (Project P12535-SPR)

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Abstract

The year of revolution in 1848 caused some far-reaching constitutional and administrative changes in the Austrian Empire. Starting with the crowning of Emperor Franz Josef I, in December of 1848, a new political age began. A year later, following the proposal of the imperial minister Ferdinand Thinnfeld, the young emperor allowed the founding of the Geologische Reichsanstalt (GRA) (Austrian Imperial Geological Survey), which was combined with a former institution called Montanistisches Museum (Austrian Mining Museum). Mining and the supply of mineral raw materials necessary for the Austrian Empire were the dominant reasons for organizing this publicly supported geoscientific research and geological survey.

Under the management of the first director, Wilhelm van Haidinger, a small staff began the geological field survey of the entire empire. Most of the members of the institute were original staff members of the former Mining Museum, founded in 1835. At this time the Austrian Empire was the second largest state of Europe, making this project an enormous undertaking for the small staff. The documentation of active mining was one of the major responsibilities of Marko Vinzenz Lipold. At the library of the current Geological Survey of Austria (GBA), formerly Geologische Reichsanstalt, 26 field books of this geologist are preserved. Handwritten reports (Sections-Berichte) to the director of the GRA and several colored maps and mining maps still remain in the collection at the GBA library. Many mining localities are registered in Lipold's maps and field books, which are now nearly undiscoverable in the field.

Lipold began his career in mining and gained many valuable experiences. He was made Begehungs-Commissär (field geologist) of the Geognostich-montanistischer Verein für Tirol und Vararlberg, a private society. This indicates he was greatly respected in this field even before the foundation of the GRA. From 1844-1845, he took courses of study from the Austrian Mining Museum under the direction of Wilhelm Van Haidinger. Lipold worked first in the alpine areas of the Austrian Empire, in upper Austria, lower Austria, Salzburg, Krain (now a part of Slovenia), Görz (now Slovenian Nova Goricia and Italian Gorizia), and on the Istrian peninsula. In 1859, Lipold was promoted to chief geologist and in the 1860s, he began geological work in the Czech countries. Still later, he did work in Banska Stiavnica, now Slovakia (formerly Schemnitz).

In 1867, M. V. Lipold was appointed the director of the imperial mining office in Idrija, Slovenia (formerly Idrai, Province of Krain). He was given the title "Hofrat", a typical Austrian title, and before his death was decorated with the Order of the Iron Crown. He died in Idrija in 1883.

Lipold's work was very important for the Austrian Empire. He documented most of the existing coal mining at that time. Most of his maps and sections are still preserved at the Library of GBA. Many of them have never been published because of the small budget of the GRA. Lipold is considered the most important geologist of GRA because he provided the first geologic map of many of the territories of the Empire. He published research results in "Abnhandlungen der Freunde der Naturwissenschaften" (founded by Wilhelm Van Haidinger) and later in "Jahrbuch der Geologischen Reichsanstalt".

By the end of the 19th century the mining activities of GRA declined and a member of the Austrian parliament aimed criticism at the GRA.

On Some Precious Materials of the Library of the Geological Survey of Austria (Geologische Bundesanstalt GBS): a Contribution to the Conservation of the Cultural Heritage in Austria

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Abstract

In 1999 the Geological Survey of Austria (GBA) celebrated the 150th year since the foundation of the Geologische Reichsanstalt (Imperical Geological Survey of the Austrian Monarchy). This year we are also celebrating 25 years of successful reorganization of the Library and Map Collection of the Geological Survey of Austria (GBA). In 1978 archival materials were separated from the main collection and the new special collection Wissenschaftliches Archiv (Scientific Archive) was established. Five years ago it was decided to establish a special collection of graphic materials (portraits, pictures, prospects, sketches, photographs, etc.) The primary goal of the reorganization was the new arrangement of the map collection and the complete cataloging of these materials because until 1975 there was not a catalogue of any kind for the GBA map collection. In the 1970's the cataloguing rules were changed from the Prussian Cataloguing Rules (P.I.) to the modern methodology of the alphabetical cataloguing rules (RAK) which were used in the German speaking countries of Europe. In 1989 the production of card catalogues was stopped and since that time all entries of documents of the Library are computerized within the bibliographic datasystem GEOLIT = GEOPAC. Also the retrospective input of bibliographic entries was started at this time. Today the complete catalogued material of the map collection, the Scientific Archive, and the Graphic Collection is openly accessible to users throughout the world via Internet (http://www.geolba.ac.at). Additionally, GBA began a project to digitize maps and other graphic materials. The improvement of the information in the database and the beginnings of improvement concerning conservation of the collected materials are now possible, especially for precious maps and graphic materials. A practical effect of this effort was the reduction of the handling of the materials and more progressive protection for non-necessary usage by the readership. In this lecture there will be shown some precious materials of the Library of GBA, such as:

- A geological map of Flurl
- A geological map drawn by Pfaundler (1803); one of the first geological maps of an Austrian territory
- A geological map of South American by Foetterle (1855)
- The first world geological map by Ami Boé
- Examples of mining and geological maps of the 19th Century
- A mining map of Idria (Idrija, Slovenia), a mercury mine
- Field books and their illustrations concerning mining in Austria
- Prospectus, sketches, and photographs of geological outcrops
- Portraits of famous geologists such as Eduard Suess
- Manuscripts on mining and the geology of Austria

Links to the History of Regional Geologic Understanding Through the Kansas Geologic Names Database Project

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Abstract

Geologists around the world have contributed to the development of the current stratigraphic nomenclature of rock units found in Kansas, while those mapping the geology of Kansas during the past 150 years have developed the regional correlation of rock units in the state. Their work has contributed essential keys to regional economic development. The Kansas Geologic Names Database project places the early geological surveys of Kansas and subsequent exploitation of identified mineral and petroleum resources within appropriate historical context. Present understanding of the stratigraphic sequence of rock units in Kansas has been linked to past interpretations through this relational database. As in published lexicons, unique applications of names to rock units are specifically identified within the database. This may be a modification from a previous use of the same name (restricting or extending the range of included beds) or a new name for the same rock unit. In each case, the portion of the stratigraphic sequence labeled with a particular name in the past is linked to the name or names currently applied to the same sequence of rocks. However, the resulting database goes well beyond a traditional lexicon of geologic names.

Rock unit names are linked to index maps showing the general geographic extent of surface exposure of rocks. The database structure also permits links to similar index maps of subsurface extent. Unlimited numbers of site-specific occurrences of a rock unit or sequence of units can be entered in the database. Detailed location information can be provided for each site, with pointers linking the database to digital images of historically significant documents describing the location, such as measured sections, or to actual digital photographs of the rock unit at that location. The database currently contacts locations of type sections (stratotype) for hundreds of named rock units. In numerous cases the defining type section of a rock unit is associated with exposure at quarry or mining operations. Digital images can be used throughout the database to improve understanding of the historical significance of rock units. Photographs of quarries or mines can be linked directly to the associated rock unit as well as to bibliographic data on the source of the photograph. The scanned digital image of an early geologic map can be linked to the important geologic units shown on the map. Each polygon in a modern digital geologic map database, representing an interval of one or more units, is linked to a name describing the mapped interval in the database. The name of the mapped interval is then linked to the descriptions(s) of each unit within the interval.

Mining History in Contemporary Mining Songs (Critical Folk/Pop Songs in the 2nd Half of the 20th Century)

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"In the event of something happening to me
There is something I would like you all to see
It's just a photograph of someone that I knew.

Have you seen my wife Mr. Jones
Do you know what it's like on the outside?
Don't go talking too loud you'll cause a landslide. Mr. Jones..."
(The New York Mining Disaster 1941 [1])

This early Bee Gees' song from the mid sixties provided a major stimulus for my research into mining and geoscience as a theme in contemporary music history. Another source of inspiration was Mr. Partsch's lecture on the "mutual effect between mining and music" given at the 1995 Leoben Symposium. Actually, my reflections can be seen as a sequel to his talk.

Mining songs from the 2nd half of the 20th century make political comments on the countries and cultures in which they were produced. An essential defining characteristic of these songs is that they want to attract attention to inhuman working conditions. In doing so, these songs aim to promote critical insights. As a genre, such songs are part of a music tradition which by and large has resisted its commercialization. Recently, there has been a decline in interest in such music as far as major record companies are concerned. One can see this development as a result of economic interests aiming for a maximization of record sales.

In the United States, singers and songwriters like Woody Guthrie, Hazel Dickins, Aunt Molly Jackson, Phillis Boyens, Pete Seeger, Merle Travis and Sarah Ogan Gunning have established a tradition of mining songs which spans a whole century and which came to a peak at the time of the great depression in the 1930s and was continued in the following 30 years.

Guthrie's song about the "Ludlow massacre" of 1914 when miners, their women and children died in defending their homes is a well known example for the social conditions of the mine workers as well as the Calumet, Michigan, massacre the year before.

Sarah Ogan Gunning (1910-1983) was one of fifteen children in a miner's family in Kentucky. During her years in New York she met many of those who became great folk singers later on : Pete Seeger, Burl Ives, Huddie Ledbettel, Earl Robinson, Will Geer, and of course Woody Guthrie who penned an affectionate portrait of his friend Sarah for the "New York Daily Worker" in 1940. Four years before her death she wrote the

song "Hello, Coal Miner." [2]

"Hello, coal miners, I'm so proud to be your friend
For the finest folks I ever knew were coal mining women and men
Were coal mining women and men...."

As shining examples for the next generation they appeared up to the eighties of the last century. In 1984 the song collection "They never keep us down: Women's coal mining songs," performed by Hazel Dickins, the Reel World String Band, Sarah Ogan Gunning, Phillis Boyens and Florence Rees represented three generations of American coal mining people. In the 1960s a new generation of musicians (e.g. Phil Ochs, Tom Paxton, The Bee Gees) contributed their share to the continuation of this tradition. Phil Ochs, one of the most remarkable singer/songwriters of this generation, made fine songs about coal mining in Kentucky. One of them is called "No Christmas In Kentucky." [3]

"There's lots of toys for children when the Christmas time is near,
But the present for the miners is a stocking full of fear.
In the dark hills of Kentucky, there's one gift that may be found,
The coal dust of forgotten days that's lyin' on the ground...."

The best known and most popular singer/songwriter of this generation is undoubtedly Bob Dylan who was a great admirer of Woody Guthrie.

Canada also possesses a rich tradition in mining songs. Its cultural and linguistic diversity has led to a wide spectrum of interesting mining songs. "And now the fields are green," [4] for example, is a brilliant collection of Canadian coal mining songs featuring artists such as The Men in the Deeps, Rick Fielding, the Steve Earle Band and the Chansons macaroniques.

The "Music of the Mines" is one of the most famous albums made by the Men of the Deeps. They have been moving audiences since 1967. The choir consists of 28 miners or former miners ranging in age from 23 to 84. They are still best known as the inspiration and back-up singers for Rita McNeil's hit song, "Working Man."

Mining songs have also played a significant role in Australian folk music since 1945. Good examples are Ron Edwards' Australian Folk Song Book [5] and the CD "Union is Strength" (produced by Peter Hicks and Geoff Francis), both including a considerable number of mining songs. Peggy Seeger, Ewan McColl, Peter Hicks and Tony Davis have also sung about topics related to mining. Davis' song about "The Miner" [6] is an example of songs that illustrate the Australian gold mining tradition and the workers condition.

"Digging holes in the ground where there's gold to be found
And most times where gold it is not
A man's like a rabbit with this digging habit
And like one, he ought to be shot."

Europe's tradition in mining songs had its heyday before the 20th century. Although some singers (e.g. Tom Jones) were miners themselves before starting their musical career, only a few performers still keep this tradition alive. One of the best known contemporary singers is Englishman Billy Bragg who in his songs has commented on the early 1980's miners' strike in UK. Outside Britain, some passages about mining can be found in Flamenco music—the Las Minas-Mining songs for example—French chansons—like Jean Ferrat did—and even in German songs. Herbert Groenemeyers "bochum" is a wonderful description of his hometown: [7]

"Du hast'n Pulsschlag aus Stahl
Man hoert ihn laut in der Nacht

Du bist einfach zu bescheiden
Dein Grubengold hat uns wieder hochgeholt
Du Blume im Revier...."

In African and Latin American music the exploitation of workers and natural resources has been addressed in some folk songs. Milton Nascimentos "Tambores de Minas" (about the mines of Minas Gerais in the southern interior of Brazil) is one of the most exciting releases from Latin America. Carol Cooper writes:

"The undeniable passion in Milton's music is palpably more of the spirit than the flesh... Nascimento recently claimed that his approach to timbre and tonality is different because the black working classes of Minas historically laboured in dark, claustrophobic mines rather than out in open fields, an environmental factor that shaped the sonic attitude of drums and vocals in Minero folk music." [8]

Finally, the tradition of mining songs lives on in contemporary rock music. References to this theme can be found in the songs of Randy Travis, the Cowboy Junkies, Whiskeytown and U2.

"From father to son
The blood runs thin
See faces frozen still
Against the wind
The seam is split, the coal face cracked
The lines are long, there's no going back
Through hands of steel and heart of stone
Our labour day has come and gone."
(From U2's Red Hill Mining Town) [9]

An interesting soundtrack from the film "Out of Darkness: The mine worker's story" was performed by Tom Juravich in the 1990's. Richard Trumka, President of the United Mine Workers of America noticed, that this is "some of the best coal mining music you will ever hear... Tom's music makes our history come alive."

The final example discussed in this paper is the legend of the "Merman." This song is about a legend which explains how a place in Austria—Eisenerz—became a mining area.

Many, many centuries ago fishermen near Eisenerz caught a merman in Lake Leopoldstein. To become free again, he offered the fishermen three choices: to have gold for one year, silver for 100 years or iron forever! They decided for iron and made Eisenerz the best known mining area in the Steiermark (which is one of Austria's nine provinces). Iron ore has been the main source of income for people living in this region.

High as the Sky (The Merman) [10]

"Three dawns ago when we pulled in our nets
We thought we had landed the best ever catch
It took us till midday to get it ashore
Yet what came to light we had not seen before.

The tail of a fish, the rump of a man
A giant in size, his hair a long mane
He trembled with fear avoiding our eyes
The mountains around us they joined with his voice.

Refrain
Please spare my life let me live
And in return I will give you
Iron as high as the sky, high as the sky.

He pointed behind us where the mountains stood tall
On the one in the middle his eyes they did fall
He said this would be our mountain of ore
With minerals rich from the crust to the core.

Driven by greed, some of us asked for more
For diamonds and gold and for silver galore
He trembled with fear, avoiding their eyes
The mountains around us they joined with his voice

If I give you gold before long
Your riches and wealth will be gone
While you can always rely on iron as high, high as the sky.

We cut the nets and the merman was safe
He quickly returned to the bottom of the lake
The next day we checked what the creature had said
The mountains grey colour had changed into red.

Refrain
Please spare my life let me live
And in return I will give you
Iron as high as the sky, high as the sky."

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Cultural Influences of Immigrants in the Hard Rock Mining Industry, Colorado, USA, 1860-1900

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Abstract

The metal mining booms of the late 1800s in the western United States drew large numbers of people to the region. These populations surged through the mining camps of Colorado, Nevada, Idaho, California, and other states. Foreign-born miners, mostly from Europe, comprised a significant part of this group in Colorado. Skilled immigrant miners such as the Cornish and unskilled mine workers from many other countries contributed to the industrialization of the mining industry in the region. Immigrant miners also played an essential role in defining the cosmopolitan nature of Colorado's hard rock mining camps. Towns grew almost overnight and larger towns developed ethnic enclaves of Cornish, Irish, Germans, Italians and others. In the setting of a small mining community these immigrants, along with native-born Americans from a wide variety of backgrounds, created an environment unique to the West.

In turn, the characteristics of Colorado's hard rock mining industry shaped the extent and nature of immigrants' cultural contributions. Mountain mining towns were geographically isolated and almost entirely dependent on local mining and smelting. Failure of nearby mines, the closing of a smelter, or the diversion of a rail line could kill a community almost overnight. Direct cultural impacts from foreign-born miners were therefore strong only as long as local mining prospered. Denver, as a transportation hub with a strong economy, was able to retain larger immigrant populations and sustain cultural identities over time. With the fading away of the mining towns, the immigrant miners' contributions to Colorado's hard rock mining culture are best recorded in the literature and mining history collections in archives and libraries of the region.

Introduction

The discovery of gold in the placer deposits on the eastern foothills of the Rocky Mountains in the late 1850s marked the start of a series of gold and silver "rushes" to the Colorado Territory. In addition to would-be miners, others came to provide supplies and services by trade or agriculture. All of these groups included immigrants to the United States. In the mid and late nineteenth century, millions of immigrants came to the US in two "Great Waves": the first composed mostly of English-speaking northern and central Europeans; the second of non-English-speaking eastern and southern Europeans. Approximately 200,000 Chinese also arrived in California between 1860-1882 [Flanders 1998]. Some immigrants were miners with experience in their native countries or in metal mining regions elsewhere in the US; others were inexperienced laborers who saw Colorado as an economic opportunity. Regardless of their motivations, immigrants provided much of the manual labor that fueled Colorado's development and brought their customs and cultures to mix with the already varied customs of native-born miners.

Colorado's Mining Industry And Immigration

At the time of the gold discoveries in the Colorado Territory this region was an "unknown" to most people in the US, isolated and sparsely inhabited by strange peoples. However, Colorado could draw on railroad

transportation and provisions from neighboring territories and the mining booms and busts promoted extensive population movements [Meinig 1998]. These in turn promoted a non-cohesive population with a wide variety of cultural backgrounds, ripe for change and new development.

The first prospectors included immigrants who, like their American counterparts, were mostly laboring-age males, single and unskilled at mining. Women of all emigrant ethnicities were scarce in Colorado; more so in the mining camps. In California Gulch in 1860 there were 2,000 males to 36 females [Goodykoontz 1946]. According to the US Census of 1860, which includes data on the Pikes Peak region, the foreign-born represented 7.7% of the region's small emigrant population. This figure for Colorado rose to over 16% in 1870, and peaked during the 1880s and 1890s (the lead-silver mining booms years) to about 20% of the population, above the national average of 13-15%. In the mining counties, the percentage was greater: by 1870 the immigrant population in Clear Creek County was about 24%, in Gilpin County about 32%. The population of the town of Leadville was nearly one third foreign in 1890 [US Census 1880, 1890]. However, by 1900 the mining industry and the percentage of immigrants in Colorado was on the decline.

Up until about 1900, immigrants to Colorado came mostly from England and northern and western Europe. The majority were from Cornwall, Wales, Ireland, Canada, Germany and Scandinavia. The Cornish, or "Cousin Jacks," arrived in numbers with the first miners and continued to emigrate to Colorado until the hard rock mining industry began to taper off in the early 1900s [Bancroft 1944]. By 1880 over 23% of the population of Gilpin County claimed English birth; another 9% claimed Irish or German birth. There was a large Chinese placer mining camp below Blackhawk in the 1870s and by 1880 the Census recorded about 600 Chinese in Colorado, making them the ninth largest immigrant group. There were over 120 Chinese in Gilpin County alone [US Census 1880; US Census 1890; Goodykoontz 1946]. Chinese miners, some with years of experience in the California gold fields, were prohibited from most hard rock mines in Colorado and instead used their expertise to work regional gold placers for profit [Ourada 1952; Zhu 1999].The Chinese numbered about 1,400 in Colorado by 1890 but were driven from the mining towns by residents fearing economic competition.

The early miners rapidly exhausted the "easy workings," the placer and surface deposits. The deeper diggings and complex sulfide ores required skill and capital to exploit and experienced miners such as the Cornish found themselves in demand. The unskilled could work as support crew, road builders, smelter workers or freight haulers until they gained enough experience to work underground. As mining in Colorado increasingly required capital and mechanization to exploit the more complex mineral deposits, industrialized mines employed larger numbers of men, creating a demand for unskilled immigrants hired at lower wages. Italians and Austrians, arriving through the late 1800s, were the seventh and eighth largest immigrant groups respectively by 1890 [Goodykoontz 1946]. An early Central City resident complained that "the old homebrew had given way to the 'Chianti' of Italy and that names ending in 'ini' appeared on store signs where once were the names Polglase or Trelawney" [Perrigo 1937]. These "Tyrolese" numbered over 500 in Gilpin County by 1900. Although the heaviest immigration of Slavs came later, by 1900 there were about 2,000 Slavs living in Colorado [Kedro 1977]. (The term "Slav" was used to refer to Poles, Slovaks, Czechs, Slovenians and others from nearby regions of Europe.) Many were employed in Colorado's smelters or in the coal mines, work more dangerous and lower in status than hard rock mining. In addition to mine labor, immigrants, particularly those from Cornwall, Wales and Germany, brought metallurgical skills from Europe, invested in the mining industry, and operated businesses and trades in the mining towns.

The Colorado Hard Rock Mining Town

Colorado's mining towns were cosmopolitan in nature despite their geographic isolation from other towns and were much more "urban" than the traditional small town. Both immigrants and native-born Americans came from a wide variety of cultural backgrounds, forming a culturally heterogeneous community. Repeating patterns in other communities, foreign-born miners congregated together where possible. Large mining towns were often a mosaic of ethnic neighborhoods. These neighborhoods provided comfort in the culture, language and foods of home; they eased the transition to American culture; they supplied entertainment and a support network for miners in need. In the environs of Central City in the late 1800s, Russell

Gulch was predominantly Welsh; Nevadaville had a large Irish population [Southworth 1997]. Most of the English immigrants in Blackhawk, Mountain City, Central City, Russell Gulch and Nevadaville were Cornish and so numerous that they did not separate into ethnic enclaves until around 1900 [Bancroft 1944; Perrigo 1937]. There was a Chinatown (the placer camp) in lower Blackhawk in the late 1870s and early 1880s; Leadville had its Finntown [Southworth 1997].

Figure 1. A saloon in Leadville, Colorado, between 1880-1910. A poster on the wall advertises the Zang Brewing Company; many regional breweries were established by German immigrants. Photograph X-294 courtesy of Denver Public Library Western History Collection.

Mining towns were not "melting pots" in that people did not forget that they were Irish, German, etc. Where possible they hired their own countrymen, organized their own societies and churches, and patronized their own saloons. Saloons deserve a special mention because of the role they played as a cultural center for ethnic groups. In addition to providing liquor, saloons were a refuge from the hard labor, dangerous mines, and barren housing available to single miners (Figure 1). Miners sang national and folk songs there and told tales to entertain themselves. Many ethnic societies met in saloons and tried to provide ethnic foods and newspapers [Kedro 1977; Noel 1977]. Even when ethnic populations were too small to organize, individuals contributed to the local culture by their very presence. In a Colorado mining camp of the time you could work a stope with an Irishman and a Swede, hear Cornish miners singing in the saloon, buy supplies from the German storekeeper, and hear the accents of a half dozen others on the street.

Miners traveled to neighboring towns or to Denver to participate in ethnic events, and maintained contacts with people in their native countries, sending money home and urging relatives and prospective brides to join them. The newspapers of towns with large Cornish populations even published rates of money exchange and postal money order charges to facilitate communication with family in Cornwall [Stratton 1953]. Denver, as the largest population center in the region and a transportation hub, was a ready source of immigrant group contact. At the time Denver supported ethnic and foreign-language newspapers, churches, and social organizations, and drew large crowds from the region for ethnic celebrations. Denver newspapers reported on ethnic events, allowing immigrant miners in the isolated mining camps to hear news of their urban countrymen's activities.

There was friction between ethnic groups but the greatest underlying source of conflict was labor. Incoming immigrants, often unfamiliar with local labor practices and willing initially to work for lower wages, competed economically with those already in Colorado. Although immigrants were active participants in Western labor movements and were often targeted as troublemakers by mine management, they were also targeted as threats by fellow workers. Economic conflict influenced cultural interactions with native-born Americans and between immigrant groups, especially involving the Chinese. Customs became part of a "negative" package that defined a group's alien-ness to others; rivalries were reinforced. However, a shared culture promoted cohesiveness within a group facing a hostile community or company. In a community of minorities, mining became the common factor both drawing people together and pulling them apart.

Figure 2. Central City Opera House, Colorado, 2000, showing the building's Cornish stonework. Copyright L. Dunn.

Immigrant Groups and Cultural Contributions

Given the nature of the Colorado mining town and its inhabitants, there are few remaining physical artifacts reflecting multicultural influences. The more successful mining towns such as Central City supported permanent structures, some of which survive today. The Cornish brought skills in stone dressing, exhibited in the dry stone walls terracing the steep hillsides of the Central City area and in the stonework of the Central City opera house (Figure 2) [Rowse, 1969 p.11]. Other immigrants surely embellished their homes in familiar styles with available materials. However, much of what was created was utilitarian, discarded when no longer useful. More information survives in newspapers, correspondence, recorded oral histories and photographs in regional libraries and archives. These describe immigrant organizations, entertainments, food and stories.

Organizations. Organizations and societies were critical to the immigrant community. Benefit organizations provided insurance and aid; clubs helped preserve culture and language by sponsoring social and educational activities; some promoted religious and/or political goals. The entire community was invited to public events. Denver-based societies extended aid to immigrants in smaller towns. Immigrant religious congregations often served much the same secular purposes as ethnic societies, providing aid and cultural comfort. However, established churches were more likely to side with management in mine labor disputes [Cochran 1980]. Small immigrant groups attended whatever church was available, but separate churches were established where possible to provide the familiar liturgy and cultural environment.

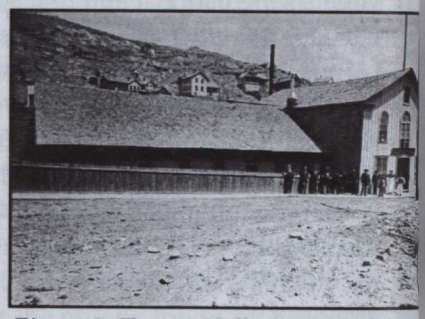

Figure 3. Turner Hall, Central City, Colorado, in the 1890s. The architectu plain and utilitarian, like most town b ings. Photograph K-289 courtesy of Denver Public Library Western Histor Collection.

Some of the most prominent organizations in the region were the German Turnvereins which flourished in Colorado by the 1870s (Figure 3). The "Turners" and other German societies actively promoted German culture and language, and encouraged music, theatrical performances, dances, athletics, and exercise as wholesome entertainment [MacArthur 1917; Leonard 1977]. The English, Scots and Welsh formed a number of organizations such as the St. George's Protective Association, the Caledonian Club, and the Cambrian Club to perpetuate their culture [Leonard 1977]. These groups held picnics, balls and socials, and celebrated national days. Denver citizens and visiting miners were treated to the Scots' celebration of Robert Burns' birthday in the 1880s, complete with bagpipes and men in kilts dancing the Highland fling [Westermeier 1951]. The Irish established societies in Denver as early as 1865 and had formed a number of organizations in the region by the 1880s. Although some of these societies were primarily political, many encouraged Gaelic literature and music, sponsored lectures, held balls, and promoted events on St. Patrick's Day [Leonard 1977; Westermeier 1951; Noel 1977]. Other immigrant groups, including the Scandinavians, Italians and Slavs, organized societies as well.

Figure 4. Independence Day (4th of Ju parade, Central City, Colorado, in the 1890s. Photograph X-2994 courtesy of Denver Public Library Western Histor Collection.

Entertainment. Ethnic societies promoted both professional and amateur entertainments for themselves and their community. Immigrant groups were a very visible part of community celebrations: they joined in parades and performed at events. The Cornish were famous for their singing in this respect and were also known for sponsoring brass bands to play music [Rowe 1974; Stratton 1953; Bancroft 1945; Perrigo 1937]. Parades were a popular form of public celebration. July 4th, Independence Day, was a time of general celebration in almost every mining community and immigrants participated enthusiastically (Figure 4). Christmas holidays were celebrated by many nationalities, again with folk songs and traditional hymns. Cornish 'curlers' (carolers) sang in the Caribou Mine in Caribou and in the mine shaft houses, homes, and streets of Central City. The English and other Europeans burnt Yule logs, decorated trees, and gave gifts to children in the com-

munity [Stratton 1953; Bancroft 1945]. Other celebrations practiced by immigrants included May Day by Cornish children [Bancroft 1945], St. Patrick's Day by the Irish [Noel 1977], Eisteddfod by the Welsh, Robert Burns' birthday by the Scots, Columbus Day by the Italians, the New Year by the Chinese [Westermeier 1951]. These celebrations often became community-wide events. Chinatown in Denver was the scene of drinking, feasting, and almost continuous fireworks for three days to celebrate the New Year [Westermeier 1951] (Figure 5).

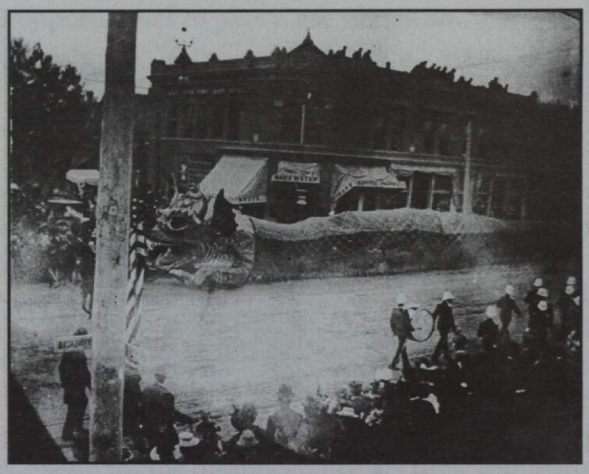

Figure 5. Chinese immigrants and a Chinese dragon, Festival of Mountain and Plain parade, Denver, Colorado, 1896. Photograph X-22071 courtesy of Denver Public Library Western History Collection.

Sporting competitions were very popular. The English and especially the Cornish promoted wrestling matches, dog races, horse races, and foot races and introduced cricket to the mining camps. Competitions were a way to address ethnic rivalries "non-violently" and the Irish and Cornish in particular competed extensively in the mining towns of the 1870s in wrestling matches and rock drilling contests [Stratton 1953; Perrigo 1937]. Rock drilling contests were the creation of the mining towns, accompanied by community celebrations, betting, and much drinking (Figure 6). The Cornish were prominent competitors but other immigrant groups competed successfully against them. The crowd cheered their favorites, often along ethnic as well as geographic lines. In the 1880s two small Cornishmen from Idaho Springs were champions for years and had a large following of their fellow countrymen [Crossan 1934].

Figure 6. Miner's drilling competition, Leadville, Colorado, between 1891-1900. Miners competed to drive the deepest hole in a block of local granite. Photograph X-60048 courtesy of Denver Public Library Western History Collection.

Food. Colorado's foods today are more of a modern development than an inheritance of the ethnic mining community, although immigrants in Denver made a significant contribution. In the mining camp, miners of all cultural backgrounds mostly ate what was cheap and readily available: a monotonous diet of hard bread, beans, pork and beef, local game, canned and dried fruits, occasional root vegetables such as potatoes or turnips, and coffee (Figure 7). Most miners lacked cooking skills or ingredients for much more. Ethnic foods that used preserved or local ingredients and were easy to prepare were the obvious survivors. Welsh "dampers," a dough of flour, water and salt, cooked on wood coals [Conlin 1986 p.181], could be prepared in a primitive camp by the unskilled. The Cornish brought a number of dishes to Colorado mining camps. Most well known is the pasty, often called "a letter from home." The pasty is a mixture of root vegetables and meat folded in a dough envelope and cooked—pasties are still around today. Other Cornish dishes from locally available items include potato and onion pies, scalded cream and treacle, and dried fruit puddings and pastries [Conlin, 1986 p.182; Bancroft 1945]. An exception to this diet was that of the Chinese, who somewhat successfully maintained a varied menu resembling their native dishes and were more likely to cultivate garden plots near their dwellings for fresh vegetables [Zhu 1999].

Imported foods were available if the demand was high enough. The Cornish created a market for "saffern" (the spice saffron) for their breads and pastries [Perrigo 1937; Bancroft 1945]; the English strengthened the demand for teas. Jewish immigrants sent away to Denver for matzoh and kosher meats if none were available locally. The Chinese imported foodstuffs including fish and rice. Most miners, however, without wives

Figure 6. Miners at a cabin, Colorado, ca. 1899; cooking conditions were primitive. Photograph X-61357 courtesy of Denver Public Library Western History Collection.

or mothers to cook for them, found better cooking in boarding houses, saloons, or restaurants in town. These establishments may have offered familiar foods such as Italian breads, German pastries and sauerkraut, kosher foods, and imported wines and beers [Noel 1977]. "French" dishes, mostly familiar foods covered with sauces, were very popular even though not very French. Both Georgetown and Idaho Springs in Clear Creek County had a "Hotel de Paris" in the 1870s, Georgetown's Hotel de Paris was actually run by a Frenchman noted for his cuisine and imported wines [Southworth 1997]. Although not numerous in Colorado mining towns the Chinese, barred from most trades, operated restaurants catering somewhat successfully to Westerners [Conlin 1986].

Language, folktales and superstitions. Immigrants brought their language and words with them to help give the mining towns their cosmopolitan feel. Cornish and Irish brogues were well known in the mining towns, as were Scandinavian, German, and other accents. The Cornish, as experienced miners, contributed a number of terms to the mining profession, described by Bancroft [1945], Todd [1967], Rowe [1974] and others. Many mining terms, such as winze, adit, lode and gossan, survive today. Non-mining terms included vittles (food), crib (lunch), run (creek), and phrases such as "close the door 'ome." Although it is likely that foreign language obscenities were widely disseminated in the mining towns, they did not receive coverage in the literature of the time, being far too inappropriate for respectable Victorian society.

Immigrant groups were a rich source of folktales, jokes, and superstitions. Jokes and stories tended to make fun of immigrants and emphasize their ignorance or ethnicity. Although often told by native-born Americans, some groups adopted stories about themselves as a source of ethnic pride. Bancroft [1944; 1945] and others record a number of Cornish "plods" or stories. Recorded ethnic jokes and stories are one of the few remaining means of determining how immigrants saw themselves, how they saw others, and how others saw them.

Immigrant superstitions supplemented those brought by native-born Americans and are recorded more often in the literature than other cultural contributions. They are frequently associated with accidents in the mine, a real and deadly danger. Although many miners shared them, the Cornish are credited with originating most of the superstitions common in the hard rock mines of Colorado. These included the beliefs that rats underground or a horseshoe affixed to a mine entrance were lucky; that whistling in the mine, measuring an ore vein, certain behaviors of birds, or women in the mine were unlucky [Stratton 1953; Bancroft 1945]. Belief in dream revelations and hunches warning of disaster were common, as was a belief in omens, ghosts, and the ability to "ill-wish" someone. Spirits such as tommy-knockers and whistle-cats varied somewhat from those in Europe, but they still hid tools and played pranks, and could turn malicious if shown disrespect. Superstitions with ethnic origins were still circulated in Colorado's hard rock mines as late as the 1930s, but many of the miners supplying the tales were careful to point out that they themselves didn't believe, or that younger miners didn't believe any more. Superstitions were told as "tales" or jokes, and the tommy-knocker had transmuted to the "guy in the red shirt" or the "little brown men" [Bancroft 1945].

A Central City Cornish miner may have been buried by members of the numerous Cornish community there, carried on the shoulders of fellow miners to the cemetery, and sung to his grave with Cornish hymns as they did in the old country. Others, however, were probably buried with minimal traditional ceremony. Domestic customs and superstitions involving subjects such as christenings, children and burials were present but played a lesser part of the stories recorded about the Colorado mining town. The lack of immigrant

women and families in many mining camps meant fewer opportunities to pass these stories on.

Conclusion

In the isolated Colorado mining towns, where supplies had to be shipped in at considerable cost, people lived in simple shelters, dressed the same, and ate much the same food. However, when they had the opportunity they sought the familiar cultural trappings of their homes in food, music, and association with others. Immigrant miners are referred to repeatedly in the records of the time. However, their cultural contributions are not as well recorded. The actual size of immigrant groups in many camps and towns was small. There was a lack of women and families of shared ethnicity—women created permanence in the community and were often the ones who prepared special foods, directed observance of family ceremonies, and reared children in the religion and customs of their native country. Where immigrant women and families settled, ethnic customs and culture persisted longer. In the small mining towns, the customs that did survive were those associated with work in the mines or those that the mining men could easily engage in: singing; fraternal societies; and work-related superstitions. The primary reason for the disappearance of ethnic influences, though, was the impermanence of the Colorado mining town and the transient nature of the majority of its inhabitants. "When mining at Caribou began to dwindle in the late 1870s and then almost completely folded up in the 1890s, the Cousin Jacks [Cornish] faded and disappeared with the same rapidity as did the town" [Stratton 1953]. Bancroft [1944] reports that in her time the rich ethnic diversity of Central City in the 1800s had all but disappeared. Those immigrants who stayed in the small Colorado mining towns through their booms and busts faced the same problems retaining cultural identities as immigrants elsewhere, even cohesive immigrant groups in Colorado's coal mining towns or in Denver. It is left to the literature and photographs of the time, available in libraries and archives of this region, to record the immigrant cultural presence in the hard rock mining towns of Colorado.

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Biographical Dictionary of Women in the Geological Sciences

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Abstract

The sources used in creating a biobibliography of 50 prominent and obscure women who have contributed to the development of the geological sciences since the 17th century include the small scholarly literature, bibliographies of geology, obituaries, periodical articles, traditional reference sources, archives and the World Wide Web. Women contributed during the "pre-professional" period of the 19th century as collectors, writers, illustrators, stratigraphers and essential assistants. The gold rushes in North America succeeded because of the support provided by the female participants. By the 20th century women had entered the profession and have gradually overcome a number of barriers, especially exclusion from fieldwork, while making unique contributions to the discipline. Further research is suggested: on early professional workers, the activities of prospectors and the role of women during World War II.

Introduction

The biographical dictionary, a work in progress, is based, in part, on a database of information on women geologists created by Dr. Barbara Sherriff of the Geological Sciences of the University of Manitoba. I felt it might be useful to create a reference resource consisting of a sample of 50 women who contributed in some unique or important way to the geological sciences, with the aim of providing as much source information as possible about each person. The choice of women is idiosyncratic and geographically limited. Because the literature is mainly in English, there is heavy representation of women from Britain and North America with some representation from Europe and Australia. An attempt has been made to ferret out some women obscured by time, to include some who are more renowned for other accomplishments, some women who typify workers in their specialty and, of course, the most renowned. All of the women are deceased. The earliest was born around 1600 and the most recent died in 1997. Each entry consists of the following: a biography varying in length from a few paragraphs to several pages; a list of memberships and awards; a selected list of publications, if any, and a bibliography of sources of information about the person, including the location of archives of papers and correspondence.

The purpose of this biographical dictionary is twofold: to pique interest in the persons by briefly describing their lives; and to provide as much source information as possible for students and scholars who wish to do further research. One might ask, why focus on women in geology? Stephen Jay Gould has referred to scientific women, in the 19th century in particular, as the "invisible women." [1] This is particularly true of workers in geology who were fewer in number than women working in botany, a more acceptable field of pursuit. This invisibility of women in the geological sciences has been perpetuated by some scholars of female scientific history as well as by compilers of biographical dictionaries of women in science, who include only the most famous women geologists. I hope that my work and that of others will help to correct this.

Sources

1. Scholars of the history of women in science. The literature is small; nevertheless, I have relied heavily on the sources cited by scholars. Well aware of citation error, I have verified as many citations as possible. The publications of Dr. Mary Creese [2] have been a very rich source of biographical and bibliographical information. She analyzed the lives of 19th century British and American scientific women who had published in journals indexed by the Royal Society. The articles of Michele Aldrich on American women and Marianne Ainley on Canadian women have been very useful sources of leads and references. [3] I have also relied on the work of scholars who have focused their work on one particular woman, for example, Hugh Torrens' work on Mary Anning. [4]

2. Bibliographies and biographical dictionaries. William Sarjeant's *Geologists and the History of Geology: An International Bibliography* is invaluable for providing a good start for tracking down biographical references. [5] Biographical dictionaries, national encyclopedias and directories have been useful for the more prominent, well-known women, particularly 20th century women. One cannot rely on these traditional sources for less than famous women; although, entries on their husbands are sometimes helpful. Therefore, I have relied heavily on periodical indexes.

3. Periodical indexes. *The Bibliography of Geology* (GeoRef) is an excellent source of publications written by the women and articles about women in the geological journals. I have also searched a number of indexes in a variety of disciplines and have found relevant articles in general magazines and journals of their times, as well as in scientific journals, history journals, women's studies journals and so on.

4. Obituaries. The richest sources of biographies of 20th century women and lists of their publications are the memoirs and obituaries in Association and Society journals and issues of journals dedicated to their life work. With the exception of a few "major" newspapers, which are covered in indexes or produce their own, I have neglected the newspaper obituaries. This is simply a case of lack of access to local indexes or local libraries and newspaper "morgues." (Many newspapers are not indexed at all.) I have left it to future researchers to track down newspaper obituaries.

5. Archives. Where information about a particular woman is thin, I have corresponded with archives in order to find out more about her. I have also consulted archivists when facts need clarifying. I have met with some success, as the archivists have been very helpful and enthusiastic. University and museum archives are good sources for articles published in unindexed alumni publications or in-house journals. I have attempted to find information about where papers are deposited by consulting directories and obituaries.

6. The World Wide Web. Apart from the indexes and full-text journals subscribed to by University of Manitoba, I have found very little reliable, verifiable and scholarly biobibliographical information on the World Wide Web. The exceptions are sites such as the *Dictionary of American Biography*, which includes excellent biographies of Florence Bascom and some of her students, and the Australian site, *Bright Sparcs*. [6] A few institutions (museums, archives, etc.) have mounted biographies of women; the number of institutions doing so increases daily.

Pre-19th Century Women

An area of potential interest to researchers would be the writings and activities of women with respect to the earth sciences before the 19th century. For example, the current "craze" for St. Hildegard von Bingen (1098-1179) has brought to light the fact that, in addition to music compositions and mysticism, she wrote about plants, animals and the sources of minerals, particularly their relationship to the "humours" and health. The earliest female earth scientist listed in biographical dictionaries [7] is Madame Martine De Bertereau (1590-1643), a self-described hereditary miner, who with her husband, Jean du Chatelet, prospected and surveyed France's mineral resources in the 17th century when efforts were being made to restore the mining industry. While her writings and reports survived, she and her husband did not fair so well. For their efforts, the infamous Cardinal Richelieu threw them in prison. France did not begin development of resources for another

century. Martine was almost two centuries ahead of her time and does not fit neatly into a pattern of the history of women in the geological sciences

19th Century

Geology was a discipline in its infancy during Madame De Bertereau's time. Two centuries later geology blossomed; and some women bloomed along with it. In England, America and even in France, the actual work of science had a heavily domestic base. The practitioners were greatly dependent on the family income and the support of family members and friends. This meant that many women were probably more involved in science in their everyday lives than later in the century, even though men occupied the very few formal scientific posts. Science was subject to "crazes" - the fern craze, the entomology craze and to a lesser extent, the geology craze. Women were just as enthusiastic, if not more so, than men. It was considered desirable for women to have knowledge and accomplishments in many areas in order to educate the children and to engage in intelligent conversation. On both sides of the Atlantic, women flocked to public lectures on geology and formed scientific societies and clubs to discuss the emerging sciences. Charles Lyell's lectures were so popular that he changed the location when the Bishop of London attempted to bar women.

The role of women who *did* the actual work of science was largely that of the "assistant" variety as illustrators, collectors, enablers, cataloguers, writers, secretaries, wives and mother-educators. Many of the 19th century collectors were women of means with a serious passion for geology. Ethelred Benett (1776-1845) and Barbara Hastings (1810-1858), for example, were astute assemblers, observers, mappers and stratigraphers. Had they been born 75 years later, they would have acquired a formal education and careers as paleontologists. In spite of being shut out of the formal organizations, they were able to live productive scientific lives and participated in the informal networks that were so important to the development of the discipline. An outstanding collection of fossils is a superb way to ensure that scientists beat a path to your door. The most famous collector is Mary Anning (1799-1847) of Lyme who was not a lady, but a working woman who collected for a living. She was probably not the only working-class collector; however, she was certainly the most gifted and knowledgeable. Therefore she was also the most renowned collector of her time.

Women in the 19th century worked as illustrators as well. It was after all part of women's education to learn some of the graphic arts. Cecilia Beaux (1855-1942) of the United States did geological illustrations before going on to a distinguished career as a portrait artist. The remarkable Lady Cumming (1798-1842) of Scotland developed a notable collection. She also took up illustration with one of her many daughters. Lady Cumming was preparing to publish her illustrations on her own; however, she died suddenly after a disagreement with Louis Agassiz about her illustrations. There were probably many more illustrators than we know of, but their work is not signed and often not acknowledged.

The role of the wife/assistant in the 19th century is exemplified by Mary Morland Buckland (d. 1857) whose work was so linked with that of her husband, it is difficult to sort out who did what. She often went into the field with William, took field notes, illustrated specimens, prepared finished drawings for his books, took dictation and repaired broken fossils. However, the life of the wife/assistant was not always easy because so much of the work of science depended on the family income from other sources. Gregory Mantell, the great geologist, was also a physician. His passion for geology so disrupted the home and threatened the family income that his wife Mary, who had ably assisted him early in the marriage, eventually left him.

Until schools took over the responsibility for teaching natural history (or not teaching it, especially to girls), mothers were expected to be responsible for educating their children in the subject. Hence, a number of "popular" books and handbooks were directed to mothers, young women and children on both sides of the Atlantic during the late 18th century and the 19th century. Lynne Barber has commented on the irony that those women who contributed to research did not publish, and "unnumbered tribes of other Victorian ladies seem to have written without ever doing an iota of research." [8] This is a bit harsh, but has an element of truth. The "tribes" of popularizers provided some male scientists, George Greenough for example, an excuse

to unfairly dismiss all writings by females.

During the 19th century, the development of earth sciences was enhanced by a number of gifted women who went beyond the bounds of convention (and borders) and emerged as original observers and commentators on the world about them. Maria Graham (Lady Calcott 1785-1842), whose interests lay in history, art and observations based on her travels, became embroiled in a raging controversy (and attack by the above-mentioned Greenough) concerning seismic uplift because of her extremely accurate measurements and diary account of the effects of the 1822 Chilean earthquake. Mary Griffith (1772-1846), an early American utopianist, feminist, and splendid eccentric, wrote several theoretical articles on the origins of springs as well as performed experiments in agriculture, optics and other scientific matters.

From the 1880s, the role of women began to change as educational opportunities became available and as the work of science and natural history education moved out of the domestic or amateur circles and into the realm of the schools and universities, geological surveys and societies. The discipline itself had by then moved into the professional period when it became, to a certain extent, dominated by public policy. For the most part the women who now did work in the geological sciences were formally educated. In Britain, geology remained a popular subject of study for girls and women at all levels of education although professional training was concentrated in a few institutions. In North America the study of geology by women was marginal until Florence Bascom (1862-1945) established a program at Bryn Mawr College. Not all early professional geologists were formally trained. A few, like Mary Jane Donald (1856-1935) of England and Luella Owen (1852-1932) of Missouri, were self-educated women of means who straddled the early 19th century enthusiast period and the later professional period.

The tradition of wide interest in geological sciences prevailed into the 20th century in Britain. Elsewhere, women who wished to study science generally chose medicine, botany and astronomy and even chemistry and mathematics. Why did the first generation of professionals choose geology? What factors in their childhood and their early education attracted some women to geology? Where formal biographies reveal little, unpublished letters, diaries and memoirs might reveal more. Some women grew up in families where children, regardless of gender, were encouraged to nurture many interests and acquire an education, either at home or formally. This was the case with Mary Emilie Holmes (1849-1906), the first woman in the United States to acquire a PhD in geology in 1893. Some of the women were from a suffragette background—Florence Bascom (1862-1945) and Marie Stopes (1880-1958). A few, like Astrid Cleve (1875-1968) of Sweden, were mentored by their scientist fathers. Alice Wilson (1881-1964) of Canada developed her interest along with her brother who hiked with her when they were children and later, accompanied her on professional survey. Luella Owen (1852-1932) became interested in loess because of road cuts outside her door. Many, like Florence Bascom (1862-1945) of the United States and Irene Crespin (1896-1980) of Australia, turned to geology because of the influence of an outstanding teacher.

The literature in English is geographically limited and does not reflect the history of women workers in the geological sciences from other parts of the world, particularly Russia and the former Soviet Union. It would be invaluable to document the past 140 years of women's contribution to geology beginning with the fascinating history of the education of those women who studied geology both inside Russia and in the universities in continental Europe during the latter half of the 19th century. Russian women forced to study abroad often found themselves pioneering higher education in their host countries. [9] Furthermore, the former Soviet Union has trained more women (particularly paleontologists) than any other country during the 20th century.

Prospecting And Mining

The biographical dictionary gives short shrift to miners, engineers and prospectors with the exception of Madame de Bertereau (1590-1643), mentioned earlier, whose works on the art and science of mineral survey are classics and could also be described as the earliest treatises on economic geology. Women and girls have worked in mines for centuries in some countries, but unlike Marie Stopes, for example, had little time to

speculate on the origin of coal. Women have managed mines in what is very much a man's world. Anne Lister of Yorkshire managed her mines in the early 19th century just as efficiently (including the exploitation of girls and women) as the male mine owners who scorned her. Women have studied mining engineering formally since the late 19th century. Florence E. Caldwell (Civil Engineer, 1898) and Grace McDermut (Engineer of Mines, 1903) were the first women to enroll in the Colorado School of Mines.

Women played a large role in the development of mines in the American West and in the great gold rush of the Klondike. Their contributions, largely taken for granted, have been described in several recent publications. [10] Only a minority were, in the end, able to go out to prospect on their own, or actually mine their claims. Dr. Margaret Woyski, in part by examining patents, has touched on another topic that would benefit from further research. [11] That would be to uncover the real contributions of early female prospectors and miners to the practices of surveying, assaying and mining. However, this would be challenging as prospectors in particular can be described as obsessive and secretive with little to say about where they went, what they did and what methods they used.

Although women may have played a small direct role in prospecting and mining, the development of claims and mines simply failed in those areas where there were no women to provide the support systems. Women were outstanding as managers of claims, wheeler-dealers and grubstakers. They immediately went into business running boarding houses, laundries, restaurants, dry goods establishments and groceries. They also provided essential services as domestics, doctors, midwives, nurses, seamstresses, teachers, dancers and prostitutes. The gold rushes offered an opportunity for women to: test their wings and gain independence; provided a means of survival for impoverished young women like the energetic and gifted Irish immigrant Nellie Cashman (c. 1850-1925); and fulfillment for many upper-class ladies like Martha Purdy Black (1866-1957) who became Dawson City's "first lady" and eventually entered Canadian parliament, the second woman to do so.

20th Century

It was a struggle for women working in geology in the 20th century. To a great extent, they were assigned so-called women's work: teaching for the most part; as well as work as museum curators and cataloguers; laboratory and field station researchers; cartographers; bibliographers; and technical writers. Pay scales for women have been traditionally lower than those for men doing the same work, promotions were hard to come by and permanent jobs difficult to find. Most of the collections in modern museums have been organized and catalogued thanks to the work of the first generations of professional female earth scientists. Many women researchers have compiled important bibliographies in their specialty as well as works like the monumental *Bibliography of North American Geology*. Women have been over-represented in the field of paleontology for two centuries, in part because of the painstaking work involved in the laboratory, to which women were all to often relegated. For example, following Esther Applin's (1895-1972) pioneering work in the 1920s in the use of microfossils in oil exploration, U. S. oil companies hired a number of young women; but many were laid off during the Depression to allow hiring of men. Teaching has absorbed the greatest number of trained geologists. Typical of the trained geologists, Marguerite Thomas Williams (b. 1895), the first African American (male or female) to acquire a PhD in geology, was a dedicated teacher for about 40 years. In the first half of the 20th century a high percentage of women in the earth scientists remained unmarried. In some cases, it was a real choice of career or marriage. Irene Crespin (1896-1980), the state palaeontologist for Australia, would have lost her job had she married.

These difficulties did not prevent women from accomplishing their goals by devising creative solutions. The Geological Survey of Canada would allow Alice Wilson (1881-1964) to do only short field trips so she chose to study the Ottawa/St. Lawrence Lowlands close to home. Issued only a bicycle by the Survey, she purchased a car, which was kept out of sight of the Survey managers. Medora Hooper Krieger (1905-1994) founded a field school for women in California to give proper training where the United States Geological Survey would not. Katherine Van Winkle Palmer (1895-1982) who could not hold a position because of anti-nepotism rules, founded a private nonprofit research institution for paleontologists. Women made an

enormous contribution during World War II, a topic crying out for further investigation. Geographers and geologists in several countries were involved in a number of projects, many of them secret, working for various agencies where their professional skills could be applied. This was in great contrast to World War I when many women put their careers on hold to engage in war work unrelated to their professions.

The most persistent theme, until recently, is the exclusion of women from fieldwork, particularly by government Geological Surveys. In 1894 Horace B. Woodward, a genuine admirer of the work of women geologists wrote: [12] "...the time has not yet come, that our civilization has not attained that high standard, when lady geologists could join the Geological Survey and wander at will and unattended over the country without danger of molestation." At the time of writing, Maria Ogilvie (1864-1939) was tramping the South Tyrol completely unsupervised, Florence Bascom (1862-1945) was hiking the Piedmont region and Luella Owen (1852-1932) was clambering through caves in Missouri and the Ozarks. More than 50 years later, a 1949 bulletin put out by the United States Women's Bureau states: "In geology where less than 300 women were employed in 1946, future opportunities for women will resemble those of the past. Teaching will absorb the largest group, while State and Federal Government and industry will employ most of the remaining number... with few exceptions, women geologists will be limited to laboratory or desk jobs in connection with which field work is rare." [13] Geological surveys in many countries have held women back from the field, and therefore from promotion. In Canada the Geological Survey's treatment of Alice Wilson (1881-1964) is shameful and embarrassing to recount. Most recently, in March 2000, female scientists who lost their jobs at the U.S. Geological Survey office in Denver during a major layoff have filed a discrimination complaint alleging they were targeted for dismissal due to their age and gender. [14]

Nevertheless, women have made great strides in the latter half of the 20th century to gain equity, access to positions in academia, private industry and geological surveys although progress is uneven when viewed country by country. It has been a privilege to study the lives of those women who paved the way for new generations of women in the geological sciences.

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Metallurgic Chemistry, the Four Elements, and the Phlogiston

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Abstract

Christlieb Ehregott Gellert was the first professor of metallurgical chemistry at the Mining Academy in Freiberg, Saxony at its founding in 1765. His book *Metallurgic Chymistry* was first published in German in 1750 as *Anfangsgründe der metallurgischen Chemie*. Although the book is a little known work, it is of special importance because it was written towards the end of the Age of Alchemy. It was also the first and only book combining chemistry and metallurgy, a course Gellert was giving at the Academy. His successor Wilhelm Lampadius separated this course into two: one for chemistry and one for metallurgy. The book, therefore, gives a glimpse at a critical period in the history of chemistry and metallurgy. It uses the alchemist symbols, it discusses the four elements, and it adopts the theory of phlogiston.

Introduction

Metallurgic Chymistry by Christlieb Ehregott Gellert (1713-1795) [Habashi 1998c] is the English translation of *Anfangsgründe der metallurgischen Chemie* published in 1750 (Figure 1). Although the book is a little known work, it is of special importance because it was written at the end of the Age of Alchemy, just a few years before the Chemical Revolution begun by Lavoisier in 1777. It was also the first and only book combining chemistry and metallurgy, a course Gellert was giving at the newly founded Mining Academy in Freiberg. His successor Wilhelm Lampadius (1772-1842) separated this course into two: one for chemistry and one for metallurgy. This book, therefore, gives a glimpse at a critical period in the history of chemistry and metallurgy. It uses the alchemists symbols, adopts the theory of phlogiston, and refers to the four elements: earth, water, air, and fire. Thus, it gives a good picture of eighteenth century chemistry and metallurgy.


Anfangsgründe
zur
Metallurgischen
Chimie,
In einem
theoretiſchen und practiſchen Theile
nach einer
in der Natur gegründeten Ordnung
abgefaſſet
von
L. E. Gellert,
der Kayſerl. Academie der Wiſſenſchaften zu S. Petersburg
Mitgliede.
Mit Kupfern.
Leipzig,
bey Johann Wendler, 1751.

Figure 1. Front page of Gellert's Anfangsgründe der metallurgischen Chemie

The Four Elements

Gellert referred to fire, air, water, and earth as the four chemical agents and not as four elements. This is a novel way of discussing this topic. The concept of four ele-

ments is erroneously thought to have its origin with the Greek philosopher Empedocles about 440 BCE and held sway for many centuries. Aristotle (384-322 BCE) added to this concept that the properties of substances are the result of the simultaneous presence of certain fundamental properties: coldness, hotness, dryness, and moistness. Aristotle and his followers believed that all substances are composed of these four elemental states of matter and this is usually cited in history of chemistry books (Figure 2). The concept is, in fact, due to the Persian philosopher Zarathustra (600-583 BCE) (Figure 3) whose name was corrupted by Greek writers to Zoroaster about two centuries before Aristotle [Habashi In Press]. It was he who described these four elements as "sacred" i.e., essential for the survival of all living beings and therefore should be venerated and kept free from any contamination.

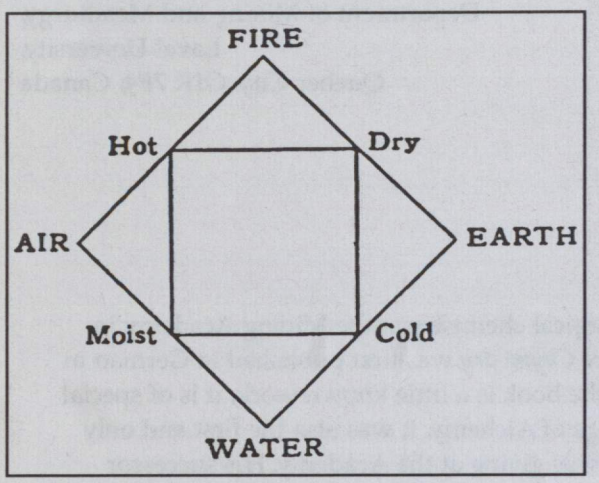

Figure 2. The four elements as represented in almost all chemistry and history of chemistry books

This concept makes more sense than the Aristotalian. Humans and animals need air to breathe, water to drink, fire to cook food, and earth to grow plants for their survival. To till the field and raise cattle are parts of one's religious requirements. Rain water when it falls in abundance to irrigate the fields is a blessing from God. When it is scarce, famine may result. Fire, on the other hand is the symbol of divinity. It is fed daily to this date in Zoroastrian temples by the attendant priests with pieces of sandalwood. These four elements, therefore, have nothing to do with the chemical elements.

Zoroaster was highly venerated in antiquity. Darius the Great (549-485 BCE), who reigned from 521 to 485 BCE, and his successors were loyal followers of the prophet. The Greeks and Romans were much impressed by what they heard of him and his religion. This is evidenced by the numerous references to him in the extant literature and by the fact that Plato was reportedly prevented from going to Persia to study Zoroastrianism first hand by the outbreak of the War of Sparta with Persia in 396 BCE. Zoroaster was also mentioned by the Egyptian alchemist Zosimos (250-300 BCE). While Zoroastrianism was the national religion of Persia, it spread to Armenia, Cappodocia, and the entire Near East. Perhaps it is only the disaster of Salamis that prevented Zoroaster's faith from becoming a major religion of the Western World.

Figure 3. The Persian philosopher Zoroaster (600-583 BC)

The concept of four elements survived for at least two thousand years. Seventeenth-century engravings attest to the influence of this theory. For example, the Flemish artist Crispijn van de Passe (1564-1637) depicts allegorical figures in decorative scenes symbolizing the four elements (Figure 4). Fire (ignis) holds brands and a burning coal. Water (agua) wields a flowing pitcher while behind her a fisherman plies his trade; Earth (terra) carries a cornucopia of the Earth's fruits while a hunter pursues its beasts. Air (aer) strides across the clouds, birds flying around him, the four winds blowing. Figure 5 shows the four elements as illustrated in a 1622 engraving. Each element was given a symbol based on a triangle; the alchemists used these symbols until the reform of Lavoisier and Berzelius.

The Phlogiston

Fire remained a mystery for about two thousand years. Early people were much more intimately acquainted with fire than in the all-electric homes of today where fire is rarely seen. To the ancient Greeks fire was a magical element stolen from the gods and given to mankind by Prometheus. Some civilizations worshipped fire just as others worshipped the sun. To the alchemists, a fire was a process by which something escaped

Figure 4. The concept of four elements as illustrated by the Flemish artist Crispij van de Passe

from the burning substance such as wood. Burning was interpreted as separation of matter into the basic elements earth, water, air, and fire. The latter three went up in "smoke," called phlogiston (phlox in Greek means name) leaving the earth component behind as ashes or calx. This can be represented as :

$$\text{Wood} \xrightarrow{\text{heat}} \text{Phlogiston} + \text{Calx}$$

Substances varied in their phlogiston content. Those with a high content burned readily and left little calx. Those with little phlogiston burned only with difficulty and left much calx. Since charcoal burned almost completely, leaving very little calx, it had been considered to be nearly pure phlogiston. On the other hand, when metals burned in air they left so much calx (oxide), hence they had been considered to be poor in phlogiston :

$$\text{Metal} \rightarrow \text{Phlogiston} + \text{Calx}$$

It was, therefore, argued that if phlogiston were added to the calx, the metal could be obtained back, which actually happened when charcoal (pure phlogiston) was heated with a calx (an ore) and metal was obtained:

$$\underset{\text{(oxide)}}{\text{Ore}} + \underset{\text{(phlogiston)}}{\text{Charcoal}} \xrightarrow{\text{heat}} \text{Metal}$$

This theory was put forward in 1697 by the German chemist Georgy Stahl (1660-1734) to explain combustion and the smelting process. Stahl further indicated that the air (gas) which escaped during the smelting process (CO_2) was phlogisticated air; i.e., air saturated with phlogiston and consequently, it would longer support combustion nor was it fit to breathe.

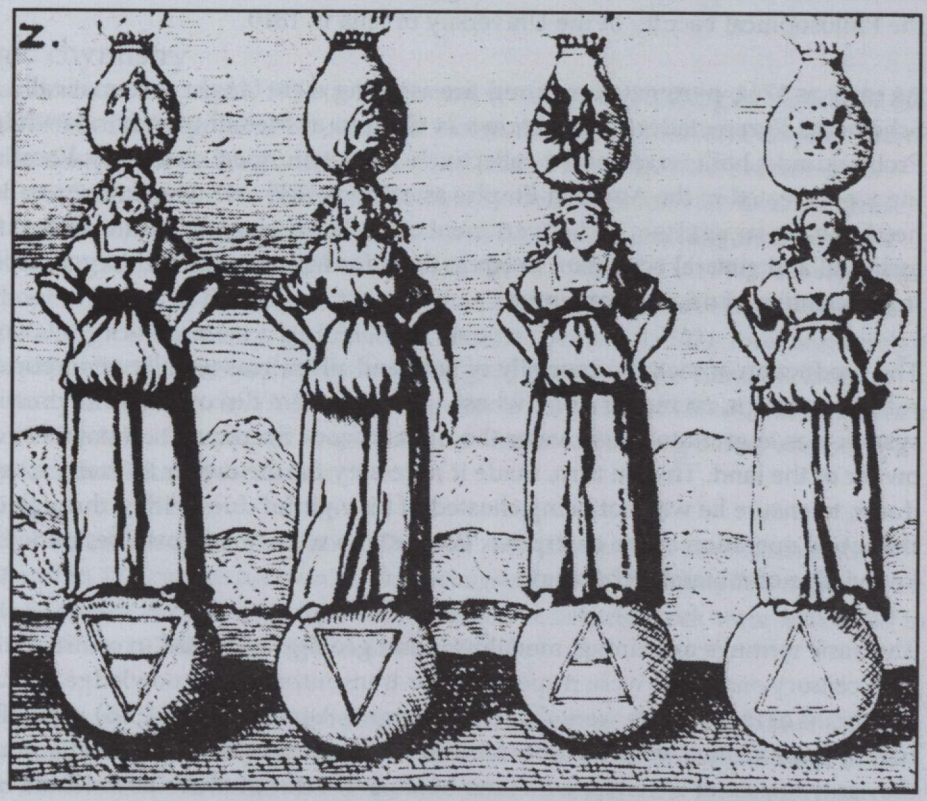

Figure 5. The four elements as illustrated in Mylius', Philosophia Reformata, *Frankfurt 1622*

When it was discovered that the calx weighed more than the metal it was concluded that the phlogiston must have a negative weight — which was absurd. But, this assumption was accounted for by the fact that smoke and fire always rises up in the sky which looked like being weightless. The theory became complicated and contemporary scientists debated its value. However, it persisted for about a hundred years, throughout most of the 18th century.

When oxygen was discovered in 1770, the great French chemist Antoine Laurent Lavoisier (1743-1794) was able to explain by 1772 that combustion was an oxidation process, thus directing the final blow to the phlogiston theory. It was Lavoisier who gave the gas its name from the Greek words *oxys* = acid, and *geinomai* = I beget, because many substances like carbon or sulfur burn in the gas to give an acid.

Although Lavoisier destroyed the phlogiston theory by his explanation of combustion, he introduced in 1781 the caloric theory of heat: i.e., heat is a fluid. This theory was proved erroneous by Count Rumford (1753-1814) a few years later. Incidentally, it was Count Rumford who escaped America during the War of Independence and married Lavoisier's widow, from whom he separated a few years later.

Chemistry, metallurgy, and metallurgical chemistry

Located 40 km southwest of Dresden, Freiberg was an important mining town. It was the capital of the mining district of Saxony and the seat of the Mining Academy which is the oldest school of mines that is still functioning on the original site. It is an ancient imperial city that owes its origin to the discovery of silver mines in its vicinity in the twelfth century. The mining district is known as Erzgebirge or Ore Mountains which is the mountain chain that separates the present Czech Republic from Germany.

The mining schools played an important role in the advancement of chemistry and metallurgy [Habashi 1999, 1998a, 1998b, 1997]. Chemistry was taught in mining schools much earlier than in philosophical academies. The Mining School of Potosi in the Spanish colony of Peru had a chair in chemistry in 1757. Customarily in Europe, chemistry was taught in medical schools. It was Wolfgang von Goethe, while education adviser to the Grand Duke Carl August, the Elector of Jena, who created the first chair of chemistry at the Philosophical Faculty of the University of Jena in 1810.

As early as 1764, pyrometallurgy and fire assaying were taught systematically at the Mining Academy in Schemnitz. Pyrometallurgy was known in German as Metallhüttenkunde while fire assaying was known as Probierkunde; both were known collectively as metallurgical chemistry. Vocational schools for teaching mining were created in the Austrian Empire as early as 1735 and were known as Bergschule. With the growing need to have supervisors and government officials, there appeared the necessity of training persons with technical and general education to equip them for higher tasks and larger responsibilities. This need resulted in the creation of mining academies.

The production of metals, especially of gold and silver, was usually an important source of income to the ruling sovereign, no matter upon whose land they were discovered. The practical way of working under this system was to grant to a discoverer the right to work the deposit on payment of a "royalty" to the legal owner of the land. This, in turn, made it necessary for the owner to exercise some supervision over the producer, to ensure he was not being cheated of his rightful dues, either through dishonesty or inefficiency, in the actual operation of the enterprise. People who were not themselves mineral producers needed thorough knowledge of mineral technology.

The basic writings on mining, metallurgy, and geology appeared in central Europe in the beginning of the 16th century and these were responsible for transmitting this knowledge for future generations. The most important of these books were those by Georgius Agricola (1494-1555), a medical doctor in the mining district of Joachimsthal, who became interested in ores and smelting operations and Lazarus Ercker (1530-1593), the assay master at Dresden, who later became director of the mint in Kutna Hora in Bohemia.

There was hardly any systematic education in other branches of chemistry before 1800. They were generally

an adjunct to medicine if they were taught at all at a university. The best place to learn it was not in a university but in a pharmacist's shop. Fire assaying, the predecessor of analytical chemistry of today, was taught at the Mining Academy not only theoretically but also experimentally. This method of teaching in Schemnitz was adopted in 1794 in the École des Travaux Publics, the later École Polytechnique in Paris, by Antoine François de Fourcroy (1755-1809). When Justus von Liebig (1803-1873) became professor of chemistry at Giessen in 1824, he immediately took steps to offer laboratory instruction in the science in the same way as he himself was taught in Paris. Students were first trained in qualitative and quantitative analysis, then they prepared organic compounds, and finally carried out a special investigation on a problem suggested by Liebig. The laboratory at Giessen received a great deal of attention and attracted students from many parts of the world.

The teaching staff at the first mining school contributed greatly to the advancement of mining and geology as well as chemistry and metallurgy. They analyzed and discovered many new minerals, discovered eight metals (Table 1), and created the basic literature in chemistry, metallurgy, mining, and geology.

Table 1 - Metals discovered by teaching staff at the first mining schools

Year	Metal	Discoverer	School
1783	Tungsten	D' Elhuyar	Vergara, Spain
1797	Seryllium	Vauquelin	Paris
1797	Chromium	Vauquelin	Paris
1789	Uranium	Klaproth	Berlin
1789	Zirconium	Klaproth	Berlin
1801	Vanadium*	del Rio	Mexico City
1863	Indium	Reich and Richter	Freiberg, Saxony
1886	Germanium	Winkler	Freiberg, Saxony

* Independently discovered by Sofstrom at Falun, Sweden in 1830.

Gellert and his metallurgic chymistry

Christlieb Ehregott Gellert was born on August 11, 1713 in Hainichen, a suburb of Freiberg as the son of the town pastor. He died May 18, 1795 in Freiberg; he never married. He studied at Meissen and Leipzig. From 1735 to 1747 he was professor in a secondary school in St. Petersburg and at the same time became associated with the Russian Academy of Sciences. On his return to Freiberg he worked in private metallurgical practice as a consultant to the local smelters. A few years later he started privately teaching metallurgical chemistry at his home to fill the gap created by the death of Johann Friedrich Henckel (1679-1744) who was the first to found a private School of Mines in Freiberg in 1735. Gellert brought back to Freiberg its reputation as a center for teaching metallurgical chemistry, and Freiberg became the choice of the local and foreign students. For example, because of Gellert's fame as the best metallurgical chemist of his time, the king of Sardinia sent five students to study under him. In 1753 he was appointed Inspector of Mines and Smelters in Saxony and in 1762 he became Chief Administrator of Foundries and Forges of Freiberg before accepting a teaching position at the newly founded Mining Academy.

While in St. Petersburg in 1746, he translated Cramer's book *Elementa Artis Docimastica* into German as *Anfangsgründe der Probierkunst* and in 1750 wrote his own work, *Anfangsgriinde der metallurgischen Chemie*, and in 1755 another work *Anfangsgründe zur Probierkunst*, both published in Leipzig. Both were translated in 1758 into French, into Italian in 1758 and 1790, and into Russian in 1781.

The metallurgy of gold and silver played an important role in the development of chemistry before the Industrial Revolution. In Europe, silver was mainly recovered from sulfide ores by smelting. Interest in the amalgamation practice used in Mexico and the South American colonies was aroused in Europe as a possibly cheaper technology. The Austrian mineralogist Ignaz von Born (1742-1791) tested this possibility by what

became known later as the "chloridizing roasting process". The silver sulfide ore which is not amenable to amalgamation, was roasted with salt then slurried with water and mercury to make silver amalgam from which silver could be recovered. The process was improved by Gellert and applied on an industrial scale in a plant near Freiberg which operated from 1790 to 1857 and produced more than 300 tons of silver.

Gellert broke the tradition of his time by writing in German instead of Latin. His book *Metallurgic Chymistry* is composed of nearly two equal parts: *Part I Theoretical*, composed of three sections: The Nature and Objects of Metallurgical Chemistry, Chemical Agents and Instruments, and Chemical Operations; *Part II Practical*, contains ninety seven experiments.

The first division of *Part I Theoretical* can be compared to modern mineralogy, ore deposits, and properties of metals (very briefly). In the second division, Gellert discusses the four chemical agents: fire, air, water, and earth. He clearly states that "fire is the principal agent in the art of chemistry without its assistance no chemical operation can be performed." About air, he argues "Since no chemical operation may be done without fire, it follows that they can neither be performed without air." He emphasizes further that no fire can exist without air and no living thing known could live and grow without air. Concerning water, Gellert states "water has that peculiar property of uniting with other bodies and to constitute therefore so perfect a mixture..." Further, he defines earth as "a simple, hard, fixed, friable body, not fluxing in the fire, and neither soluble in air nor water, nor spirits of wine, nor in any oil."

In addition to the four agents, Gellert devotes an appreciable space to "Dissolvent Menstrua." This is a general term which in modern language could be equivalent to fluxes, to acids forming aqueous solutions, and to metals forming alloys. Gellert then devotes a chapter to furnaces and laboratory utensils such as the alembic (a distillation flask), tongs, etc. Chemical operations discussed in the third division are classified according to the four agents. Thus, operations performed by *fire* include fusion, roasting, calcination, sublimation, distillation, evaporation, etc. Those performed by air include "solution of metals by the air" (oxidation?), fermentation, putrefaction, etc. Those performed by water include washing, elixiviation (leaching), edulcoration (purification by washing), etc. An operation performed by earth is fixation. In addition, Gellert cites chemical operations performed by means of "Dissolvent Menstrua," which include amalgamation, solution in the dry way like glass making, making of brass, soldering, scorification (formation of slag), reduction of "metalline calces into metal," and "solution in the liquid way."

The experiments mentioned in the second part of the book were apparently supposed to be conducted by students. Each experiment has a number, a title, and is divided into two parts: Method and Observation. Sometimes more than one method is described for the same experiment. Although they are written in a systematic way there was no attempt to group related experiments together. Most of the experiments are related to metals, salts, stones; e.g., inorganic. Very few are organically based; e.g., preparation of soaps from an oil.

Conclusion

The concept of four elements: air, water, earth, and fire, erroneously attributed to Greek philosophers is in fact due to the Persian philosopher Zoroaster, who described these four elements as "sacred," i.e., essential for the survival of all living beings and therefore should be venerated and kept free from any contamination. Fire, on the other hand, remained a mystery for about two thousand years. The theory of phlogiston was introduced in the seventeenth century to explain its formation: a substance burns because it contains the combustible principle "the phlogiston" which is liberated in form of a flame. The theory was abandoned, however, a hundred years later when oxygen was discovered and the phenomenon of combustion was explained by Lavoisier in 1777 as an oxidation process. This began modern chemistry. Shortly before Lavoisier's revolution in chemistry, a book entitled *Anfangsgründe der metallurgischen Chemie*, written by Christlieb Ehregott Gellert, was published in Germany in 1751 and an English translation entitled *Metallurgic Chymistry* followed in 1776. This book is of special importance because it gives a glimpse at a critical period in the history of chemistry and metallurgy.

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Historical Libraries Of Science in the Quebec Province

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Abstract

Quebec City, the capital of New France from 1608 to 1764, was a center of French culture in North America and the birthplace of scientific education in Canada. Two institutions contributed to this reputation: Le Collège des Jésuites, founded in 1635, and La Société des Mission Étrangères, known as Le Séminaire de Québec, founded in 1663. Le Collège was closed permanently in 1776 and its library, which contained old and valuable books, was partly donated to the library of Le Séminaire and to other institutions and individuals. Le Séminaire, on the other hand, flourished under its founder François de Montmorency Laval, the first Bishop of New France. In 1852 Queen Victoria transformed it into Laval University in honor of its founder. The Séminaire Library has an excellent collection of some 200,000 volumes in the various fields of science, medicine, history, law, agriculture, and religion. A multi-million dollar project recently integrated the library with the Musée de Civilization. In Montreal, the Osler Library of the History of Medicine bears the name of its principal benefactor, Sir William Osler, a physician who is regarded as McGill University's most eminent medical graduate. The Osler Library opened in 1929 with a collection of about 8,000 books, mainly on the history of medicine, but over the years, it has increased to about 49,000 books. It incorporates the Frank Dawson Adams Collection containing many books on geology, mining, metallurgy, chemistry, and other disciplines.

Introduction

Quebec City, the capital of New France (Figure 1) from 1608 to 1764, was a center of French culture in North America and the birthplace of chemical education in Canada. After the British conquest in 1764, Montreal became one of the most important scientific centers of the British Empire in the second half of the nineteenth century.

Quebec City was founded by Samuel de Champlain (1567-1635) in 1608 (Figure 2). Le Collège des Jésuites was founded in 1635 (i.e., one year before Harvard University) and La Société des Missions Étrangères, known as Le Séminaire de Québec, founded in 1663 (Figure 3). Le Collège was closed permanently in 1776 and its library, which contained old and valuable

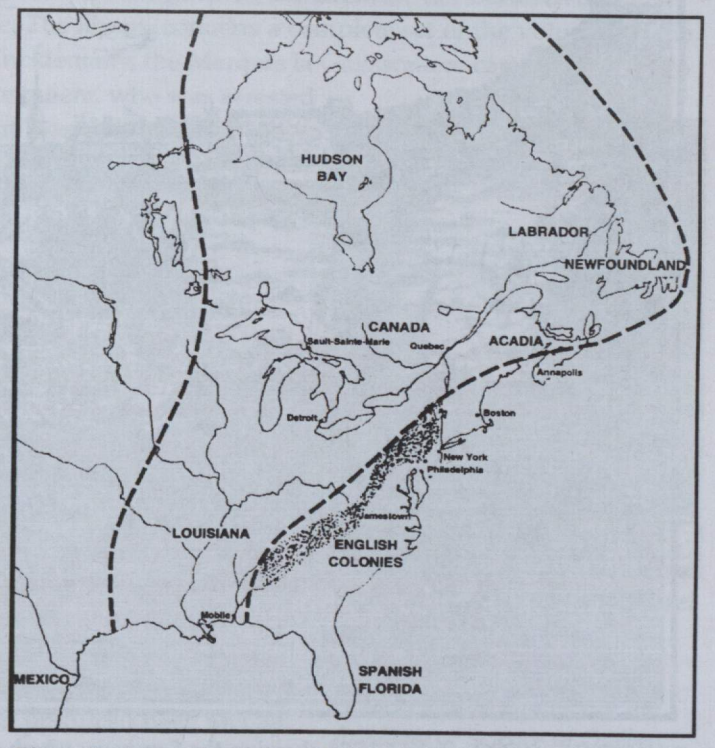

Figure 1. Approximate boundaries of New France in 1712.

books, was partly donated to the library of Le Séminaire and to other institutions and individuals. Le Séminaire, on the other hand, flourished under its founder François-Xavier de Montmorency Laval (1623-1708) (Figure 4), the first Bishop of New France during the reign of King Louis XIV. In 1852 Queen Victoria transformed it into Laval University in honor of its founder. In 1876 the University of Montreal was founded as a branch of Laval University; it became independent in 1920.

Figure 2. Samual de Champlain (1567-1635) founder of Quebec City in 1608.

The Seminaire Library

The Séminaire Library, at 3 rue de l'Université in Old Quebec, has an excellent collection of old books, composed of some 200,000 volumes in the various fields of science, medicine, history, law, agriculture and religion. This represents 200 years of continuous support to teaching and research. The library gives a fair idea of the intellectual and cultural life in New France. The present authors have examined the chemistry and geoscience collections and compiled a list of the most important books. The oldest book in the chemistry collection is a 1621 folio edition of "De Re Metallica." This work was first published in 1556 in Basel, Switzerland. It became known in North America when it was translated into English in 1912 by Herbert Hoover, the mining engineer from Stanford University who became President of the United States, and his wife. The author, Georgius Agricola (1494-1555), was a German from Saxony and the title means "Of Things Metallic." This work was *the* reference book on mining and metallurgy for at least two centuries.

Figure 3. View of Québec of 1688 showing the Seminary which was destroyed twice by fire.

Another old book is the 1643 Latin edition of "Basilica Chymica" and its French edition of 1623, entitled "La Royalle Chimie." This work, first published in 1609 in Geneva, is considered one of the important books on alchemy. The author, Oswardus Crollius (1580-1609), was a German chemist. Other 17th-century authors are Nicolas Lémery (1645-1715), Pierre Thibault, dit le Lorrain (?), Christophe Glaser (died about 1670), and G. Sauvageon (?), all French, van Maets (1640-1690), a Dutchman, and Ch. Benvardus.

Figure 4. Monsignor François de Montmorency Laval (1623-1708), Vicar Apostolic and first Bishop of Québec (1674-1688), founded the Québec Seminary in 1663, which laid the foundation for the first French-Canadian university in North America, Université Laval.

In the Seminaire Library 18th century chemistry is represented mainly by books of French chemists, who were leading the way at the time. Their work was extensively translated into other languages. At the top of the list are books by Lavoisier (1743-1794), Fourcroy (1755-1809), Chaptal (1756-1832), Baum (1728-1804), and Macquer (1718-1784). Chaptal's work, "Chimie Appliquée aux Arts," is considered to be the first book on industrial chemistry. Of more recent authors, books are found by the French chemists Berthelot, Gay-Lussac, Moissan, Regnault, Thenard, Wurtz, and French translations and original books by foreign authors such as Berzelius, Davy, Faraday, Fresenius, Guldberg and Waage, Gmelin, Karsten, Liebig, Lothar Meyer, Ostwald, Roscoe and Schorlemmer, Thomas Thomson, Wöhler and others.

Of great value to researchers in the history of chemistry is a 1796 book, available in the Seminaire Library, giving the old names of compounds and their "new" names in table form. The book is published anonymously. It was not unusual at that time to publish books anonymously, or with only the author's initials. The four-volume work by A.E. Barbier, "Dictionnaire des Ouvrages Anonymes," published in Paris in 1872, is available in a reprint edition by Maisonneuve & Larose, Paris. This work was classified at the Laval University Library (code: Z 1067 B 236 L 554) to identify the names of authors who published their books under their initials.

The Académie des Sciences was formed in Québec by Marquis de la Galissonière (Figure 5) during his short administration of New France (1747-1749). The Academie strengthened the scientific ties between the chemists in Québec and their colleagues in France. The library contains a complete set of the volumes of the "Comptes Rendus de l'Académie des Sciences." Incidentally, the Marquis la Galissoniére came to Québec to temporarily take the place of the Marquis de la Jonquière, who was arrested by the British enroute to Québec. A recent multi-million dollar project integrated the library with the Musée du Seminaire de Québec to form a Museum of French America in the old buildings of the seminary. The Museum is administered by the Musée de la Civilization.

Montreal, founded by Paul de Maisonneuve (1612-1676) in 1642 as a fur trading post, became an important cultural and economic center after the conquest. When the Industrial Revolution took place in England, Canada was a potential source of needed raw materials. In 1842 the Geological Commission of Canada was created in Montreal with Edmond Logan as director. Charles Lyell (1797-1875), the famous British geologist, visited Canada to evaluate the coal deposits in Nova Scotia.

Figure 5. Marquis Roland-Michel Barrin de la Galissonière, governor of New-France from 1717-1749 and Founder of the Academy of Science in Québec.

In the second half of the nineteenth century, Montreal was one of the scientific centers of the British Empires. Major industrialists contributed to the prosperity of the city: William C. MacDonald was in the tobacco business; Peter Redpath was in the sugar refining business; Donald A. Smith (Baron Strathcona) constructed railways; and John Molson produced beer. McGill

University was founded in 1822 from an endowment fund left by the rich Montreal merchant James McGill. Three Nobel Prize winners, Rutherford, Soddy, and Otto Hahn were former researchers at McGill.

The Osler Library

The Osler Library is named after William Osler (1849-1919) (Figure 6), who obtained a medical degree in 1872 from McGill and then did postgraduate studies in London, Berlin, and Vienna. He returned to Montreal to serve as a member of the Faculty of Medicine of McGill University for ten years. Then in 1884 he went to Philadelphia as professor of medicine at the University of Pennsylvania. Five years later he moved to Baltimore at the newly-founded Johns Hopkins Hospital (1889). There he founded a Society for the study of the History of Medicine. In 1905 the family left for Great Britain, where Osler became professor of medicine at Oxford, a post he held until his death.

By the turn of the century, Osler was probably the best-known physician in the English-speaking world. He achieved this position with a combination of superb practice, excellent and innovative teaching and wide-ranging publication. His textbook, "The Principles and Practice of Medicine," first published in 1892 and frequently revised, was considered authoritative for more than 30 years. His description of the inadequacy of treatment methods for most disorders was a major factor leading to the creation of the Rockefeller Institute for Medical Research in New York City in 1901.

The first printing of Osler's book (3,000 copies) appeared in late February 1892, supplies were exhausted by mid-March; the second printing was ready by mid-April, a good indication of its popularity. The book was translated into Russian (1905-1906), French (1908), German (1909), Spanish, and Chinese (1909-1910). Osler was awarded many honors, the greatest of which was the baronetcy conferred on him in 1911 by King George V. Osler's life and correspondence are well documented in a two-volume work entitled "The Life of Sir William Osler," by Harvey Cushing. Osler's work is extensively cited in books on the history of medicine. In 1969, the Canadian Post Office issued a stamp bearing his picture on the occasion of the fiftieth anniversary of his death

Osler built up a magnificent book collection, which he bequeathed to his alma mater, McGill University. The collection includes first editions of great works in astronomy, physics, chemistry, and biology, as well as strictly medical texts. For example: Newton's "Principia," 1687; the "De Revolutionibus" of Copernicus, 1543; Agricola's "De Re Metallica," 1556; Gilbert's "De magnete," 1600; Galileo's "Dialogo," 1632; and the works of Priestley, Lavoisier, Galvani, Dalton, Linnaeus, Darwin, along with other great names in the history of non-medical science. The philosophers are here too: the five-volume, first-printed, Greek edition of the works of Aristotle, put out by the Aldine Press between 1495 and 1498, Bacon, Descartes, Locke, and others.

Among the medical books are works by: Hippocrates, Dioscorides, Galen, Avicenna, Paracelsus, Vesalius, Gesner, Paré, Harvey, Boerhaave, Laennec, Pasteur, Virchow, Lister, Koch, Ehrlich, Röntgen, to name a few. The McGill University Library also contains Arabic and Persian manuscripts dating from the thirteenth century, as well as numerous books on medical astrology. Osler wished that his ashes be placed amongst his books. The urn containing the ashes of Sir William and Lady Osler is concealed behind a bronze bas-relief of Osler.

The McGill Medical Library donated all books published before 1850 to the Osler Library. This is a significant addition since the Medical Library can trace its origins as far back as 1823, when the members of the medical staff of the Montreal General Hospital established a medical school, the first in Canada, under the name, the Montreal Medical Institution. The school was set up in a rented house on St. James Street not far from the hospital. The school was provided with a library of several hundred volumes, most, if not all, from the private libraries of the teachers. In 1829 the Montreal Medical Institution became the Medical Faculty of McGill University and its library became the McGill Medical Library. The gradual transfer of older books to the Osler Library included those books contributed by the Montreal Medical Institution founders.

The Adams Collection

Frank Dawson Adams (Figure 6) was born in Montreal. He received his education in geology at McGill, Yale, Johns Hopkins, and Heidelberg universities. After a short period with the Canadian Geological Survey, he was appointed to the staff of McGill University, where he served in the following capacities: as Professor of Geology; as Dean of two Faculties: Applied Science and Graduate Studies and Research; and as Vice Principal. He was elected Fellow of the Royal Society in 1907. Adams donated his entire collection of books in the history of geology to the Osler Library. He authored "History of the Birth and Development of the Geological Sciences," 1938.

The Adams Collection contains mostly books on geology and chemistry in Latin and German. A few books on theology and its relation to geology can also be found. Among the most famous authors to be found there are Georgius Agricola, Albertus Magnus, Aristotle, Avicenna, Johann Joachim Becher, Tobern Olaf Bergman, Jöns Jakob Berzelius, Vannoccio Biringuccio, Boerhaave, Ignaz Edler von Born, Robert Boyle, John Andrew Cramer, Georges Cuivier, Lazarus Ercker, Johann Glauber, Wolfgang von Goethe, René Haüy, Robert Hooke, Alexander von Humboldt, Jabir iben Hayyan, Plinius Secundus, Giovanni Antonio Scopoli, Theophrastus, and Thomas Aquinas. The catalogue of the collection is available on microfilm.

The Library Catalogue

The "Bibliotheca Osleriana" lists all the books and manuscripts bequeathed by Osler to McGill University. It was published originally in 1929, the year of the official opening of the Osler Library. After being long out of print, it was reprinted in 1969 and in 1987. It is a voluminous volume of 834 pages, published by Clarendon Press, Oxford in 1929, and reprinted by McGill-Queens University Press in 1969.

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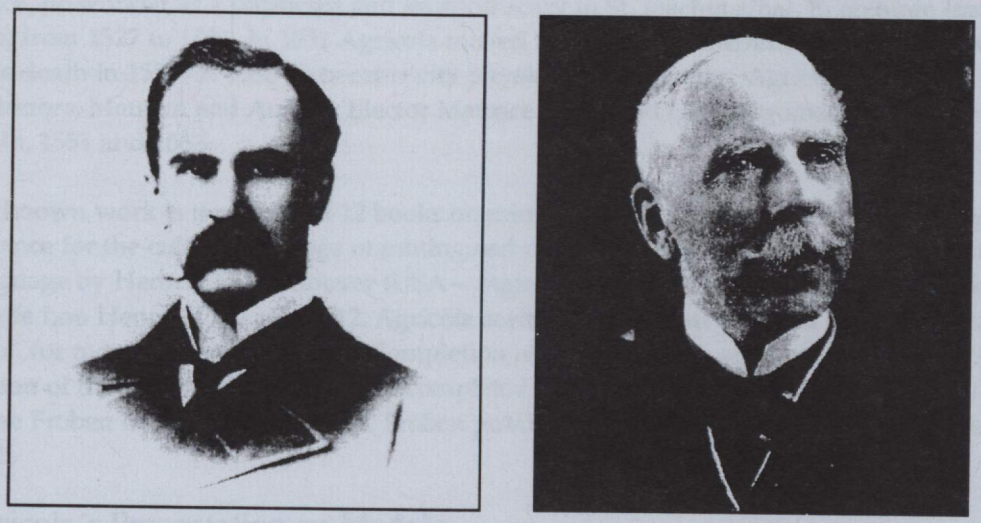
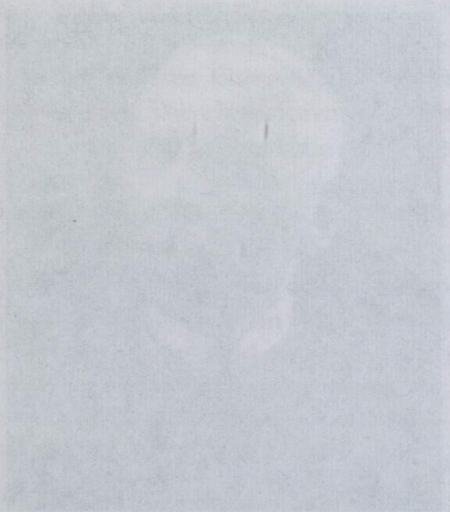
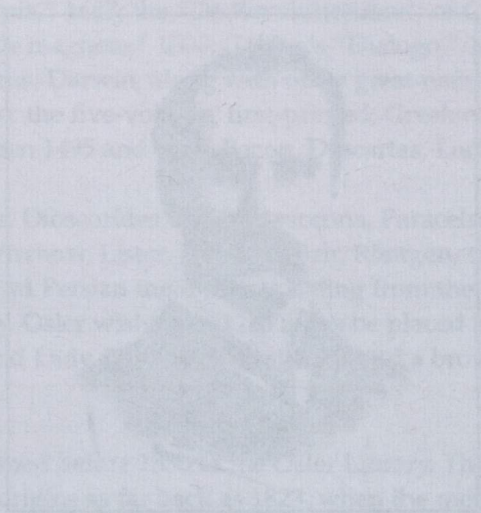


Figure 6 Left: Sir William Osler (1849-1919) in 1881 when he was Professor at the Institute of Medicine at McGill Medical College in Montreal. His collection of books formed the core of the Osler Library in Montreal. Right: Frank Dawson Adams (1859-1942), Dean of the Faculty of Applied Science, at McGill University, whose collection of books on geosciences were added to the Osler Library.





Georgius Agricola A Man of Honours on Medals

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Abstract

Several types of Agricola medals were considered. Most of the medals discussed herein show Georgius Agricola facing left, after the best-known copperplate from Johannes Sambucus of 1574. Only few medals have the portrait, facing right, referring to Paul Freher's copperplate of 1688. The woodcut of "De re metallica," Book IX, page 415 [1] shows probably the only authentic picture of Agricola. This image was used for a medal (Medal 94.9) to commemorate the 500th anniversary of his birthday.

Introduction

Georgius Agricola, the great Saxon metallurgical and mining scientist, has to be placed in the first rank of any discussion of mining and metallurgical Cultural Heritage. Born in the city of Glauchau, Saxony in 1494, he lived in the 16th century and attended schools in Glauchau and Chemnitz, Saxony. Agricola studied at Leipzig University from 1514 to 1518, obtaining the degree Baccaleureus Artium in 1518. From 1518 - 1522 he worked as a teacher in Zwickau, Saxony, became Vice-Principal in 1518 and Principal in 1520. In 1522 he returned to Leipzig and became a lecturer in the University. After extensive studies in Bologna, Padua, Rome and Venice, he worked as a physician and an apothecary in St. Joachimsthal, Erzgebirge (modern day Czech Republic) from 1527 to 1531. In 1531 Agricola moved to the city of Chemnitz, Saxony, where he resided until his death in 1555. In 1535 he became city physician of Chemnitz. Agricola was much favored by the Saxon Electors, Maurice and August; Elector Maurice appointed him burgomaster (mayor) for three terms 1546 - 1548, 1551 and 1553.

Agricola´s best known work is the series of 12 books on mining and metallurgy, titled "De re metallica libri XII." Its importance for the cultural heritage of mining and metallurgy is emphasized by the translation into the English language by Herbert Clark Hoover (USA – engineer, President of the United States from 1929 to 1933) and his wife Lou Henry Hoover in 1912. Agricola seems to have been engaged in the preparation of "De re metallica" for more than twenty years. Completion of the books was apparently delayed a long time by the preparation of the 292 woodcuts. Agricola completed the manuscript in 1553 and gave it to the Swiss publishing house Froben in Basel, Switzerland. Froben published "De re metallica" in 1556, one year after Agricola's death.

Georgius Agricola´s Presentation on Medals

Agricola was honored by many contributions to literature on the occasion of the 400th anniversary of his death in 1955 and the 500th anniversary of his birth in 1994. Many medals honoring Agricola were also issued on these occasions.

Of interest in this brief space is the kind of pictorial presentations of Georgius Agricola on medals. There is no known contemporary picture of Georgius Agricola (Figure 1: Pictures of Agricola, 1566, 1574, 1688). The

most authentic image is a copperplate with a diameter of 12cm completed by Johannes Sambucus in 1574. [2] Sambucus' image shows a bust of the bearded Agricola, facing left, dressed with doublet, beret and coat with wide sleeves (German. Schaube). A copperplate by Paul Freher in 1688 [3] shows the same bust, but facing right. Scholars have theorized that Frehers' portrait is an inverted copy of Sambucus' image. Another portrait, often interpreted as Agricola, was done by Heinrich Pantaleon in 1566 [4]; this image shows a general physician of the time and bears little resemblance to the more authentic Sambucus' image. However, none of these images were contemporary pictures of Georgius Agricola.

All biographies of Georgius Agricola, written prior to 1955, make evident that the most authentic picture is that of Johannes Sambucus done in 1574. However Hans Prescher, Director of the Museum of Mineralogy and Geology in Dresden and publisher of "De re metallica" in the German language, [5] discovered a contemporary picture of Georgius Agricola in the woodcuts of "De re metallica". Prescher evaluated all 292 woodcuts of "De re metallica" and found in Book IX (p. 415)[1] on the picture with tin-furnace and tin-casting, a writing man with his secretary (Figure 2: woodcut p. 415, writing penman). The penman's clothes, book, penholder and accompanying secretary make him an unsuitable metallurgical plant worker. He additionally has the characteristic features attributed to Georgius Agricola: age; form of the nose; high forehead; beard; and a receding hairline. Hans Prescher cites a letter of Georg Fabricius (1516-1571), in which he writes, that Johann Wilhelm Reifenstein possessed a picture of Agricola; however, the picture has been lost. The woodcut to which Prescher attributes Agricola's image was made by Hans Rudolf Manuel Deutsch (1525-1571); however, it is not signed. It remains unclear what connection, if any J.W. Reifenstein and H.R.M. Deutsch might have had. [6] Deutsch may have used Reifenstein's image of Agricola to prepare his woodcut; however, there is not sufficient evidence to support or refute this speculation.

A: Medals with the Sambucus Portrait

Sambucus' image of Agricola is the most commonly used image for medals bearing the scientist's portrait. In 1924 the German Society of Metallurgists and Miners (Gesellschaft Deutscher Hütten- und Bergleute) minted a bronze medal with the Sambucus portrait for a meeting in Freiberg, Saxony (Figure 1, Medal 24.1). Friedrich Wilhelm Hörnlein, Dresden mint engraver from 1911 to 1945, designed this best-known and most commonly used portrait. [7] In later years the obverse of this medal was used by the Freiberg Mining Academy (Bergakademie Freiberg) for a series of medals issued to distinguished scientists (struck in sliver) and graduated students (struck in bronze).

In 1955 in connection with the 400th anniversary of Agricola's death several Sambucus-portrait-medals were struck. The Georg Agricola-Gesellschaft (West) used coal for a 125mm medal. [8] The Zentrale Agricola-Kommission (Ost) of the eastern part of Germany produced porcelain medals with diameters of 38mm and 40mm, with partially gold edges. [9] A 48mm brown porcelain medal was issued in Karl-Marx-Stadt (modern day Chemnitz; the town was called Karl-Marx-Stadt from 1953-1990). A white 38mm porcelain medal (Figure 1, Medal 55.1) was produced for the VIIth Workshop on Mining and Metallurgy (VII Berg- und Hüttenmännischer Tag) in Freiberg.[10]

In 1976 a medal was struck to commemorate the 50th anniversary of the Agricola Society. This 28mm silver medal reverse shows a portrait of Oskar von Miller, founder of the German Museum in Munich (Figure 1, Medal 76.1).

A great number of medals were struck in 1994 to commemorate the 500th anniversary of Agricola's birth. The medals produced in 1994 show more pictorial presentations on the reverse sides than previous medals (Figure 1, Medals 94.2; 94.4 and 94.8). Below is a list of production information for each of the medals, as well as a description of the reverse image:

- Brand-Erbisdorf near Freiberg, 46mm Sn, ([1] p. 213): Descending into the shaft by sliding down on the bottom.

- Chemnitz, 40mm Ag, ([1] p. 284): A stamp mill, in which iron-shod stamps crush ore.

- Ehrenfriedersdorf, 30mm Sn, ([1] p. 185): Water pump (Ehrenfriedersdorfer Radpompe) "The seventh kind of pump, invented 10 years ago (ca. 1540), which is the most ingenious, durable, and useful of all, can be made without much expense."

- A 40mm silver medal of Chemnitz (Figure 3, Medal 94.3) registered the main phases of his life and his activities, including the cities he lived in and the positions he held: Glauchau; Leipzig; Zwickau; Bologna-Venedig; Joachimsthal; Chemnitz; Geologist; Mineralogist; Miner; Metallurgist; Physician; Teacher; Historian; Philologist; Burgomaster; and Diplomat.

- A 100mm artist medal from P. Güttler (Dresden) (Figure 3, Medal 94.7) shows a quasi half relief portrait on the obverse and the letters "G.A." between the dates of birth and death, the Saxon coat of arms and a "winged head" on the reverse.

Further medals are listed in the following short catalogue.

B. Medals with the Freher Portrait

Medals from the city of Glauchau, the birthplace of Georgius Agricola, show Agricola facing right (Figure 3, Medal 76.2). This right facing image is similar to the Freher portrait and contrary to the Sambucus portrait that faces left. The designer and engraver of these medals, Alfred Brand of Sehma, Saxony, used a bronze monument of Agricola as a model for the medals. The monument was created by Rudolf Löhner (1880-1971) and erected near the railway station in the city of Glauchau on 23 March 1958.

C. Medals with Prescher´s Penman

H. Prescher´s penman was probably first used by the "Coin Friends of Freiberg" (Freiberger Münzfreunde) in 1994 in commemoration of the 500th anniversary of Agricola's birth. The obverse of the medal shows a seated Agricola writing with penholder and inkpot (Figure 3, Medal 94.9). The features illustrated on this medal are not as good as those of the woodcut. Agricola is shown too young and with too much hair. The reverse of the medal shows a part of the woodcut (descending into the shaft by sitting on a stick) from "De re metallica" ([1] p. 213).

D. Other Medals

A brown porcelain-medal was produced by the Institut für Bergbausicherheit, Leipzig in 1985. They used the "De re metallica" woodcut from page 212. [1] The reverse of the medal illustrated "the old system of ventilating by the constant shaking of linen cloth." [1] The image on the medal is of Agricola as a working miner with hammer and chisel (Figure 3, Medal 85.1); however, this is contrary to the woodcut image that does not show Agricola as the working miner.

In the following small catalogue 37 Agricola-portrait medals are listed. These are not, without a doubt, the only ones to have been struck; the author would be thankful for further references to Agricola-portrait medals.

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No.	Year	Material	Diam. in MM	Obverse	Reverse	Occasion	Engraver	Literature
24.1	1924	Bronze	45.2	Facing Left	8 lines of text	Visiting Medal	Horlein	
24.2	1924 & later	Bronze/Silver	45.2	Facing Left	free for the names	Medal of Distinction		
55.1	1955	White Porcelain	37.7	Facing Left	6 lines of text	"VII Berg- und Hüttentag, Frieberg"		
55.2	1955	White Porcelain	37.7	Facing Left	5 lines of text	400th Anniversary of Agricola's death	Freiberg Agricola-Kommission (East)	"Promoted Jan. 14, 1955"
55.3	1955	Porcelain edged in gold	40.0	Facing Left	5 lines of text	400th Anniversary of Agricola's death	Agricola-Komission	
55.4	(1955)	Coal	125.0	Facing Left	3 lines of text	400th Anniversary of Agricola's death		
62.1	1962	Porcelain	42.0	Facing Left		100 years celebration of the Zwickau Mining School		
62.2	1963	Porcelain	83.0	Facing Left	Miner	Distinction Zwickau Mining School		
76.1	(1976)	Silver	28.0	Facing Left	Oskar von Miller	50th Anniversary of Georg-Argicola-Gesellschaft (West)	German Museum Munich	
76.2	(1976)	Bronze/Aluminum/ Gold	37.3	Facing Right	Glauchau coat of arms	10th Weaver's Festival		
76.3	(1976)	Copper/Nickel & later	60.0	Facing Right	Glauchau coat of arms	Honoring Medal		
77.1	(1977)	Brown Ceramic	48.4	Facing Left	Karl-Marx-Stadt coat of arms	Karl-Marx-Stadt Information	Karl-Marx-Stadt (Chemntiz)	
80.1	1980	Brown Ceramic	40.0	Facing Left	3 lines of text	"VII Berg- und Hüttentag, Frieberg"	Bergakademie Freiberg	
84.1	1984	Brass	60.0	Facing Right	Glauchau coat of arms	125 years celebration of the G. Agricola grammar school		
85.1	1985	Brown Ceramic	63.0		IFB (Institut für Bergbausicherheit) Leipzig	25 years celebration of IFB		
85.2	1985 & later	Brown Ceramic	63.0		Honoring Medal	Honoring Medal		

No.	Year	Material	Diam. in MM	Obverse	Reverse	Occasion	Engraver	Literature
86.1	1986	Copper/Silver	40.0	Facing Left	Monument in the city of Saalfeld	25 years celebration of the hospital in Saalfeld		
	?	White Metal	60.0	Facing Right	7 lines of text	Uranium Mines	Kremntiz (Czechoslovakia)	
	?	White Metal	60	Facing Right	7 lines of text	Uranium Mines	Kremntiz (Czechoslovakia)	
90.1	1990	Bronze	60.5	Facing Left	Mining Instruments	Mining in Slavkovsky les (Czechoslovakia)		
94.1	1994	Silver	35	Facing Left	German Mining Museum Bochum	500th Anniversary of Argicola's Birthday	Euro-mint Bochum	
94.2	1994	Tin	46.5	Facing Left	Woodcut p. 213	500th Anniversary of Argicola's Birthday	Barthel Brand-Erbisdorf (near Freiberg)	
94.3	1994	Silver	40.2	Facing Left	12 lines of text	500th Anniversary of Argicola's Birthday	Sparkasse Chemnitz	
94.4	1994	Silver	40.2	Facing Left	Woodcut p. 284	500th Anniversary of Argicola's Birthday	Sparkasse Chemnitz	
94.5	1994	Brass? Golden	40.2	Facing Left	Buildings in Chemnitz	500th Anniversary of Argicola's Birthday	Günnewig Hotels	
94.6	1994	Brown Ceramic/ White Paint	65.0; 88?	Facing Left	3? lines of text	500th Anniversary of Argicola's Birthday	Georgius Agricola Komitee Chemnitz	
94.7	1994	White Metal	100	Facing Left	Winged Head	500th Anniversary of Argicola's Birthday	P. Güttler Dresden	
94.8	1994	Tin	30.1	Facing Left	Woodcut p. 185	500th Anniversary of Argicola's Birthday	Ehrenfriedersdorf	
94.9	1994	Bronze/Silver	40.2		Woodcut p. 415	500th Anniversary of Argicola's Birthday	Freiberger Müzfreunde	
94.1	1994	Brown Ceramic	40.6	Facing Left	4 lines of text	500th Anniversary of Argicola's Birthday	Bergakademie Freiberg	
94.11	1994	Silver/Gold	25	Facing Left	Glauchau coat of arms	500th Anniversary of Argicola's Birthday	Glauchau	
94.12	1994	Silver	25	Facing Left	Saxon coat of arms	500th Anniversary of Argicola's Birthday	Garcia-Greno Glauchau	
94.13	1994	Silver/Gold	30	Facing Left	Minerals	500th Anniversary of Argicola's Birthday	Majestic-Gmb H Großostheim	

No.	Year	Material	Diam. in MM	Obverse	Reverse	Occasion	Engraver	Literature
94.14	1994	Silver/Gold	30	Facing Left	City of Zeitz	500th Anniversary of Argicola's Birthday	Majestic-Gmb H Großostheim	
94.15	1994	Bronze	50.2	Facing Left	Mining Museum	500th Anniversary of Argicola's Birthday	F.Scheppat; W. Godec	
94.16	1994	Bronze	?	Facing Left	Silver Street across the Saxon ore mountains	500th Anniversary of Argicola's Birthday		
0.1	2000	Lead	46	Facing Left	Reverse Free		Jachymov	
0.2	2000	Tin	30	Facing Right	6 lines of text	5th Cultural Heritage Symposium, Golden, CO USA	T. Brand, Sehma, Saxony	

Figure 1: Agricola portraits of 1566 (H. Pantaleon), 1574 (J. Sambucus) and 1688 (P. Freher). Medals Nos. 24.1; 55.1; 76.1; 94.2 (reverse page 213); 94.4 (reverse page 284) and 94.8 (reverse page 185).

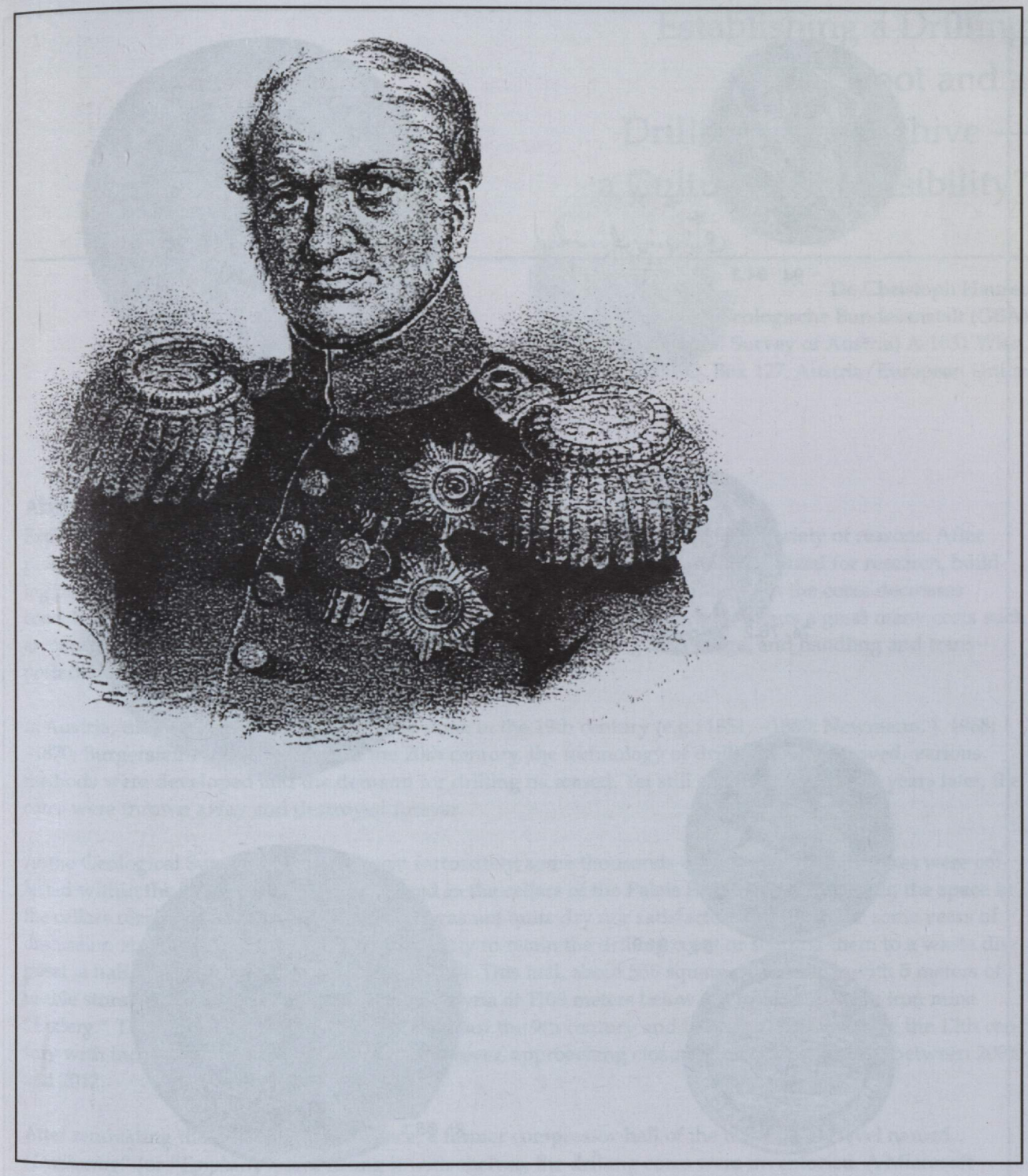

Figure 2: De re metallica, woodcut page 415 [1]. The person on the left, sitting and writing, may be according to H. Prescher [6] the only contemporary portrait of Georgius Agricola.

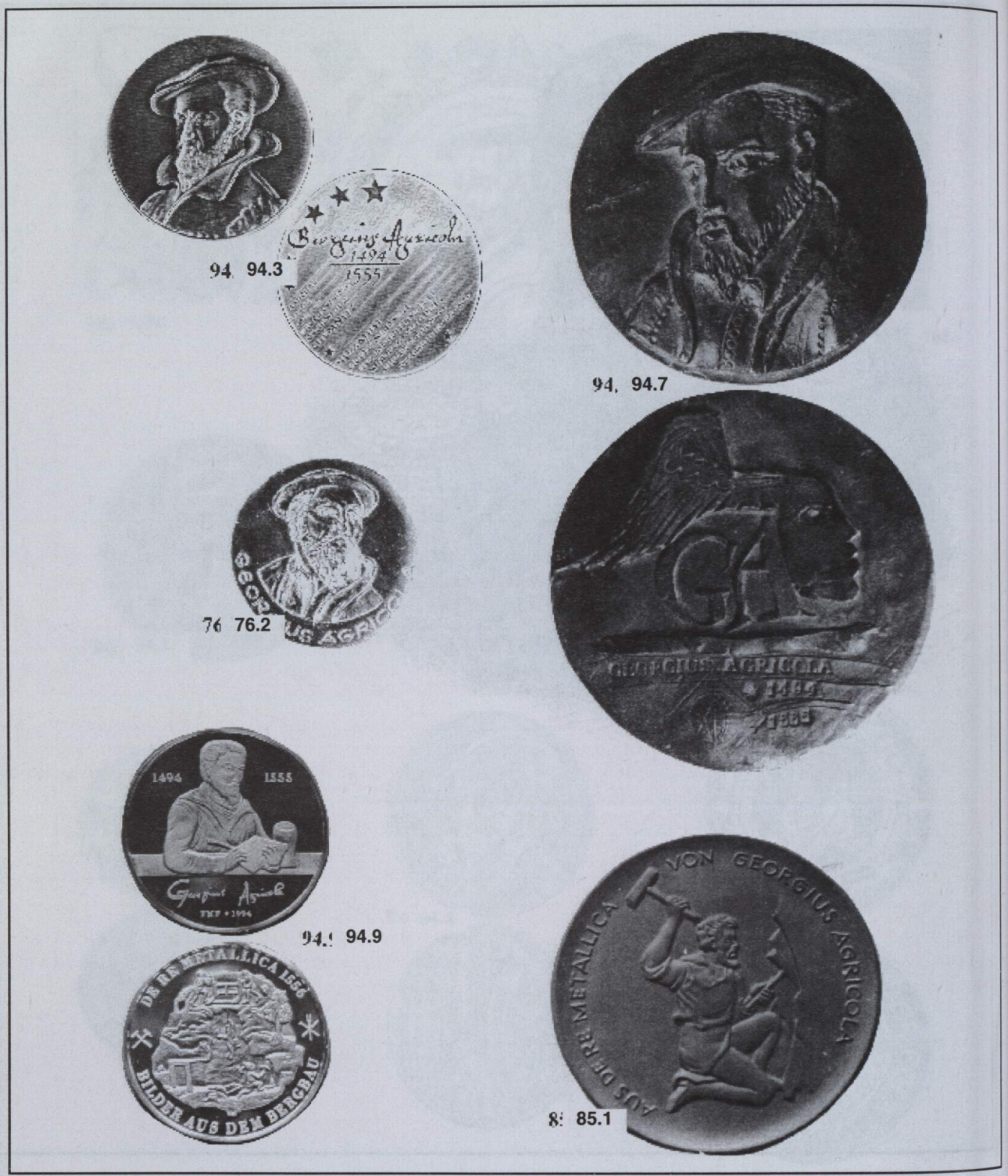

Figure 3: Medals Nos. 94.3; 94.7; 76.2; 94.9 (reverse page 213) and 85.1 (page 212).

Establishing a Drilling Core Depot and a Drilling Core Archive — a Cultural Responsibility?

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Abstract

Experience shows that expensive drilling with the retrieval of core is done for a variety of reasons. After prospect sampling of the core, measuring, and core analysis, the information is utilized for research, building purposes, or quarry work. After completion of the project, however, interest in the cores decreases considerably. Keeping the cores for a longer time, for succeeding generations, incurs a great many costs such as storage rental or building costs, operating costs, special shelving for storage, and handling and transportation costs.

In Austria, the first reports of drilling were done in the 19th century (e.g.; 1851; ~1860; Newmann, J. 1968; ~1870; Burgerstein, L. 1882). Later, in the 20th century, the technology of drilling was improved, various methods were developed and the demand for drilling increased. Yet still sometimes, perhaps years later, the cores were thrown away and destroyed forever.

At the Geological Survey of Austria, most fortunately, some thousands of meters of drilling cores were collected within the last few decades and stored in the cellars of the Palais Rasumofsky. However, the space in the cellars reached capacity and the storage was not quite dry nor satisfactorily clean. After some years of discussion about finding further storage capacity to retain the drilling cores or sending them to a waste disposal, a hall was rented in the beginning of 1999. This hall, about 550 square meters large with 5 meters of usable storage height, is situated at Eisenerz/Styria at 1100 meters below sea level within the iron mine "*Erzberg*." This mine has been known since at least the 9th century and has been working since the 12th century with increasing importance. It is now, however, approaching closure, probably sometime between 2008 and 2012.

After renovating the newly acquired space, a former compressor-hall of the mine, at the level named "*Dreikoenig*" (or "*Epiphany*") and fitting it with shelves, the drilling cores were inventoried. A Microsoft ACCESS database was developed and the cores were moved with the help of the Austrian Federal Army by 18 trucks to the Erzberg.

This was the first step to protect partly irreplaceable cores for the future. New methods of investigation can be applied, verifications and evidences can be obtained. In the future it is expected that cores from other public authorities and mining and engineering companies, will be stored at Erzberg with the data added to the database, providing knowledge of the samples and a usable body of data for industry and science.

The Discovery of Silver in Nevada: the Grosh Brothers' Correspondence, 1849-1857

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Abstract

The discovery of rich silver and gold deposits at Virginia City, Nevada, led to a second western gold rush that provided immense wealth to a nation in need of financial stability during and after the Civil War. The Grosh Brothers' correspondence of 1849-1857 is perhaps the most historically important collection of correspondence regarding the development of the west that has been studied in modern times.

Brothers Eathan Allen (Allen) and Hosea Ballou Grosh joined the California gold rush from Pennsylvania in 1849. Their letters and those of their father after their deaths describe their gold digging expeditions, inventions, sicknesses, and work on the Comstock. The one hundred eleven letters are beautifully written, dutifully descriptive, and illustrative of their every life experience. They were eternally optimistic in all their endeavors despite terrible difficulties and tragedy. Their optimism is indicated in all letters to their father Aaron and brother Warren Grosh.

The historical record references accounts of these letters although the letters were only made available to U.S. Geological Survey researcher Elliott Lord. Aaron Grosh provided Lord with quotes from a few of the letters. Family records indicate no other historians contacted the family. A second group of letters was in the possession of Grosh's attorney for use in a claim against the major mining companies in the early 1860s. This set of letters has been apparently destroyed. The settlement is not recorded in the historical court record nor is the disillusionment with the attorney who may have kept the settlement payment, letters, and the original map from the brothers. This attorney also conspired with another lawyer to conceal the original samples and maps that were in the possession of Allen when he died tragically after crossing the Sierra Mountains in high winter in 1857. The third group of letters is between the surviving partner of Allen and Aaron Grosh, which continued for the remainder of Aaron's life. It chronicles the legal activity and the aftermath of the public Comstock discoveries.

The Gold Ingots of the SS Central America, 1857

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Abstract

The *SS Central America* treasure has been discussed in the media as the greatest American treasure of the 20th century with a value of about $100 million. The treasure consists of nearly three tons of gold ingots, nuggets, and gold coins freshly minted at San Francisco. The treasure was recovered in 1990-1991 using advanced innovative scientific technology.

The treasure is remarkable for its historical value as well as its monetary value. The ingots tell an interesting story of the assaying business during the California gold rush and about the bullion business in general. Various aspects of the marking on the bullion reveal that the ingots were tested and marked in a centuries-old manner. The data gained from the five different California assaying firms is the first such solid data to surface in modern times. Surviving documents from these assaying firms during the same period help define the methodology of the bullion transactions.

Gold dust, nuggets, amalgam, and specimens recovered from the wreck also shed light on other aspects of gold trade during the gold rush period. These represent some of the few gold nuggets actually mined during the California gold rush with irrefutable provenance.

Distinguished scientists - W.L. Bragg , L. Pauling, and N.V. Belov - in exhibition at the Earth Science Museum at Lomonosov Moscow State University

Tatiana Ivanova [1], Galina Dorokhova [2] and Elizaveta Belova [3]
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Abstract

The Earth Science Museum traditionally collects and preserves memorabilia of the distinguished native and foreign scientists who have greatly contributed to the development of the Earth Sciences. In the halls of the Museums are more then 100 busts, bas-reliefs, and portraits of the most famous Russian and foreign scientists. Scientific achievements are outlined in posters (over 300). A new poster "Mineral Structures" outlines the scientific ideas of the leaders of British, American, and Russian crystallographers—W.L. Bragg, L. Pauling and N.V. Belov. Three themes of crystal chemistry and structural mineralogy are represented in the poster. They are: theory of closest-packing, the structure and crystal chemistry classification of silicates, and crystal chemistry of sulphide minerals. Interior structures of minerals are represented by spherical or polyhedral models, the latest showing the cation polyhedrons. This method of representation of closest-packing structures has been developed by Linus Pauling, American scientist and twice Nobel Prize laureate, and improved by N.V. Belov. The poster aids the students of the University in their crystal chemistry courses and serves as an educational program for the Museum's greater audience.

Introduction

The Earth Science Museum at Lomonosov Moscow State University (MSU) is an educational and scientific exhibition center as well as a cultural center. Traditionally, all posters and samples were used for scientific and educational purposes since the Museum opened in 1955. This educational support continues to be the primary purpose of the Museum today.

The Earth Science Museum occupies the top seven floors of the main university building of the Sparrow Hills (Vorobjovy Gory). In recent years, the entire exhibition was been refurbished and new information included. This was made necessary by advances in science and technology as well as changing educational programs at the Moscow State University. The posters were designed to exhibit new methods such as: 1) to analyze and categorize new scientific information, 2) to present the historical context of scientific information; and 3) to coordinate the scientific content of the posters with the educational programs and courses of the departments of earth science at MSU.

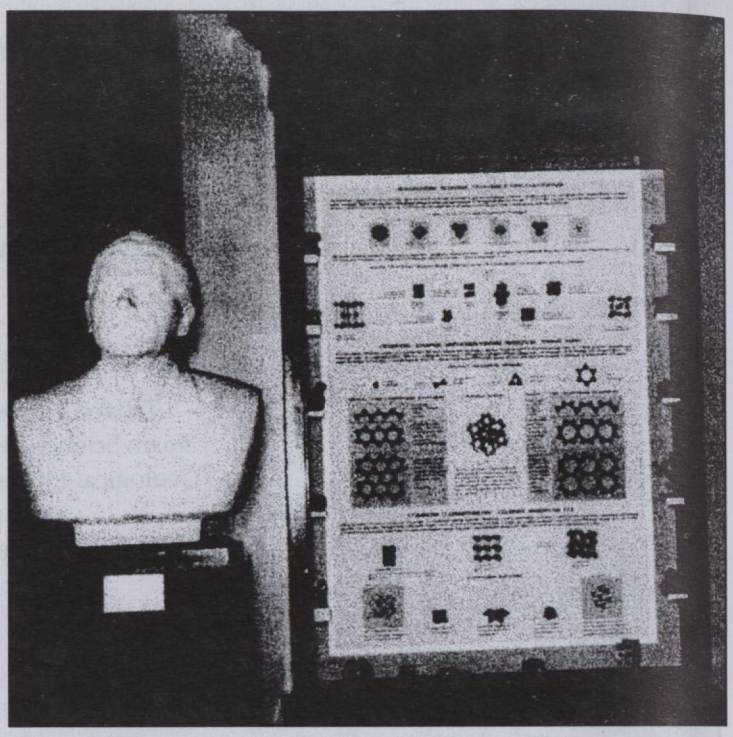

Figure 1. The bust of academician N.V. Belov and the poster "Mineral Structures"

The main themes of crystallography are represented in the exhibition "The Process of Formation of Minerals and Mineral Resources." This exhibition is located on the 27th floor of MSU and contains five sections: "The Processes of Mineral Formation," "The Processes of Ore Formation," "Metal Deposits," " Non-metallic Ore Deposits," and "Fossil Fuel Deposits." Along the center of each section there are large display-cases. Collections of minerals, properly classified, are exhibited in ten showcases, while two showcases display a collection of genetic mineralogy.

Fifty posters and panels containing hundreds of varied collections and ten stained-glass panels are demonstrated in the sections. About 100,000 natural specimens are grouped into 50 thematic exhibits arranged in showcases and adjacent storage cases. Seventeen pictures reflect the formation of minerals, location of mineral recourses, and methods of their exploration. In addition to the busts mentioned above, this division contains 24 portraits of the most prominent scientists, including geochemists, crystallographers, mineralogists and geologists who studied the processes of the formation of minerals and mineral resources.

For the purposes of this paper, the new poster "Mineral Structures" is described. It outlines the scientific ideas of the leading British, American, and Russian mineralogists: W.L. Bragg; L. Pauling; and N. V. Belov.

"Mineral Structures" Poster

The first posters of the exhibition "The Process of Formation of Mineral and Mineral Resources" only represented specific achievements. The authors have created new posters, which outline fundamental achievements as well as the development of scientific ideas. This approach has been received favorably and these posters have been included in the refurbishing of the exhibition. The scientists of the Museum and professors and students in courses of mineralogy, crystallography, crystal chemistry, and geology taught in the geological, geographical, biological, and soil science departments of MSU are actively using this exhibition as an educational opportunity.

The poster "Mineral Structures" outlines the scientific theories regarding crystallography of leading British, American, and Russian scientists - William Lawrence Bragg, Linus Pauling and Nicolay Vaciljevich Belov. Three themes of crystal chemistry and structural mineralogy are represented. They are the theory of closest packing, the structure and crystal chemistry classification of silicates, and crystal chemistry of sulphide minerals (Figure 1).

Closest packing in crystal chemistry. What is the theory of closest packing? The geometrical problem to fill as much space as possible with "balls" has an infinite multitude of solutions. Two of them are particularly important for crystallography. They are cubic and hexagonal closest-packing. On this poster those two types, cubic and hexagonal, closest packing are illustrated. The balls occupy nearly 75% of the total space. The free spaces between the balls are octahedral and tetrahedral vacancies. The relationship between the spheres and the octahedral and tetrahedral vacancies can be described as 1:1:2.

The laws of closest packing affect the distribution of atoms in structures of different classes of minerals. In these structures, the anions create the closest packing, thereby also creating the vacancies. The regular distribution of cations around the anions determines the type of structure and physical properties of minerals. The structures of minerals are demonstrated by the balls or polyhedral models, the newest also show the distribution of the cation polyhedrons. This method was proposed by Linus Pauling, American scientist and twice Nobel laureate. Using this approach, the distribution of octahedral or tetrahedral vacancies can be seen. Pauling believed the cation bonding to be extremely important in crystal structure [Pauling 1960].

Russian scientist-academician N.V. Belov used these two known types of vacancies in closest packing for the description of even very complicated structures as well as further developing this theory [Belov, 1947]. He used this method for crystals with distorted closest-packing and without closest-packing. Now scientists demonstrate the crystal structures in view of not only tetrahedrons and octahedrons, but also cubes, prisms, and 12-sided figures with different degrees of distortion. "Belov's model" is often used for demonstration of the complex structures of different compounds such as silicates, borates, sulphides and others.

Complex chemistry of silicates. Silicates have a very complex chemical composition and compose a third of all known minerals. In the 1930s British scientist W.L. Bragg and his colleagues began to study the structures of silicates with the help of X-ray crystallographic analysis. They determined that the main structure of silicates is the silicon-oxygen tetrahedron SiO_4.

W. L. Bragg based his systematic classification of silicates on a type of SiO_4 tetrahedral linkage. Thus, silicates with finite and infinite Si-O tetrahedrons were described [Bragg 1937].

In the early 1950s, N.V. Belov and his colleagues studied the more complex structures of silicates as tourmaline, ramzaite, and epidote. It was established that the diortogroup Si_2O_7 is the main structural unit in silicates with large cations. Silicon-oxygen structures are not rigid, as Bragg considered, but flexible and adaptable to the main cation placement and bonding in structures [Belov 1976].

It became clear that classic "structure of silicates" of W.L. Bragg was only the first definition of the silicate's crystal chemistry. Figure 1 shows the silicates with finite Si-O motifs and silicates with infinite Si-O motifs by combining the approaches of Bragg and Belov.

Description of sulphides. This portion of the poster shows the Belov's method of the structure description being used to describe this very important class of minerals—sulphides. The chemical composition of sulphides is relatively simple but for a long time it was impossible to explain the connection between the structure and physical properties (for example, metal - metal connections in pyrrhotite). N.V. Belov created the crystal chemistry theory of sulphides and sulphosalts on the basis of the idea that atoms in these structures form the stable electronic shells as in noble gases (8, 18, etc.) or with 13, 14, and 22 electrons and the co-coordinating numbers of sulfide elements in different structures. Belov was able to define certain numerical laws for the sulphide descriptions. Many sulphides are characterized by clusters (groups of metal atoms) with the additional metallic association [Belov 1976].

The poster illustrates the structures of some of these minerals: chalcopyrite $CuFeS_2$ (electronic configuration for Cu -"18", for Fe "13"), galenite PbS (structure similar to galite NaCl), pyrite FeS_2 (anionic dumbbell S_2), penflandite (cluster of 8 groups of Ni-tetrahedra is shown), milerite (cluster of three Ni-semioctahedra). This

part of poster also illustrates the details of such structures as pyrrhotine, represented by transparent octahedrons complicated by faces. Ellipsoids of metals are inside of octahedrons; also illustrated are semioctahedra of sulphosaltical ribbon SbS_5 .

Conclusion

The new poster "Mineral Structures" outlines fundamental achievements in different areas of crystallography. It is used by the scientific workers of the Museum and the professors of the Geological Department, among others, of Lomonosov Moscow State University in the courses mineralogy, crystallography, and crystal chemistry for the students of geological, geographical, biological, and soil-science departments.

The authors of this paper T. Ivanova and G. Dorokhova were the students of academician N.V. Belov. E. Belova is N.V. Belov's daughter.

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Pauling L. 1960. The Nature of Chemical Bond and the Structure of Molecules and Crystals: an Introduction to Modern Structural Chemistry. Ithaca, NY: Cornell University Press. 3rd edition. 664 p.

Funeral Customs and Symbolism of Miners' Tombs in Central European Mining Regions

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Abstract

Mining has brought mortal danger through the ages; violent and sudden death were daily companions to the miners, particularly in the early epochs of mining, when technical opportunities for working in the mines safely were very scarce. Special ties to heavenly protectors are noticed very early in the cultural heritage of mining communities. In medieval mining regions in Europe, miners prayed to saints like St. Barbara, St. Daniel, and St. Anne. When a miner died, his death was a warning to his co-workers despite of all his personal belief. The miner was brought to his tomb in a particular way; e.g., there was a special choice of symbols such as the characteristic Schlaegel und Eisen (hammer and chisel) set upside down to mark death as the great destroyer of human order. Funeral music and funeral songs of miners are a special kind of veneration to their comrade who was either killed by accident in the mine or died otherwise. Even retired miners are currently honored in similar ways. Velvet sheets covering the bier, embroidered with symbols of mining, are still in use. The miner's companions will wear their festive dress, the *Bergkittel*. Banners of the miners' associations are covered with black crepe bands as a sign of grief. High-ranking owners of mines or engineers could afford very pompous tombs and monuments. A slide presentation of a selection of these with their typical symbols and pictorial presentations will be shown during the lecture. The monuments are from Austria and Germany and from the Middle Ages to present. Medieval examples are abundant in Tyrol, Carinthia, Styria and Saxony, but the apex of these monuments was in the 19th century during the technical revolution, when mining was one of the main sources for economic development.

Introduction

Mining has brought mortal danger through the ages, and even today, when highly skilled technology runs the mines, sudden and violent death of miners occurs.

Figure 1. Saint Barbara protecting a miner. Tomb in St. Peter/Freienstein, Styria, 1912.

One of the most severe disasters happened just two years ago in the talcum mine of Lassing (Styria/Austria). Ten miners were killed and there has been no opportunity to recover their corpses to date.

Special ties to heavenly protectors can be noticed very early in the history of mining. During the Middle Ages miners were inclined to pray to protectors like St. Daniel or St. Anne, because those saints had close relations to mining within the biblical records. St. Daniel is considered a prophet of ores and gems, who also mastered the danger of death deep in the pit of lions. St. Anne is regarded as a "celestial mine," having born Mary as silver and Jesus as gold. Since about 1500 A.D., St. Barbara adopted the role as protectress of miners' lives. She was considered a patron saint against sudden death in general, according to her legend, when she took shelter in a mountain, fleeing her pagan father.

Miners developed the habit of praying to their saints, who were cherished by Catholics and Protestants alike, even during the fierce quarrels between both faiths. In the 19th century, in the age of the industrial revolution, when the human society was changing due to the ideas of Marxism and Socialism, miners did not—as opposed to other industrial workers—leave the path of faith. "A worker in an industrial plant is starting his shift with a curse, while a miner is beginning it with a prayer" was a common saying.

The danger of death accompanies a miner every day. The old miner's greeting *"Glueck auf!"* is a formula of hope to come back safely from the depths of the mine after work is done. It means, "come back with luck from beneath" and is used very commonly even today, in a time, when many other traditional sayings have faded away. For centuries it has illustrated the ups and downs of a miner's fate. [1]

Historically when a miner died, his corpse was treated in a particular manner. Dying was accompanied - if possible - by the priest of his faith. A coffin was ordered by the family at a carpenter's workshop. The corpse was washed and dressed in his festive *Bergkittel*, the traditional miner's clothing. The bier stood in the miner's lodging for three days, the companions, relatives and friends paying their respects. Praying in company in the evening and keeping guard beside the coffin during the night were very common. Afterwards, the coffin was closed and covered with a special sheet of black velvet, embroidered in silver with miners' symbols such as Schlaegel und Eisen (hammer and chisel), hands clutching in friendship, and crosses.

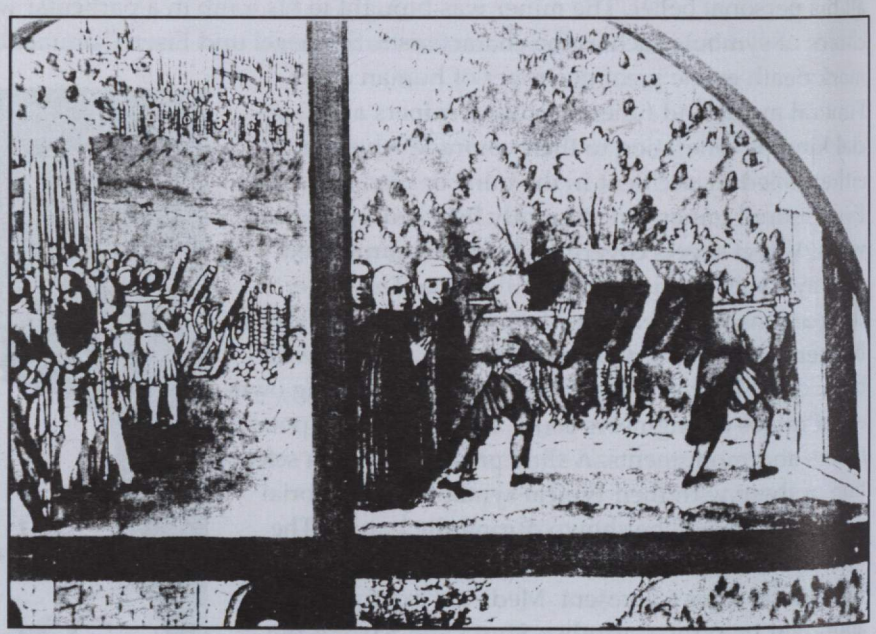


Figure 2. Miner's funeral. Schwazer Bergbuch, 1556.

This special ceremonial cloth had its parallels in the craftsmen's guilds from the Middle Ages. The origins are found in the customs of medieval fraternities (Bruderschaft, confracernitas) and the prayer and funeral associations of Christian laymen responsible for organizing funerals for their members.

The funeral itself was called "Die ltzte Schicht" (last shift), indicating a miner's life meant work and danger until the last day. All the stations of a miner's life, especially in Saxony, were illustrated by the renowned German painter Eduard Heuchler (1801-1879), professor of arts at the Mining Academy of Freiberg in Saxony, in his album of drawings "The Miners in their Professional and Family Lives," [2] which shows a miner's funeral as the last image.

In Heuchler's drawing the coffin is resting over the tomb's mound, decorated with wreaths. In the mining regions of Austria and Germany the expression "Letzte Gruhenfahrt" (last descent to the mine) was also used and can often be found as inscription on miners' tombstones in the 19th century.

Figure 3. Miner's funeral. Drawing by Eduard Heuchler, 1857.

In the past, a dead miner's corpse was often dressed in the *Bergkittel* mentioned above. When the highly respected administrator of citizenship's mines of Leoben (Styria, Austria), Eduard Hollara, passed away in 1847, he was laid onto the bier in his white *Bergkittel*, the characteristic traditional dress of the Erzberg miners since about 1500. Ninety-four miners in their uniforms brought the coffin to the grave, four of them carrying it in a funeral procession. When a student of the Mining Academy of Leoben died, he was honored in the same way. Even when a mine owner's wife died, miners would accompany her body to the cemetery, as it happened to Maria Egger von Eggenwald at Leoben in 1856. [3]

Figure 4. Miner's funeral at Maria Lankowitz, Styria, 1985.

A description of a miner's funeral of more than a century ago can be found in a regional newspaper of Leoben (Styria). [4] In Eisenerz, the town at the foot of the Styrian Erzberg, the central iron-ore mine, a high ranking official died. "Father" Heigl's corpse was laid on the bier in the Kammerhof, a very important building in the center of the village. As was usual at that time, the funeral took place in the evening. The companion miners had lamps in their hands; the workers from the iron plants had torches. A music band of miners (Bergmusik) was playing. The coffin was carried by miners in black *Bergkittel*, six officials on each side accompanied the bier with burning lamps. Other miners brought wreaths, while others were presenting the medals of honor of the deceased on velvet cushions. The old bell was ringing from the *Schichtturm*, a tower from the 16th century, where the signals for starting and ending the shift in the mine were given. There was another acoustic signal given by the *Klopf*, a large iron disc, beaten by a worker; it called "End the shift!" When the coffin was lowered into the grave, all the miners extinguished the lights of their lamps calling *"Glueck auf! Farewell Father Heigl! Glueck auf! Glueck auf!,"* thus ending the ceremony.

Figure 5. Tombstone at Landl, Styria 1559 showing a miner's hammer in the mine owner's coat of arms.

When a tragic event like a mine accident happened, the funeral and final resting place of the victims might be communal, as many examples prove. The victims were buried in the cemetery like dead soldiers after a battle. [5] In 1865 a disaster happened in the coal mine of Seegraben near Leoben (Styria); five miners were killed and buried in the cemetery of Saint Jacob, the former parish church of Leoben. The tablets commemorating their death still can be seen there. [6] There is another communal tomb from another fatal accident in the same mine that occurred in 1928; five miners died.

The tombs of common miners did not differ very much from those of other workers. The existence of those graves is not as permanent as the tombstone, as in most cases only a wooden cross was set onto the grave, commemorating the status of the deceased by means of simple symbols. The most common of them was – and still is – the sign of Schlaegel und Eisen (hammer and chisel), representing the most important tools of the miners.
On tombstones, but also on printed materials such as invitations to a funeral, one may recognize these mining tools in the common way, laid crosswise. But often in connection with death, this general symbol for mining is put upside down (gestuerzt), indicating that death will alter everything radically.

Figure 6. Hammer and chisel upside down as a symbol of death at a miner' s tomb in Knittelfeld, Styria 1990.

The first representation of the crossed Schlaegel und Eisen (hammer and chisel) is said to have been found in the great parish church of Freiberg in Saxony, the so-called Cathedral (Dom). There are two early tombstones with this symbol dating back to 1508 and 1509. One memorializes the canon Andreas Kreul, who died in 1508. It is a small shield of bronze in the wall near a separate plate with an inscription commemorating the dead. It can be assumed that both of tablets belong together. The other tomb plate with the symbol bears an inscription for Nikol Korb and is dated 1509 on the same tablet. [7]

If a miner's ore car is overturned, it can have the same negative meaning. Some monuments for the owners of mines and high-ranking mining officials, engineers or technicians show overturned ore cars, mostly hewn in stone in or near a mine entrance. As a sign of grief and affliction, weeping and mourning miners sit nearby. This kind of presentation was preferred particularly in the very sentimental period of the 19th century.

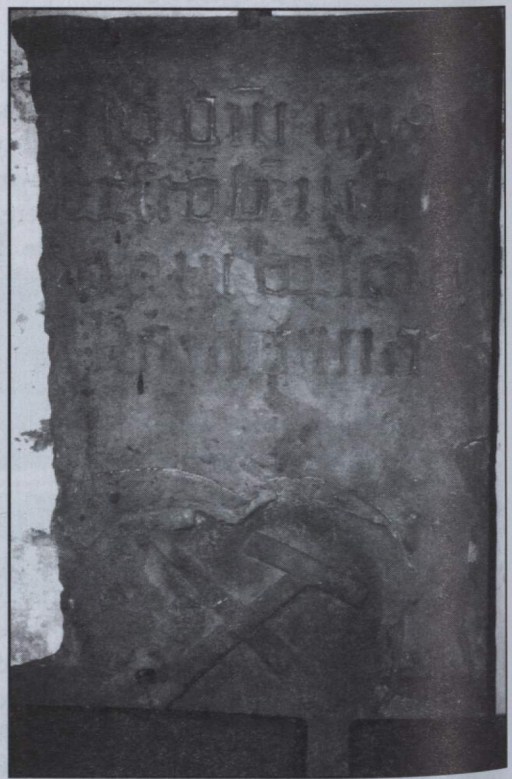


Figure 7. Tombstone of canon Nikol Korb from 1509 at Freiberg/Saxony, presenting hammer and chisel crosswise for the first time.

Footnotes

1 Franz Kirnbauer, 1935, "Ueber bergmaennische Grussformeln," Wiener Zeitschrift fuer Volkskunde, Vol. 40 (1935). Nr. 1/2, p.1-2.
2 Die Bergknappen in ihrem Berufs- und Familienleben. Dresden 1857.
3 Guenther Jontes, 1973, "Leobener Bergparaden, Knappenaufzuege und bergmaennische Feste 1728-1880," Der Leobener Strauss. Beitraege zur Geschichte. Kunstneschichte und Volkskunde der Stadt und ihres Bezirkes. Vol. 1 (1973), p. 134.
4 Obersteirische Zeitung Leoben, Vol. 6 (1890), No. 17, p.2.
5 cf. Wolfgang Paul, 1971, Mining Lore. An illustrated composition and documentary compilation with emphasis on the spirit and history of mining. 2nd ed. Portland Oregon 1971, pp. 548-551.

6 Guenther Jontes, 1991, "Der Jakobifriedhof. Begraebnis und Grab im alten Leoben," Streiflichter, vol. 4 (1991), p. 6-32.

7 Otfried Wagenbreth, 1986 "Freiberger Geschichte widergespiegelt in historischen Grabmaelern. Zur 800-Jahrfeier der Stadt Freiberg," Freiberg i.S. 1986, p. 8.

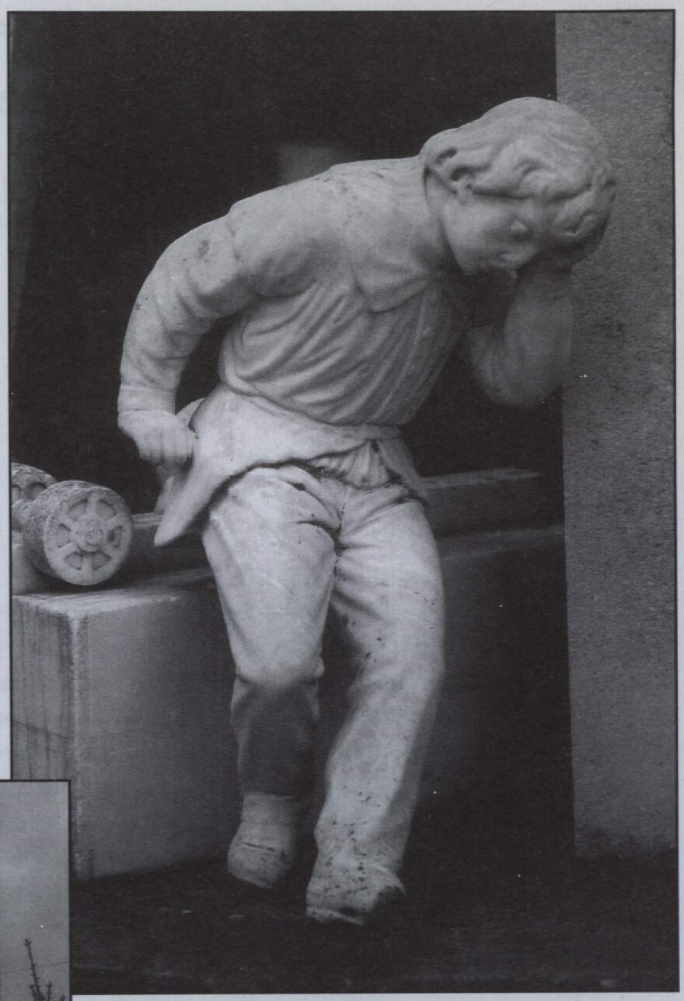


Figure 8. Mourning miner on an overturned ore car, Oberzeiring, Styria 1860.

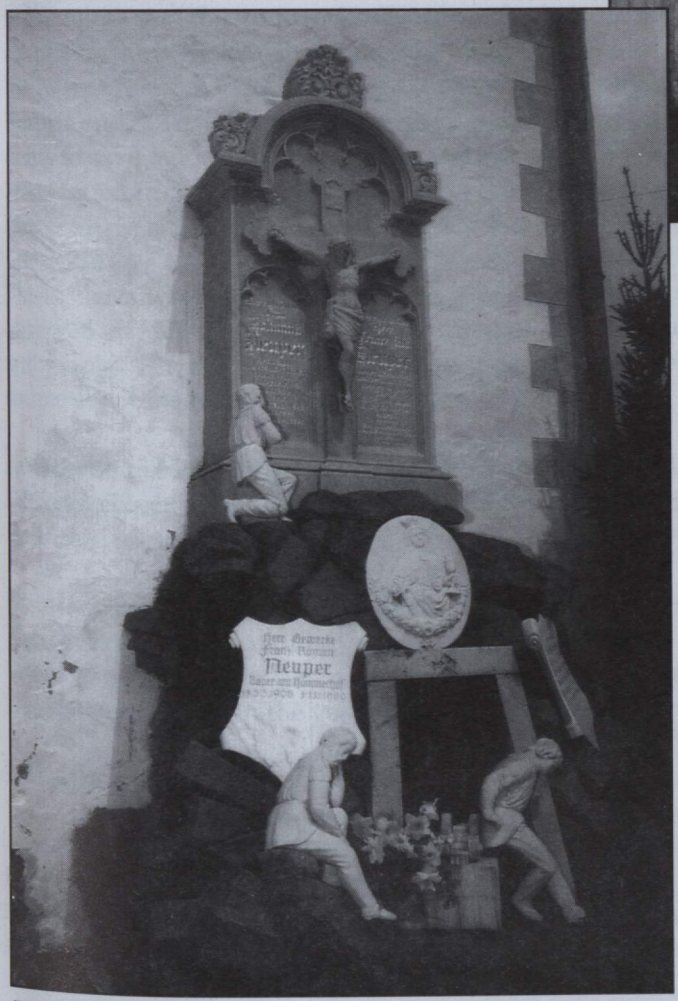
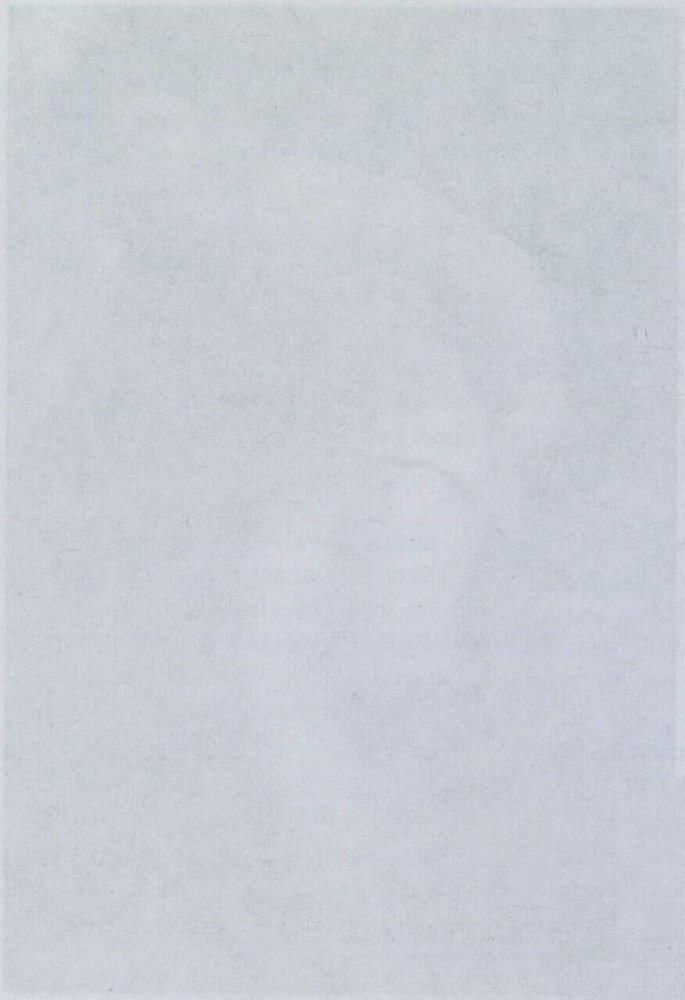
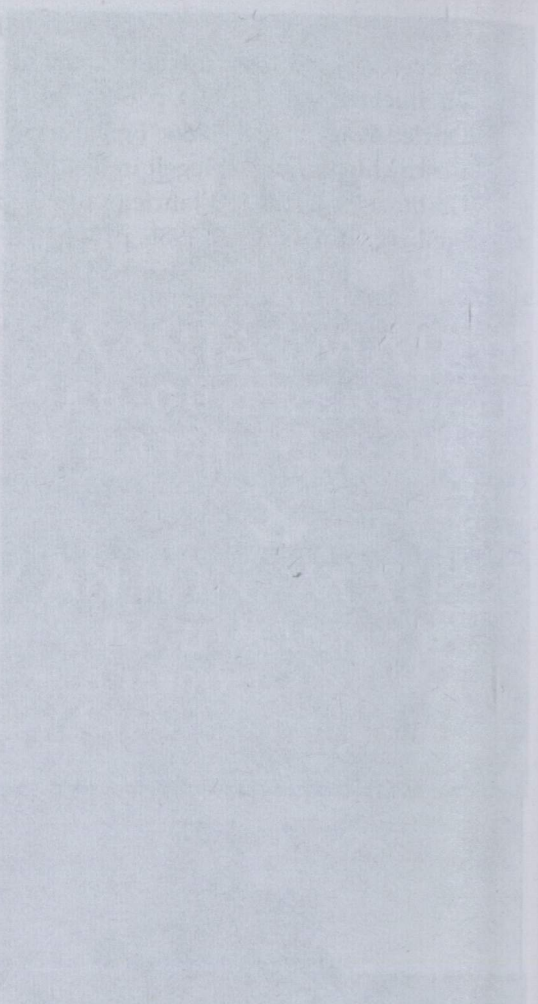
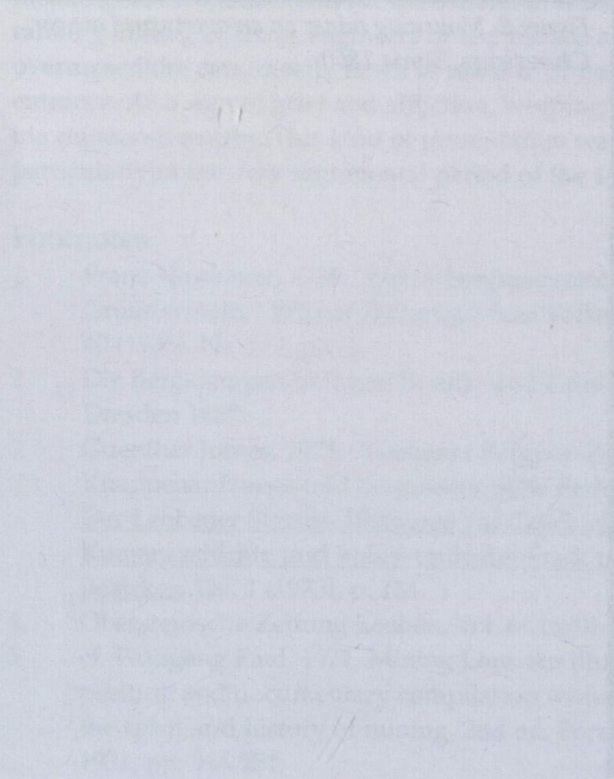
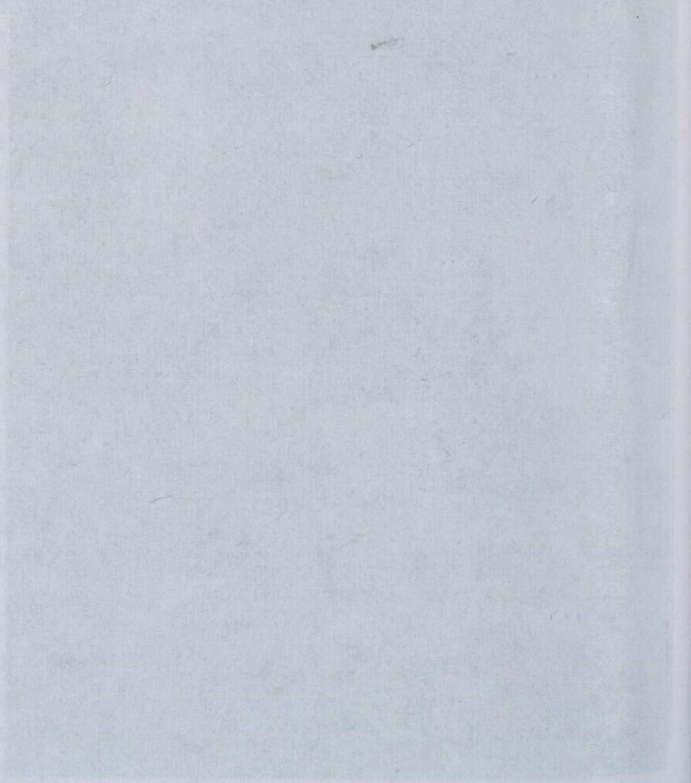


Figure 9. Tomb of the mine owner Franz Xaver Neuper at Ober_eiring, Styria 1860.









Students' Manuscripts as Sources of the History of Mining and Metallurgy

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Abstract

The University Library Leoben holds some manuscripts written by students during the early years of the Mining School in Leoben. The school, later named the Mining Academy, was founded in 1840 in the small village of Vordernberg near Leoben, to improve Austria's iron and steel industry. Therefore the location for the school was very well chosen, being near the great iron ore body, the Styrian Erzberg, and the big iron-works nearby. The program of studies supported the practical side of education. The students had to work in the mines and the iron works. Every week students went on an excursion to nearby mines and metallurgical plants; the big excursion at the beginning of the summer vacation was always a great journey, even from the tourist point of view. It brought students and their professors into a great part of the Austro-Hungarian Empire and the neighboring states. A large part of the journey was made on foot, because it helped the students to save money and the railway did not reach every part of the country. For example, the journey in 1841 started from Vordernberg on foot to the upper part of Styria, then to parts of Salzburg, Carinthia, Lower Styria and back to Leoben and Vordernberg, covering almost 1,000 kilometers.

The students wrote reports about their experiences which their professors completed by adding their own observations. These reports were often written with great accuracy; the text was also illustrated with figures and graphs. The reports often gave a very detailed picture of mines and metallurgical plants; they are a vital source about the history of technology.

Another source of mining history are the maps drawn by students in mine surveying. The University Library Leoben has a fine collection of these drawings, which are often the only sources of information to the history of small mines.

Besides those works for the examinations, in the first years of the School, the students wrote the textbooks. There was no money to build up a library, so the students wrote down the lectures of their famous professor Peter Tunner. There are lectures in mining and ferrous metallurgy, written and duplicated by Alois Neubauer, a student in the year 1842-43.

Introduction

In the 18th century, the importance of coal and mineral resources for industry was recognized; increasing attention was given to the development of mining and metallurgy. It was believed that these subjects should be taught scientifically. As a consequence, mining colleges were established in Europe, including Freiberg, in Saxony, in 1765; Schemnitz, now in Slovakia, in 1770; St. Petersburg, in Russia, in 1773, and Clausthal, in Germany, in 1775.

In the Austro-Hungarian Empire, studies in mining and metallurgy could only be done in Schemnitz . To

increase knowledge in the field of iron mining and metallurgy, the Styrian government wanted to establish a chair for mining sciences at the newly founded Joanneum in Graz. In 1835, the government found a suitable location and an able teacher. The place was Vordernberg, a small village near Leoben, a place with 14 furnaces and the great iron ore body of the Erzberg nearby. The teacher was Peter Tunner, a young metallurgist who accomplished research travel throughout Europe to all the important locations in his field. After five years of travel and study, he returned to open his school in 1840.

The first conference held in Vordernberg declared that students should have to attended preliminary studies at a university or a polytechnic before coming to the mining school. The aim of the school was to produce superior mining functionaries.

The Excursions

When Tunner presented his curriculum, one major point was the weekly excursions to nearby works, to give the students practical experience for their future calling. At the end of the term, a trip to works farther away for scientific study was undertaken. [1] These excursions played an important role in the studies first in Vordernberg and then in Leoben. The University for Mining and Metallurgy (Montanuniversitaet) did not break that tradition, the main excursions every year are compulsory exercises in all courses.

The students wrote reports on their excursions, the best of which were printed in the scientific journal edited by the Mining School. [2] These reports are very accurate descriptions of the mines and plants they had visited with their professors. These manuscripts have become important sources for the history of mining and metallurgy. It is a pity, that very few of these manuscripts have been preserved and can be used publicly in libraries or archives.

The University Library Leoben holds some of these manuscripts from the early years of the school. To show the importance of these works for the history of mining, two books shall be examined more closely: The Metallurgical Excursion 1844; and the Mining Excursions 1856-57.

The Metallurgical Excursion 1844

Alois Neubauer [3] who visited the school in Vordernberg in the third year of its existence, gave in his record concerning the excursion on metallurgy [4] a very detailed description of the ironworks the students were visiting. Beginning in June, the excursions always lasted 6 to 7 weeks. The students had to pay for themselves; therefore, the professor tried to keep the costs low, which meant a great part of the journey was made on foot. Besides the scientific and educational purposes, these journeys could be quoted as tourist highlights, being the first group tours for low-budget travelers.

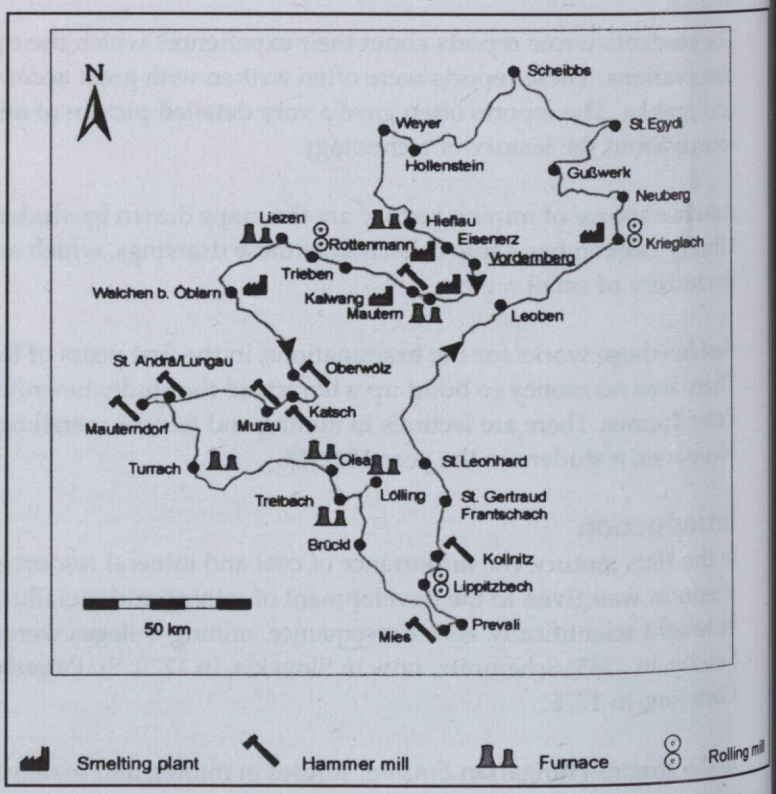

Figure 1. Metallurgical excursion in the year 1844.

The 1844 excursion started in Vordernberg and went across the mountains to visit especially famous iron works in Styria and the neighboring countries. It was not always fun to travel in company of a very serene

professor, but the students saw these excursions as possibilities to travel, to gain knowledge about their country, and of course, to meet people and make friends.

We do not know, exactly when the excursion started, but at the end of it Alois Neubauer's manuscript was read by Peter Tunner, the director and only professor at that time, who also went with the students on their journey. The note does not say, if the professor was satisfied, but Neubauer passed the exams on the 2nd of September with good notes (gut bestanden). At age 27, he finished his studies and went on to get a job in the industry. We do not know very much about his life; however, he became the administrator of a hammer mill in Katsch near Murau (Styria), owned by the Prince of Schwarzenberg, who had given him a scholarship during his studies in Vordernberg. In 1875, Neubauer was still an administrator in one of Schwarzenberg's works, he resigned in 1898 and died in Murau, in 1901.

The excursion started in Vordernberg, going on to Mautern, where the ironworks owned by Ritter von Friedau were visited. These works had two puddling furnaces with preheating furnaces and a sheet rolling mill with a gas-welding furnace (Gas-Schweissofen).

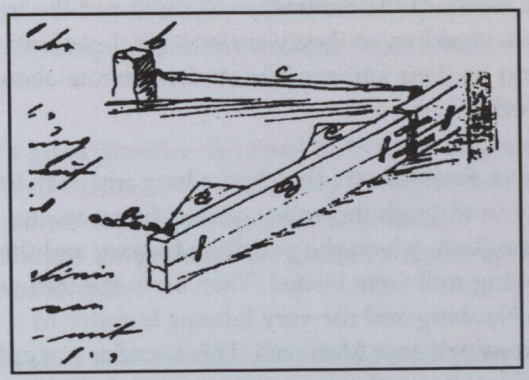

Figure 2. Rake in the Enns river, figure in Neubauer's manuscript

The journey went on to Kalwang, to see the hammer mill and the copper works. Neubauer described the steel hammer down to the last detail; it was a hammer working in the ancient Styrian method. However, Professor Tunner is not content with the hammer mill itself. In his remarks printed in the Berg- und Huettenmaennisches Jahrbuch, [5] he qualified the works as "not remarkable." Neubauer went on to give very precise figures about the production of copper for the month of November 1843 in the Kalwang copper works. [6]

Continuing on their journey, the students visited: the scythe hammer in Trieben; the puddling furnaces and rolling mills in Rottenmann; and the furnaces and foundry in Liezen, which was one of the biggest furnaces in Styria at that time. The next place they visited was a copper and silver works in Walchen, near Oeblam. Charcoal was made nearby. This is one of the very interesting reports in Neubauer's manuscript as it was not known there was a rake in the river Enns to get the wood for charring and also peat was charred here as well.

From Walchen, the students and their professor crossed the mountains on a small trail and finally reached Oberwoelz after 12 hours walk. In Oberwoelz, they examined the steel hammer; next they went on to Niederwoelz to visit a steel mill; then on to the hammer in Katsch; and finally to Murau, where they could visit some hammers and iron works. Their way then led to Salzburg, first the steel hammer in Mauterndorf and the famous furnace in Turrach. The iron works in Turrach had been built by Peter Tunner and his father; [7] therefore, his students had to be very observant.

Figure 3. Furnace in Turrach, 1830.

They left Turrach on a small steep track, crossed the mountains called Fladnitz in a nine hour march and reached the iron works in St. Salvator. The furnace was not working at that time, but they could see the hammers. The next furnace they could see was in Olsa in Carinthia and then they visited the furnace in Treibach. This furnace had been the best one in the country for a long

time; however, it had not kept up with recent improvements. In Loelling, the students visited two more furnaces. Neubauer here notes that the woods nearby had been reforested. The iron works needed a lot of charcoal, so the woods were of enormous interest to the metallurgists.

The next stops were Eberstein and Brückl with furnaces and foundries; however, one furnace was not working because of a lack of coal! The students visited the hammers of Schwarzenbach and Mies, some very famous works in Carinthia, and were on their way to Prevali (now Prevalje in Siovenia). Prevali is quite a large working with seven puddling furnaces, nine welding furnaces, a rolling mill, hammers, and brickworks for the production of refractory bricks.

The students traveled back to the iron works in Lippitzbach, then traveled four short hours (vier kleine Stunden) to the hammer in Kollnitz and the iron works in Wolfsberg. When the students arrived, no furnace was working, so they went on to St. Leonhard and St. Gertraud. The puddling furnaces in Frantschach were next on their journey. The students wrote about their good impressions of the progressive ways of the iron works.

From Frantschach, they had a long trip back to Styria through the valley of the Muerz, to Krieglach, where the puddling furnace and the rolling mill were visited. Then on to the iron works in Neuberg and the very famous foundry in Gusswerk near Mariazell. This foundry not only made guns and cannon balls for the Austrian artillery, [8] it was famous as an art foundry. Jewelry made from iron was a specialty in Gusswerk. [9]

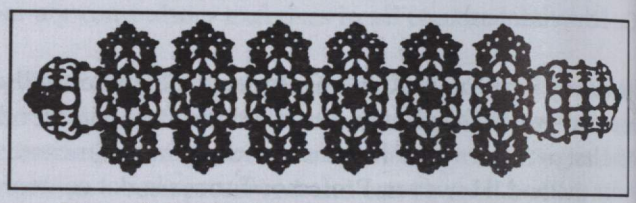

Figure 4. Iron bracelet.

Neubauer writes in his manuscript, that the yearly production of casting was about 3,000 metric tons. In addition to the furnaces, the foundry also contained a carpenter's workshop for the models, workshops for sand, clay and artificial moldings, as well as other large workshops. The iron ore came from the mines in Gollrad nearby; the smelting was still done with charcoal, whereas in England coal was already used in iron metallurgy since the end of the 18th century.

Figure 5. St. Florian on the bridge leading to Toepper's house.

From Gusswerk they marched 8 hours across the mountains to St. Egydi in Lower Austria, where a famous wire rolling mill was located. After 4 more hours the party reached Annaberg. After another 3 hours march the group reached Puchenstuben; and after only a 3 hours walk they arrived in Scheibbs and its iron works. The owner of the works in Scheibbs, Andreas Toepper, owned a lot of factories in the region. He was a very good manager of all the iron trade in the country north of the Styrian Erzberg. [10] To show his importance and to point out that iron made his fortune, he had his house remodeled from an old storehouse used for iron; he also had figures cast in iron adorning the bridge leading to his house.

The students left Scheibbs via Gaming and Lunz and traveled to Hollenstein with its furnaces and melting refineries. The next visiting point was Weyer in Lower Austria, where steel hammers were located. Then they turned back to Styria and visited the steelworks and charcoal burning in Hieflau. [11] Hieflau was one of the largest places for charcoal burning in Austria; however, Neubauer's manuscript does not mention anything about this important fact. The last works the students visited were the iron works in Eisenerz. While Neubauer didn't write much about them, Peter Tunner, in his report on the excursion, wrote quite a lot about them. [12] It was the end of a very long journey; they had walked (or traveled by cart)

about 834 kilometers (518.3 miles). The students returned to Vordernberg very tired.

We learn more about the route of this excursion from Peter Tunner's report in the "Berg- und huettenmaennisches Jahrbuch." Neubauer did not organize his report in order of the works they visited. Instead, he split his text into iron works (Eisenhuettenbetrieb) in Styria, Carinthia and in Lower Austria, hammer and puddling works and rolling mills (Hammer-, Puddlings- und Walzwerke) in those countries, then he described the copper works (Kupferhuettenbetrieb) and the lead works (Bleihuettenbetrieb). His manuscript was read by Peter Tunner on August 26, 1844.

In spite of the great physical demands, these excursions were always very gay and romantic. One excursion in the year 1859 gives us a very personal view of such a journey. We have notes in the diary of student Rudolf Flechner, [13] son of the owner of a nickel mine near Schladming in Upper Styria. While these notes come from a different year than Neubauer's manuscript, all the simplicity of life in those years speaks to us in these lines:

> These journeys were besides the practical value always a great pleasure. A crowd of 18 to 20 diligent and happy young men, clad in their picturesque miner's costumes, were wandering through the wonderful landscape of the Austrian Alps, often using the oddest ways of transportation, greeted everywhere warmly by their professional colleagues. All these things made the journey a memorable one, bringing more joy and happiness than in all the years to come.
>
> In the excursion of 1859, 24 students took part, we left Leoben with two carts decorated with green brushwood, we were singing our happy students' songs and made our way through the sunny landscape on the street to Kalwang. There, on the next day we visited the copper mines, on foot we went on to Rottenmann to see the patch of peat and the iron ore at Blahberg near Liezen. There I left my friends and hurried up to Schladming (Flechner's home) to look for the accommodation there.
>
> It was during the wonderful summertime (8th of July), but there was still some snow remaining from the previous winter....Then my colleagues arrived and we all had an improvised outdoor lunch. My mother had prepared lots of excellent roasted chamois, salads, cakes, good wine and a whole barrel of beer, which was cooled in the ice nearby. We sat at a great table outside, looking at the Dachstein mountains in front of us, everybody filled with joy and happiness....
>
> (Some days later) The day after our visit to the salt mines in Hallstatt, the administrator invited us to a formidable breakfast. Meanwhile a ship used for the transportation of salt, now decorated with flowers, ribbons and brushwood like a wedding vehicle, came up to us, there was a band of miners and of course the oarsmen. With this funny vehicle we crossed the lake and the Traun river,...until we reached Ischl. The miners' band was playing, we were singing our students' songs, in Ischl a crowd of people was observing our landing, they looked at the happy young mining students, who jumped down the decorated ship to look for the inns nearby. ...The next station was Gmunden, where according to our plan we had a day of rest. It was Sunday and wonderful weather. There the plan of an improvised ball occurred, our friendly professor [14] was bombarded by the ladies, to stay at least one more day in Gmunden, the professor agreed, and so the ball was to take place the following evening....

The Mining Excursions 1856-57

Every weekend the students went on small excursions to mines and metallurgical plants nearby. As this was also part of their education, they wrote reports on their experiences. One nice example is a manuscript from student Anton Jugoviz, [15] who gave very good descriptions and pictures from the coal mines near Leoben and the copper ore in Kalwang.

Each Saturday they took a small trip. On November 10, 1856, Jugoviz describes the geology of the Tertiary basin of Leoben; he continues his descriptions of the basin on November 17th and 26th. At the beginning of December (11th and 18th), the coal mines in Seegraben near Leoben are described. One whole excursion, on

December 29, 1856, shows the smithery of the coal mines. On another occasion, the excursion took students to the coal mines in Seegraben near Leoben which they surveyed. The next excursions showed the underground works, especially the shaft timbering in the coal mines. On Saturday, January 15, 1857, the pupils visited the copper mines in Kalwang and observed the hoist for the transportation of rock to the slagheap. On one Saturday excursion in February, Jugoviz describes very accurately an ore car in the coal mines in Moskenberg near Leoben.

Jugoviz lists 19 excursions in his manuscript, the last one on March 23, 1857. His descriptions and especially the drawings give a very vivid picture regarding 19th century mining techniques.

Mine Maps

From their practices in mine surveying, the students had to draw mine maps. These maps are done in a very delicate and meticulous way. They are of special interest to the history of mining, as they are often the only available maps of smaller mines. In earlier times, when a mine closed, all of the official maps were not saved and collected in archives.

Textbooks

When the mining school in Vordernberg started with lectures in November 1840, the Styrian authorities promised that a library should be installed. In the beginning, students had to study from Peter Tunner's own manuscripts, as there was no textbook he found suitable for his students. In his first lecture at the opening of the school in Vordemberg, Tunner only mentioned three works he thought to be of sufficient use for his students. However, there was no money to purchase those books, so the students wrote the textbooks by themselves. We have some examples of these books, like "Lehrbuch der Bergbaukunde" (textbook on mining), written by a student, Alfred Neubauer (1843), who also wrote the record on the excursion in metallurgy (1844).

All these manuscripts and maps are part of the collection of historical books in the University Library Leoben. We are very grateful, that so many things of importance to the history of mining have come to this University library. A document indexing the valuable subjects for the better use by scholars is being prepared. Our patrons come from all parts of Austria and abroad. They may be people who want to open up an old mine as a visitor's mine; they may be students from the historical departments of a university or scientists who want to write down the history of that special scientific discipline. Therefore, it is very important libraries and archives are well staffed with able people and enough funding to acquire those unique things, so that our cultural heritage can be preserved.

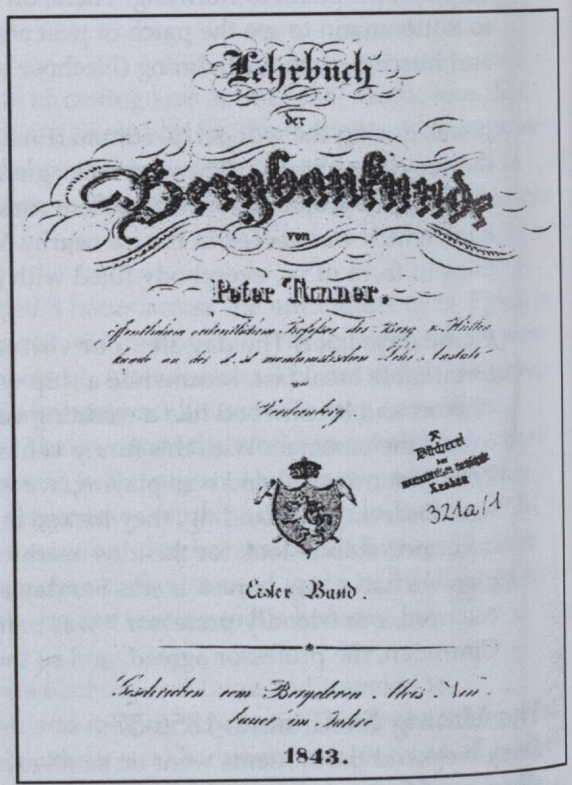

Figure 6. Peter Tunner's "Textbook on mining", written by Alois Neubauer 1843, title-leaf.

Footnotes

1 University archives

2 Berg- und Huettenmaennisches Jahrbuch, today BHM - Berg-und huettenmaennische Monatshefte

3 Alois Neubauer (1816 - 1901) started his studies in Vordernberg in the year 1842/43

4 Bericht ueber die Huettenbereisung im Studienjahre 1843/44, Manuscript University Library

5 General-Bericht ueber die berg- und huettenmaennischen Hauptexkursionen in den Jahren 1843 bis 1846, Berg- und huettenmaennisches Jahrbuch. Vol. 3-6 (1847), pp. 67 f

6 Neubauer, fol. 115-116.

7 Hans Joerg Koestler, 1990, "Peter Ritter van Tunner 1809-1897. Ein einsenhuettenmaennisches Lebensbild", 150 Jahre Montanuniversitaet Leoben 1840-1990, Graz 1990, pp. 761-772.

8 Lieselotte Jontes, 1977, "Das Gusswerk bei Mariazell und seine Bedeutung fuer die oesterreichische Artillerie", Ausstellung Geschichte des Giessereiwesens in Literatur und Kunst vom 27-30. April 1977 in Leoben, pp. 6-88.

9 Gertrud Smola, 1968, "Das Gusswerk bei Mariazell", Der Bergmann, der Huettenmann, Graz 1968, pp. 445-459. Matthias Pichler, 1963, "Der Mariazeller Eisenkunstguss, Wien, Montan-Verlag (Leobner Gruene Hefte. 65.) Otfried Kastner, 1962, "Eisenkunst in den oesterreichischen Alpenlaendem", Der Anschnitt. Vol. 14 (1962), pp. 27-34.

10 Kraus-Kassegg, E., 1979, Andreas Toepper - vom Nagelschmied zum Großindustriellen. Ein Lebensbild aus dem 19. Jahrhundert" St. Poelten
Kusternig, A.[Ed.], 1987, Seines Glueckes Schmied. Die Eisenwurzen und der Aufstieg des Andreas Toepper, St. Poelten, Niederoesterreichisches Pressehaus

11 Mittermueller, F., 1994, "Holzkohle für Innerberg. Zur Brennstotrversorgung eines Reviers vom 16. bis zum 19. Jahrhundert", Karl-Franzens-Universitaet Graz, Diplomarbeit
Dietrich, V., 1847, "Das Ganze der Verkohlung in stehenden Meilem oder die sogenannte italienische Koehlerei nach den 30jaehrigen praktischen Erfahrungen und Betriebsresultaten zu Hieflau in Obersteiermark", Kienreich, Graz
Beschreibung der italienischen Kohlungs-Methode. Herausgegeben von dem k.k. inner-oesterreichischen Oberkammergrafenamte, Wien 1812.

12 as in ref. 5, pp. 109 ff.

13 Rudolf Flechner was born 1837 and started his studies in Leoben 1858

14 Professor Albert Miller von Hauenfels (1818-1897)

15 Anton Jugoviz (1836-1902), started his studies in Leoben in the year 1856, he was metallurgist at the Leoben Ironworks (Alpine Montangesellschaft). Today he is known for his description of the railway from Vordernberg to the Erzberg with a lot of illustrations (Illustrirter Fuehrer auf der Bahnlinie Eisenerz - Vordernberg, den Steirischen Erzberg und Umgebung. 3rd ed. Wien 1894).

The Mining and Metallurgy of Silver Ores in the Central Slovakian Mining Centers to the End of the 18th Century

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Abstract

The mining of silver was very important in the history of Slovakia. Silver was first applied in the decorative and manufacturing industries. Later, silver was critical for minting. In Slovakia, silver was the most important minting metal from antiquity to the 19th century. As with gold, silver was considered as an equivalent of value.

Silver ore mining and ore dressing together with the metallurgical and working characteristics of silver provide one of the most important facets of the Slovak national economy. For centuries the extraordinary copious supplies of silver attracted groups of varied ethnic populations, who participated in the development and production of silver.

There are two mining regions of silver deposits. The first is the territory of lower Hungary (central Slovakia) mining towns. The second territory is that of upper Hungary (eastern Slovakia or Spil-Gemer).

Count E.F. Kankrin (1774-1825) Russian Minister, German Writer, Miner

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Abstract

Egor Kankrin (George Cancrine) was born in Genau, Germany, in 1774. His parents both belonged to the families of mining officials. His father, Franz Ludwig, was a scientist who developed mining practices of the time and probably influenced his son's interest in this subject. In 1783, Franz Ludwig Kankrin accepted an invitation of the Russian government to become director of the salt works at Staraya Russa. In 1797, he asked for the assistance of Egor, who had graduated from Marburg and Gessen Universities with the Doctor of Law degree. Egor had also studied other various subjects, including mining, finance, architecture, philosophy, and poetry. He had also written a novel and a few books on architecture.

During his first years in Russia, Egor Kankrin suffered many disappointments and privations. The city of St. Petersburg would not have later become one of the architecturally beautiful cities if not for him. His lack of knowledge of the Russian language did not allow him to fill a post in accordance to his rank in the Russian administrative system. In 1800, he became his father's assistant at Staraya Russa and assisted in putting the salt work in proper order. As an official of the Ministry responsible for salt and wood affairs, beginning in 1802, Kankrin became acquainted with the different regions of Russia, its people, and its language. He became so fluent in Russian that he liked to use Russian proverbs in his conversations.

Kankrin continued to write during his time in Russia; however, all his books were written in German. Alexander I, Russian Emperor, noticed one of his books. This led to Kankrin being named to the post of Russian Army Lieutenant-General. He fulfilled his duties very well during a wartime full of hardships. His rank and awards notwithstanding, he was forgotten when the war ended. His personal honesty and incorruptibility while performing in the State's interest made Kankrin enemies. He resigned at the age of 47 and his career seemed to be over.

However, in 1823, he was appointed as the Russian Financial Minister. He occupied this post as long as his health allowed – until 1844 when he was 70 years old. In 1829 he was given the rank of Count. Kankrin, as minister, served Russia during a time when Russia was making tremendous progress in industry and improving their national economy. His most significant contributions were made to the mining industry and education. Part of Count Kankrin's duties included oversight of the mining schools of Russia. The St. Petersburg Mining Institute was enlarged and the first Russian science and technical periodical, Mining Journal, was established. Kankrin invited Alexander von Humboldt to Russia and organized von Humboldt's journey throughout Russia.

The story of Count Egor Kankrin is one of unselfish love and service of one German man to the land of Russia. It is the story of an exceptional person and remarkable statesman.

The Czar Who Studied Mining

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Abstract

The year 2000 is the anniversary year of the Russian mining industry. In November 1700, Peter the Great passed the law establishing the Mining Affairs Ministry (Ore's Order). This spurred the quick development of the mining and metallurgical industry, begun along with mining administration. He also enacted laws and regulations on the mining and metallurgical industry.

Peter the First, also known as Czar-the-Carpenter and Czar-the-Worker, was thirsty for knowledge. He was famous for his inexhaustible energy, for his wish to take a tool in his own hands and try everything.

Many mining experts from Saxony were at the dawn of Russian industry at the turn of the 17th and 18th centuries. These Saxon experts in Russian mining resulted from Peter's visits to Saxony in 1698, 1711 and 1712, during which he learned about mining and ore-fusing and hired miners and metallurgists. It is not well known that Peter the First visited mining works, learned about ore smelting, and visited mineralogical collections.

Figure 1. Czar Peter the Great.

Introduction

The rule of Czar Peter the Great (Figure 1) in Russia showed variety in politics and law. The boyar (noble) form of government, where the aristocracy received rights by succession, was abandoned. Business training and experience began to be more significant than noble origin. Together with the bureaucratization of the state machine, the Russian Czar started its centralization, a system of hierarchical slave entities, each of which managed a precisely determined area. Russian mining administration was begun by Peter the First, because of his personal influence and energy.

Before Peter the First, mining factories were operated either by district military chiefs, where they discovered and developed prospects of ore, or by proprietary owners of factories. Between the 1560's and up to the end of the 17th century, many Orders (Ministries) at the Imperial Court, such as Ambassadorial Order, Order of the Large Treasury, Siberian Order, Weapon Chamber and Gun Court Yard, interfered in mining. Archive documents show that Ambassadorial Order accepted applications regarding foreigners' salaries; other orders required money for drivings; the third required information about ore mining successes; the fourth tracked metal production. Not one among the numerous Orders was especially for mines. For example, the oldest metal works of Vinius, Marselis and Akema were transferred from the jurisdiction of one office to another six times between 1638 and 1668.

Peter the First began centralizing mining and metallurgy control at the very beginning of the 18th century. The establishment of Ore Mining Ministry, or Order, variously called Ore's Order, Order of Ores, Order of Ore Mining, began higher mining administration in Russia. The Czar became the head of mining and was interested in the smallest details.

On August 24, 1700, Peter the First issued the Nominal Decree, which declared that "okolnichiy Alexei Likhachev and dyak (clerk) Kozma Borin should rule gold and silver mines over Moscow and occupy a separate place at the Large Treasury Order." The Nominal Decree following on November 2, 1700, ordered "to call in cities and districts, on tenders and fairs, per trade days, whether anyone knows about the existence of different ores; after deriving announcement to prospect ore immediately and to notify the Ore's Order." The Czar's rewards for discovery and punishments for hiding ore were promised. If any information was available anywhere in the districts, it must immediately be sent to the Ore's Order in Moscow. Ore's Order kept information on ores; employment of specialists, both Russian and foreigners; oversaw construction of factories and assignment of peasants to them; assembled information about the extracted metals and newly opened mineral deposits; assigned mineral deposits for establishing factories, including private ones, and also punished those who failed to announce new discoveries or counteracted investigating ores. In addition, the Order founded the lab for inspection of ore samples. Ore's Order provided reports to the Czar and was directly governed by him.

The primary task of the Order was to free the Large Treasury Order from importing gold, silver and copper and to facilitate their mining within Russia. It started with ore prospecting. Later it should have begun independent industry and supervision over proprietary factories. Gold, argentine and copper ores should have been mined at the expense of State Budget, and other ores, including ferrous, at the expense of private persons.

For the first 11 years of existence of the Order, 121 fields were inspected. Because of its activity and constant attention from Peter the First to mining, the industry developed rapidly.

In June 1711, Peter the First tried to transfer control of ore prospecting and ore factories to the governors of those districts where they were situated, and eliminated Ore's Order. The well-known miner Johann Blier protested strongly against the move. Blier arrived in Russia from Saxony in 1699 as a core sampling master; he later prospected for ores in different parts of Russia. With his tireless transactions he promoted the beginning of mining in Olonetskiy edge, Ural and Siberia. He was well brought-up, familiar with mining management in West Europe, loved mining and knew it well. In 1712 he proposed placing mining not under the command of governors and urban chiefs, but only under the command of either His Majesty or Senate, pointing out improper use and oppression of peasants in mining works. Keeping in mind Russian mining progress, Blier suggested forming a Collegium of specialists deserving respect.

On May 15, 1715, Peter the First issued a new Decree station "for Ore's Order to exist as before... ." The revived Order, transferred to St. Petersburg in July 1715 and called the Ore Office, was not identical to the former entity. In 1716 a Decree of Senate subordinated ore factories and working people to the Ore Office and declared that no other office should deal with mine building and ore prospecting.

In January 1716, Peter the First took a biannual trip abroad. During this trip he became acquainted with baron Anthony Christian Pottu fon-Liuberas, who would be the outstanding person in Russian mining in the future. The Czar told him to write "A Sketch of Collegium's Institution in a Right State Economy" and also to invite foreigners to Russia to fill posts on the Boards. Liuberas visited Hamburg, Luebeck, Berlin, Giessen, Saxony, Czech and Silesia and gathered 15 people. Both Blier's and Liuberas's projects were based on ore mining experience of the two European countries considered the most advanced in managing the mining industry: Saxony and Sweden. Blier kept in mind Saxony and Liuberas kept in mind Sweden. However, the Berg-Privilege law on mining published in 1719 changed those designs with reference to particular Russian conditions. Ore mining became only Berg-Collegium business. The Collegium had about 20

men on staff, subordinated solely to His Majesty or Senate. Interfering in Berg-Collegium affairs was categorically forbidden to voevodes, the governors of provinces. Peter the First put his companion-in-arms and favorite, Yakov Brius, at the head of the Collegium. Brius was born in Moscow in the family of a colonel who moved from Scotland to Russia during Cromwell times; two of his ancestors had been kings of Scotland in the 14th century. In 1698 he accompanied Peter the First to England and Holland, and in 1704 was named major chief of all artillery, which he supervised in battles of the Northern war. Then Peter the First sent him to Germany to invite experienced officers and specialists to join Russian public service. On the instructions of Peter the First, Bruis accomplished the following: he translated many books from foreign languages; he composed brief geometry information for His Royal Majesty; he composed the well-known centenary calendar; and he compiled the detailed geography of Russia. Peter the First conferred with him about science as he was the most learned man in the country.

Thus, the closing of Ore's Order and Ore Office meant not the end of such an institution, but only a variation of its shape. The Berg-Privilege created the necessary prerequisites for engaging private and merchant capital in the mining industry. Its main point was declaring a principle of mining freedom, "It is authorized to everyone, not looking at rank and virtue, to prospect, fuse and clean any metals in all places, both on own, and on another's grounds too."

The precursor Russian mining legislation recognized that underground resources belong to the proprietor of the land, just as the land surface. The statute of 1632 permitted Vinius to build factories only on royal lands. Later, government authorized building factories on private grounds, too, but stipulated this resolution by a mutual, voluntary agreement of the industrialist with a monastery, landlord or landowner. However, industrialists and landowners were not always good neighbors. Landowners simply did not let ore prospectors on their land. The Berg-Privilege in 1719 entailed riches as the property of the Czar. As the monarch, he possessed treasures of earth, irrespective of who possessed the ground. The landowner had preferential right to start mining mineral resources first. But if he "does not want ... he will be forced to bear others searching and digging ore and minerals in his grounds." In this case the landowner received 1/32 of the profit made by the industrialist. Further Berg-Privilege announced the firm right on possession of factories. One of the reasons for sluggish progress of the mining and steel industries was the fear of confiscating factories. Such fear was reasonable, since in 1647, 1663, 1668 and 1702 Treasury confiscated some factories. Therefore the assertion of Berg-Privilege that factories would not be taken away, either from industrialists or from their successors, had important political value. Besides, ore and foundry masters were released from monetary duties and liability for military or navy service, could possibly get grants from the Treasury, the right to sell iron, tin, lead; and, at last, pinpointing the size of remuneration for the ore found. The significant innovation simplified financial relations with the Treasury. Each industrialist was obligated to return 1/10 of the profit for the benefit of the Czar, who as monarch possessed mineral resources. Removing encumbrances for building several factories in one area enabled competition between businessmen. This provided an index of mining growth in Russia.

The formation of Berg-Collegium revealed a lack of professional staff. Intelligent specialists were needed, who would have broad minds, the ability to reform spirit and create ideas for ways to reform. All during his rule, Peter the First and, under his order, all officials living abroad, searched actively for specialists, ore prospectors, miners, and metallurgists, and invited them to Russian service. Their salary was much higher than that of similar Russian masters, and one of their duties was teaching Russian masters. In 1721, for example, among Berg-Collegium members there were six foreigners, excluding Brius: privy counselor fon Liuberas, Berg-adviser Michaelis, assessors Heinrich Schlatter, Vinzent Reiser, Yakov Delein and Gavriel Bagaret. At the same time, since military service was a pathway to state office, those who controlled mining began public service in the military.

Peter the First knew about the lack of competence of the officials and decided to initiate change. On October 16, 1724, he decreed that each Wednesday, all employees should gather to listen to imperial Decrees and other documents which they needed to know. This was an original way to improve their qualifications.

Soon after Peter the First's death, political changes caused reorganization of the previous administration. Some institutions did not outlive their founder. The Collegiums, including Berg-Collegium, appeared steady; its position among high governmental agencies was saved, and they were only partly reorganized.

Peter's contemporaries and offspring noted his curiosity and his wish to try arts with his own hands. When visiting factories in Tula, he enjoyed hammering a steel belt or any detail, and was not averse to taking money authorized for the work. He loved to spend his free time at the lathe, which was set up even in his temporary residences. He headed the fleet, knew how to use an axe, and knew shipbuilding perfectly. Since childhood, long before trying any profession, he learned about printed materials and could not part with books during the rest of his life, even during military campaigns. Peter the First's library catalog includes 1663 titles in Russian, Latin, Dutch, and French. The books and manuscripts concerned construction, military science, metallurgy, mining, geography, history, as well as other arts, sciences and professions. Peter the First became familiar with them all. In 1710 he reformed printing, so the old slavic alphabet was changed to the new civil type, comprehensible and easy for typesetting. Peter the First participated in editing and publishing manuscripts and checked to see if translations were correct.

The famous Great Embassy of March 1697 from Moscow to Europe is mentioned in practically all literature about Peter the First, and much attention is paid to his other travels outside the Russian Empire, as well as his interest in ships and artillery. Publications rarely mention episodes with a direct bearing on Peter's knowledge and practice in mining.

Officially the head of Great Embassy was Franz Lefort, and guards headed by Prince Cherkasskiy escorted the Embassy. Young noblemen were sent along to study military and ship matters. Among them, bearing the name of village constable Peter Michailov, was 25-year-old Peter the First.

When in England, after Peter came from Holland with 16 accompanying volunteers, including Brius, Peter the First regularly visited the Mint. He practiced making coins, planning to use a recently purchased English coin stamping machine in Russia. At first Peter the First placed monetary matters under the jurisdiction of the mining administration. He also visited Voolich, the center of artillery production, three times. Peter would later place the same person, Brius, at the head of both Berg-Collegium and artillery service.

When Peter the First was in Holland, King August II learned of the planned travels of the Czar, who was traveling incognito, through Saxony. Peter the First arrived in Dresden on June 1, 1698, and at 1 p.m. set off to inspect Kunstcamera. In the morning he visited the Casting Yard, where he surprised everyone with his exact knowledge of guns, noted slight deficiencies of instruments demonstrated to him, explained the reasons for those deficiencies, and again visited Kunstcamera. He was then expected to go to Freiburg, the worldwide mining center in Saxony, but did not go. Peter arrived in Dresden for the second time in September 1711. He visited Freiberg, examined the mining factories carefully, and listened to the miners' music. Then the Czar left for Carlsbad. On his return, he stopped again in the capital of Saxony, where Count Lesgevang's collection of minerals attracted his attention. Peter's acquaintance with the Count continued during his last visit to Saxony in 1712, the third visit. He was in Dresden by November 17 and November 19-25 he looked at melting ores and practiced fine points of ore sampling in Lesgevang's laboratory.

Willgelm de Gennin, eminent person of the epoch, associate and companion of Peter the First, was a specialist in mining and metallurgy. Gennin developed the plants in Carelia, in northwest Russia. In 1722 the Czar sent Gennin, author of the Russian manual on mining, to conduct mining and metallurgical industries in the Urals. Gennin's reports to Peter reflect in full the period of its most intensive development, 1723-24. The reports of the smallest details and remarks enable tracing of the development of the mining industry in the Urals month by month. The Czar read them carefully, thereby studying the subject. His answers to Gennin where he discussed the problems of mining industry formation prove this.

Thus, testimony shows that apart from Peter's well-known capacities in carpentry, shipbuilding, foundry, turning and artillery, he was knowledgeable in mining as well.

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On Some Problems Concerning a Bio-bibliography of Austrian Geoscientists and Collectors (1748-2000)

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Abstract

To document a serious history of geoscience in Austria it is necessary to establish a suitable database of biographic data of those people who were occupied with the research of the earth's crust or collecting geologic materials. Reviewing the value of commonly-used biographic dictionaries and other sources, it is apparent that there are only a few entries about Austrian geologists which often contain incomplete information. Therefore, the aim of this proposed project is to create a database by examining and evaluating all relevant dictionaries, catalogues, bibliographies, archival materials and databases. The plan is to publish the bio-bibliographic database of Austrian geologists and collectors of geological material (1748-2000) as a book. The information would additionally be available on line.

Historical Research of Geoscience in Austria

It must be the aim of historical research on any science to know exactly its genesis and impact on society. Moreover it is the task of a history of science to demonstrate the centers of research and studies in their mutual relations, as well as show the history of universities, of museums and other research departments. But such a history of institutions without precise biographic research remains quite incomplete.

To document a serious history of geoscience in Austria it is necessary to establish a suitable database of biographic data of those people who were occupied with the research of the earth's crust or collecting geological materials. Unfortunately I have to mention the difficult conditions in Austria compared with the international standard of scientific research. In this respect, no institution in Austria is occupied with the history of natural science. There are only the Kommission für die Geschichte der Naturwissenschaften, Medizin und Mathematik der Österreichischen Akademie der Wissenschaften (Commission for the History of Natural Science, Medicine and Mathematics of the Austrian Academy of Science) and the association Österreichische Gesellschaft fiir Wissenschaftsgeschichte (Austrian Society of the History of Science). Fortunately, in the last few years there were some hopeful inquiries concerning the study of geoscience. The Montanhistorische Verein für Österreich (Association of Mining History of Austria) that publishes the magazine *"Res Montanarum"* is intensively occupied with the research of the history of mining. Since 1998, there also exists a section of the Österreichische Geologische Gesellschaft (Austrian Geological Association) whose goal is to study several periods of geology and mining history in Austria. *Österreichische Historische Bibliographie* (Austrian Historical Bibliography), edited by the university of Klagenfurt in Carinthia gathers literature of Austrian geologists and miners. I must also reference a biographic documentation, founded by Dr. L. Jontes, who is the director of the library of the Montanuniversität Leoben (Leoben, School of Mines) in Styria.

However, in spite of those hopeful beginnings there is still not a complete or nearly complete bio-bibliography of Austrian geologists, miners and collectors. Though the Naturhistorische Museum (Museum of Natural History, 1998) and the Geologische Bundesanstalt (Geological Survey of Austria, 1999) in Vienna presented the history of their institutions, the named two works do not offer precise information about Austrian geoscientists working in these research institutes.

To change that deficiency, Dr. T. Cernajsek, Dr. C. Hauser and I have begun the task of elaborating upon bio-bibliographies of Austrian geoscientists. Our starting point is a card-index containing information about Austrian geoscientists and collectors from 1748 until 2000. The initiator of this index, Dr. Cernajsek, started his work in 1977 and, to this date, has indexed approximately 2000 geoscientists. The period he has reviewed is well documented; in 1748, Emperor Franz Stephan I bought the collection of the Florentine noble Johann Ritter von Baillov. This collection marked the beginning of the Museum of Natural History in Vienna. Since that time, there exists a record concerning geoscience work organized under the Austrian state.

There are many difficulties in finding appropriate compilations for comprehensive studies concerning Austrian geoscientists and collectors. The well known great dictionaries and encyclopedias analyzed below, give only small and brief surveys of a few important Austrian geoscientists. One may only find the names of Ono Ampferer (1875-1947), Franz Kossmat (1871-1938) or Eduard Suess (1831-1914), but seek in vain for the large number of geoscientists who collectively created the whole progress of geoscience in Austria. To characterize all these people in a precise biographic and bibliographic way, it is absolutely necessary to collect the following data: biographies, obituaries, locations of bequests, bibliographies and so on. The study of biographic sources also needs an exact knowledge of literature and archives. Subsequently, I want to give a short survey of national and international dictionaries and other encyclopedias as they are dealing with Austrian geoscientists and collectors.

Bio-bibliographic Dictionaries and their Importance for Geoscience in Austria

Austrian dictionaries

I will only analyze dictionaries dealing with the 19th and 20th centuries. Because of space constraints, I am not able to describe several encyclopedias of the 18th century.

Österreichisches Biographisches Lexikon (Austrian Biographic Dictionary), edited by the Österreichische Akademie der Wissenschaften (Austrian Academy of Science) since 1957, contains information about people who lived in the Austrian-Hungarian monarchy as well as in the Republic of Austria and died between 1815 and 1950. The last volume (nr. 11) of this publication (which will be finished in four further volumes) reached the letter *"SCHW."* As this dictionary generally treats many people of importance in Austrian history, it contains a relatively small number of geoscientists.

The *Österreich Lexikon* (Austrian Dictionary, Bamberger, 1995) contains specific subject categories as well as important people of the past and present who have effectively influenced or are still influencing the political, economic and cultural development of Austria. In this work, geoscientists are not sufficiently represented, perhaps only 100 are listed; the biographies are small and inexact. This dictionary does not offer a sufficient base for further studies.

The *Biographisches Lexikon des Kaiserthums Österreich* (Biographic Dictionary of the Austrian Empire, Wurzbach 1856-1891; Register of the Supplements 1923) offers a survey of approximately 25,000 people who lived between the middle of the 18th and the end of the 19th centuries. The first volumes contain only short biographic data, while the articles that were written for later volumes are more complete. The bibliographies are quite detailed; however, because of the age of this work the literature is antiquated. Although only a few Austrian geoscientists are listed, the articles dealing with them are quite sufficient.

Introduced in 1987, the supplement of *Index Palaeontologicorum Austriae* (Index of Austrian Palaeontologists), compiled by Helmuth Zapfe, contains biographic data of 620 people. These two volumes index Austrian

paleontologists who lived in former centuries as well as contemporary scientists.

German Encyclopedias

Kürschner Deutscher Gelehrten-Kalender (Almanac of German Scientists, edited by Kürschner), whose first edition appeared in 1925, continues to be updated. For example, the 13th edition, authored by Schuder in 1980, shows, in the first two volumes, 43,000 German-speaking scientists who are still alive and doing important work in the fields of research and teaching. The third volume offers a necrology of people who died after 1976 as well as the data of anniversaries of the scientists. A register of science is also included, as well as subregisters on geology, geochemistry, mineralogy, petrology, paleontology and so on. Therefore, this work, although generally structured, offers a helpful and efficient base for further biographic studies.

International dictionaries

The *Biographisch-literarisches Handwörterbuch zur Geschichte der exacten Wissenschaften* (Poggendorff 1863ff.) (Biographic-Literary Concise Dictionary of the History of the Exact Science, edited by Poggendorff) contains detailed biographic and bibliographic information concerning the included scientists. Unfortunately, only a few Austrian geoscientists are represented. Additionally, the dictionary ends in the 1970's; thus, all of the scientists of the last quarter of the 20th century are not included.

The almanac *Palaeontologi:Catalogus bio-bibliographicus* (Palaeontologists : A Bio- bibliographic Almanac, published by Quenstedt, Lambrecht, et al, 1938) not only deals with scientists, but also with collectors and draftsmen. In this work, approximately 3,500 paleontologists and collectors of paleontological materials are represented. The editors' goal was to present a complete catalogue of paleontologists and collectors for all periods; however, many German-speaking areas did not have sufficient collections. The result is an incomplete work.

The great work of William A.S. Sarjeant, *Geologists and the History of Geology*, published in 1980 in five volumes and three supplements, contains special bibliographies concerning the history of geoscience and also addenda regarding the biographies of geoscientists. The first volume contains a register of geological institutes and associations. Volumes 2 and 3 contain bio-bibliographic information about geoscientists through 1980. Volume 4 offers an index of geologists structured by nationalities; unfortunately, these national assignments are very often incorrect. The fifth volume contains an index of authors, editors and translators of geological literature. In Sarjeant's work only 168 Austrian geologists were represented. Because the author based his studies primarily on the geological literature, some previous authors' errors were transported into Sarjeant's work. Therefore, we have to include in the project studies of unpublished biographic materials to correct some of the incorrect data that has been passed down.

Aim of the Project

The aim of the project is to produce a complete survey of Austrian geoscientists and collectors of geological materials who lived in the Austrian state in the last 250 years. Also included will be those people who did not graduate from geological studies, as before 1850 there were only a few possibilities of scientific instruction, e. g. courses in mineralogy in the great Austrian museums as the Joanneum in Graz, in Styria or the Hofmineralienkabinett in Vienna.

A bio-bibliography of geoscientists or collectors should contain the following data:

- Biographic data (D): First and last name; dates of birth and death; places of birth and death
- Picture (P): Portrait or photograph
- Short biography (B): This point should also include the profession and important performances in geoscience of the person in question
- Bio-bibliographic sources (O): This rubric should contain literature, unpublished materials, obituaries and so on
- Honorable awards (E): e.g. Holder of the Haidinger-medal, corresponding member of the Geological Survey of Austria or corresponding member of the Austrian Academy of Science etc.
- Important performances in geoscience (L):

- Scientific Publications (W):
- Location of bequests (N): These bequests could be found in the following institutions: Geological Survey of Austria, Museum of Natural History in Vienna, in several Austrian county museums and county archives, in the Austrian State Archive and even in foreign institutions, as in Hungary, Czech Republic, Slovakia, Poland, Slovenia, Croatia etc.
- Designation of fossils, minerals and toponymes (S): e.g. Wilhelm Haidinger, the founder of the Geological Survey of Austria: Fossils: *Mytilus haidingerii* Hornes; mineral: Haidingerite; Topography: Mount Haidinger in New Zealand
- Monument (M): e.g. Otto Ampferer: Memorial in Innsbruck in the Tyrol; Wilhelm Haidinger: Bust in the Geological Survey of Austria in Vienna; Eduard Suess: Bust at Schwarzenbergplatz in Vienna
- Grave (G): e.g. Eduard Suess: Grave at the cemetery in Marz, Burgenland

To show a practical example of the bio-bibliographical criteria, the life and work of Hilda Gerhart (1881-1963) is illustrated in Appendix A.

Foreign Pilot Examples

In Germany, two recently published books could serve as models:

Prescher, H. und Ch. Hebig, *Lexikon der Geowissenschaftler. Ein halbes Jahrtausend Geowissenschaftler aus und in Sachsen 1494-1994.* - Schriften d. Staatlichen Mus. f. Mineral. u. Geol. zu Dresden, 8, Dresden, 1998 (Dictionary of Geoscientists. Half a Millenium of Geoscientists in Saxony 1494-1994. - Bulletins of the State-Museum for Mineralogy and Geology in Dresden 8, Dresden 1998)

Wiefel, H., *Biobibliographische Daten über Geowissenschaftler und Sammler, die in Thüringen tätig waren.* - Geowiss. Mitt. von Thüringen, Beih. 6, Weimar 1997. (Bio-bibliographical Data of Geoscientists and Collectors who Worked in Thuringia. - Geoscientific Bulletins of Thuringia, Supplement 6, Weimar 1997)

Both works are more precise than the great dictionaries and encyclopedias that have been analyzed above. The project will produce a published bio-bibliography of Austrian geologists and collectors of geological materials as a book, as well as placing the information on-line. Additionally the collected data should be included within the Austrian Biographic Dictionary (ÖBL).

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Appendix A

Gerhart Hilda

- D:
  * March 11th 1881 in Vienna, Austria
  = September 7th 1963 in Klosterneuburg, Lower Austria

- B:
  1888-92 Primary school in Vienna
  1892-95 Elementary school in Vienna
  1895-01 High school in Vienna
  1901 Leaving examination in Salzburg, Austria
  1905 Doctor's degree at the university of Vienna
  1910-40 Professor at girl's schools in Vienna
  1941 Retirement and removal to Weidling near Klosterneuburg, Lower Austria

- G:
  Cemetery of Weidling near Klosterneuburg, Lower Austria; grave number 674

- Q:
  Archive of the university of Vienna, Doktorats- und Rigorosenakten, Nr. 1932 (1901); Austrian Biographic Dictionary, Austrian Academy of Science, Vienna, Austria; roman-catholic parish of Weidling near Klosterneuburg, Lower Austria

- L:
  Together with Franz Eduard Sueß, son of the famous Austrian geologist Eduard Sueß, she was occupied with geological field-mapping in the Waldviertel, Lower Austria

- W:
  1905 Über die Veränderung der Krystalltracht von Doppelsulfaten durch den Einfluß von Lösungsgenossen. - Univ., phil. Diss., Wien
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Scientific Books at the Québec Séminaire Library, 1678-1910

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Abstract

The Séminaire de Québec, the first Francophone institution of higher learning in North America, was founded by Monsignor François Montmorency de Laval in 1663. It became, through the years, an important educational institution with an impressive library of over 180,000 volumes in the various fields of sciences, medicine, history, law, agriculture and religion. Queen Victoria transformed the Seminaire into the first French University in 1882. Science teaching started in there in 1771, and distinguished priests such as Jérôme Demers, Jean Holmes, Joseph-Clovis Laflamme, and others enriched the library with books they authored or purchased. The Library also has an excellent collection of teaching instruments in the so-called "Cabinet de Physique." An overview of the library and its "old holdings" are outlined.

Introduction

The Séminaire de Québec's library, at 2 Côte de la Fabrique in Old Québec, has an excellent collection of old books; some 180,000 volumes in the various fields of sciences, medicine, history, law, agriculture and religion, ranging from 1450 to date, including 34 incunabula, books printed before 1500. For over three centuries, the Séminaire served education as a Catholic classical college and a university. For this purpose, it built a priceless collection for explaining and illustrating the evolution of this society and its role in the growth of French culture in North America. Located in the heart of Québec City's picturesque Latin Quarter, the library is a documentary treasure trove for exhibits, research and other cultural activities.

Since June 1995, an integration has linked the oldest museum in Canada, the Musée de l'Amérique française, formerly known as the Musée du Séminaire de Québec, and its Library and the Musée de la Civilisation.

The First and Oldest French Library in North America

The origin of the Séminaire de Québec's library dates back to 1663 when Monsignor François Montmorency de Laval, Canada's first Bishop, founded the Séminaire to educate the colony's younger generation for priesthood, whereas the Jesuits took care of general education. On April 12, 1680, Monsignor Laval donated his personal library to the Séminaire, an example followed over the centuries by many priests from the Séminaire and the diocese.

In 1764, the British Conquest led to the closing of the Jesuit's College and the disappearance of the classical school. The priests of the Québec Séminaire took over from them. The Jesuit community was broken up in 1773. Before he died on March 18, 1800, Father Casot, the last surviving member, distributed what remained of the library to Québec Séminaire to prevent it from becoming the property of the British government. These books at the first institution in Canada, old and rare as most of them are, are the pride of the Séminaire, which contained 5,000 volumes in 1782. Those volumes were mainly on theology, religion, history

and belles lettres, such as grammar, literature, medicine, physics, mathematics and philosophy.

In 1851, conforming to the unanimous wishes of Bishops attending the first Canadian Council of Bishops, the Séminaire established the first French language university in Canada. On December 8, 1852, Queen Victoria signed the Royal Charter in Westminster Hall and Laval University officially became the first French university in Canada. It was recognized as a Catholic institution, granted by a papal charter in 1876, under the direction of a Seminary superior as Rector. Copied from the old style universities in France, there were, for a half-century, four faculties: Theology, Law, Medicine and the Arts. On May 1860, the Seminary established its famous library with a collection of about 15,000 volumes. It also holds 700 works printed in Québec between 1764 and 1820, representing one of the most important concentrations of Canadian incunabula published in French America.

Since then, the collection has grown at a fast rate, because of the University's zeal in obtaining the documentation required for teaching and research purposes, and also because of the generosity of benefactors, both lay and clerical. The number of volumes thus increased from 15,000 in 1858 to over 120,000 in 1905. When Laval University moved from the site of the Séminaire in 1964, the Québec Séminaire Library kept all works acquired prior to 1910.

In June 1995, the "old holdings" of the library became the Musée de la Civilisation's responsibility when an integration agreement linked the oldest museum in Canada, the Musée de l'Amérique française, formerly known as the Musée du Séminaire de Québec, and the Musée de la Civilisation in Québec City.

The Handwritten Catalogue of Seminaire De Quebec

The author of the first and the oldest manuscript catalogue of the Séminaire is Father Amault-Germain Dudevant. Born in Bordeaux, France in 1753, he studied theology at Québec Séminaire and was ordained in 1777. He taught theology at the Séminaire and occupied different important positions. In 1782 before returning from Québec to France, he composed a catalogue. The inventory of this handwritten catalogue indicates the presence of about 4,883 volumes for 2,121 titles covering the following topics: theology; canon law; philosophy; sacred history; medicine; arts including architecture, music, and rhetoric; sciences, including astronomy, medicine, physics, chemistry, zoology, botany, navigation, mining, military, and commerce. During more than a century (1675-1782), 101 volumes of the collection were acquired. This collection was chiefly composed of Bishop Laval's library and the generous donations of benefactors, including Bishop St.-Vallier, the Governors, the Intendants, Jean Talon, or from the priests of the Séminaire des Missions Étrangéres de Paris. Some purchases were from Europe and the United States.

Important basic writings on mining, metallurgy and geology in the sixteenth century published in Central Europe are held by the library. The catalog mentions "De Re Metallica," (Basel, 1621) by Georgius Agricola (1494-1555) and "Aula Subterranea Domina Dominantium Subdita Subditorum," (Frankfurt, 1672) by Lazarus Ercker (1530-1593). Agricola, a Saxon medical doctor, practiced medicine in the mining district of Joachimsthal, where he became interested in ores and smelting operations. Ercker, also from Saxony, was the assay master at Dresden and later director of the mint in Bohemia. Another rare and old book is the 1643 Latin edition of "Basilica Chymica" published in Geneva, and its French edition, entitled "La Royale Chimie", published in Lyon in 1623 by Oswardus Crollius (1580-1609); Crollius was a German chemist. The work was considered one of the important books on alchemy. Another 17th century author is Nicolas Lémery (1645-1715), a French chemist, born at Rouen. He established a laboratory, and his lectures were attended by numerous classes. He became a pensionary and associate chemist of the Academy of Sciences in 1699. His work, "Cours de Chimie," (Paris, 9th ed., 1697; 11th ed., 1730; and new ed., 1757) is often cited. He also published "An Universal Treatise of Drugs," (Paris, 1714). Joseph Roger Boscovich (1711-1787), a geometrician and Jesuit, born at Ragusa, professor of mathematics at Rome, published "De Defectibus Lunae et Solis." As his knowlege of optics, geometry and metaphysics was great, he was employed in measuring a degree in Lombardy. He also improved the theory of achromatic glasses. He was greatly admired for his

poem, "De Solis & Lunae Defectibus."

Mining in the 18th century is represented by the famous book of Christoph Andreas Schliiter, "De la Fonte, des Mines, des Fonderies, Paris, 1750-1753." It was translated from German by Jean Hellot (1685- 1766), author of works of merit on philosophical and chemical subjects and a member of the Paris and London Societies. He also conducted the Gazette of France for some time. An another interesting and rare book is "The Tabulœ Astronomicœe of Tycho," by John Kepler (1571-1630), a celebrated astronomer, born at Wiel (Wirtemberg). After the death of his friend and imperial patron Tycho Brahe, he finished the tables Tycho began. He dedicated them under the title of "Tabulœe Rudolphinœ, Astronomicœe Scientiœ..." (1627, in-fol). Alvaro Alonso Barba was the author of a scarce book called "Arte de los Metallos," (1640; reprinted in 1729 with the addition of Alonzo Carillo-Lasso's "Treatise on the Mines of Spains"). His works were abridged in French by Gosfort, published as "L'art Metallique" in one volume in 1751. Blaise Pascal (1623- 1662), a French scholar, born at Clermont in Auvergne, was the ablest mathematician and the greatest philosopher at his time. He wrote, besides the "pensées" on religion and other subjects, the "Equilibrium of Fluids," edited in French, "Traitez de L'équilibre des Liqueurs, et de Lapesanteur," (1698).

The Collection of the Jesuit College Library: 1635-1760

The library holds the largest and the most varied collection of the Jesuit College. It was built up gradually from 1632 to 1745 and contained volumes from the 15th to the 18th century. The contents of this library reflect the role of the Jésuits in New France: pastors; missionaries; teachers; custodians of higher learning; and pioneers in the new country. The collection also reflects the traditions and the knowledge of the time.

Among the 685 titles traced by distinguished Canadian historians, 64 pertained to sciences. The 15th century is represented by "Legenda Sanctorum by Vorgine," edited in 1483. Among some 35 books of the 16th century, the most valuable and rare one is from the famous bibliophile Jean Grolier's library, entitled "Ortus Deliciarum;" elegantly bound it contained his famous Latin inscription, "Johanni Grolierii et amicorum," at the bottom, signifying that Grolier wished his book to be used by his friends as well as by himself.

The Jesuit College Library quite naturally abounds with works in physics. The seventeenth century materials include a copy of Nicolas Granger's (1680-1730), "La Mecanique Dufeu," (Paris 1713); Jacques Rohault's (1620-1675), "Traité de Physique," (Lyon 1681); Pierre Varignon's (1654-1722), "Projet D'une Nouvelle Méchanique," (Paris 1687). Vargnon's "Projet", enhanced by drawings and ornate lettering, was presented by the author to the Gentlemen of the Academie Royale des Sciences. Rene Anthony Ferchault de Caumur (1683-1757), a French philosopher of Rochelle, was inclined to mathematics and physics. His reputation procured him a seat in the Academy of Sciences in 1708. His works were very ingenious, and much admired. The best is his "History of Insects," in volumes 6.

Chemistry of the 17th century is represented by books by French chemists, who were leading the way at that time; their works were translated in other languages. Some examples are Pierre Thibault's, "Cours de Chymie," (1667) and Jean-Baptiste Senac's (1693-1770), "Nouveau Cours de Chymie, Suivant les Principes de Newton et de Stahll," (Paris, 1723).

The earliest book in mathematics held by the library is "Algebra" by Christophe Clavius (1537-1612), a Jesuit and mathematician, from Bamberg. This treatise was used at the College of Québec during the 18th century. Other works are by renowned authors such as Charles-René Reyneau, who was born in Anjou, taught philosophy, and was promoted to the mathematical chair at Angers in 1683. He published "Analysis Demonstrated," (2 vols.), a popular work, in which he reduced to a body the theories of Newton, Descartes and Leibnitz. He authored "Science du Calcul des Grandeurs," (2 vols.), and "A Tracr on Logic." Simon Stevin (1548-1620), of Bruges, instructed Maurice of Nassau in mathematics, and was made superintendent of the dikes of Holland. He invented the failing chariots which were for some time adopted by the Dutch. He is author of "Treatise on Statics; Geometrical Problems and Les Oeuvres Mathématiques," (Leyde 1634). Gaspar Schott (1608-1666), a Jesuit born at Wurtsburg, in Franconia, wrote "Cursus Mathematicus, Sive

Absoluta Omnium Mathematicorum," (Herbipoli, 1661).

Materials relating to hydrography are abundant. One of the rarest is "Le Compost Manuel Calendier, et Almanach Perpétuel"(Rouen, 1595) by Jean de Seville. The first edition of this work, also published in Rouen, is dated 1587. Engravings illustrate the following proverb, "Those who go down to the sea in ships, see the works of God." Georges Fournier (1595-1652) wrote "Hydrographie," (Paris, 1667). The Library of the Jesuit College also holds the first edition of "Hydro graphie" published in Paris in 1643; the work contains a very interesting lexicon, "List of words and expression used at sea." C.F. Charles de Millet (1625-1678), authored "L'Art de Naviguer," (Paris 1677). Paul Host (1652-1700), wrote "Théorie de la Construction des Vaisseaux," (Lyon, 1697). Host was a French Jesuit, professor of mathematics at Toulon, where he died in 1700 at the age of 48. Host authored "Traitté des Evolutions Navale," (in-folio, 1727) and "Traité des Mathematiques les Plus Necessaires à un Officier," (3 vols., translated into English by W. Webster).

Among the medical books, the library contains 65 works of famous authors like Hippocrates, Michel Ettmuller(1644-1683), Herman Boerhaave (1668-1738) and John Freind, (1675-1728).

The study of botany was described by Denis Dodart (1634-1707) in "Mémoires pour Servir à l'Histoire des Plantes," (Paris 1679). Rembert Dodoens (1518-1585), wrote "Florum et Coronariarum Odoratarumque Nonnularum Herbarium Historia," (Antverpinœ, 1568). This work by the Flemish botanist is illustrated with engravings attributed to R. Weigel. It is valuable when accompanied by two other studies entitled: "Frumentorum, Leguminum," (Antverpœ, 1569), and "Purgantium Radicum," (Antverpœ, 1574).

Father Jerome Demers (1765-1835) and the Physics Cabinet of the Quebec Seminaire

In 1771, science was introduced into the program at the Québec Séminaire. According to the "Plan d'Éducation du Séminaire de Québec" of 1790, the senior year of philosophy was devoted to mathematics, physics, and geography, followed by higher mathematics, physics, some chemistry and astronomy. The physics and mathematics examinations were public events.

The teaching method was based on book learning. At that time the work highly successful in Europe and around the world was "Leçon de Physique Expérimentale," (Paris, 1745), written by Father Jean-Antoine Nollet (1700-1770), a professor at the Collège de Navarre and in 1757, philosophical instructor to the royal family. Though an ecclesiastic, he devoted himself to philosophical pursuits. He visited England with Dusay, Duhamel and Jussieu in 1734, and gave lectures on experimental philosophy with illustrations of chemistry, anatomy, and natural history. His experiments and discoveries contributed to the advancement of science. He published "Treatises on Electricity," (5 vols.) and "L'art des Xpériences," (3 vols.; 1770).

This new style of using objects to supplement teaching was immediately adopted by Jérôme Demers, a priest, architect and teacher of natural philosophy at the Séminaire from 1800 to 1840. Considered an instigator of reform, Demers more than anyone else was the founder of science teaching at the institution. Recollet Bossuet (his uncle) and McCarthy prepared him well to give the first lesson in physics in 1804. He combined the concept of "experimental" physics with the theory of his course. By 1816 he expanded the curriculum so that some mathematics was taught in the penultimate year, followed in the senior year by higher mathematics, physics, some chemistry and astronomy. He adopted the Aimé-Henri Paulian's plan, "Dictionnaire de Physique," (3 vol., Avignon, 1761). To prepare his courses he used the textbooks of the following individuals: Mathurin-Jacques Brisson's (1723-1806), "Traité Elementaire ou Principe de Physique," (1789); "Cours de Physique Expérimentale," (1777) by Jean Sauri (1741-1785); "Abrégé D'astronomie," (1775) by Joseph Jérôme de Lalande (1732-1807). Lalande was particularly renowned for his astronomical textbooks. In this he covers the full spectrum of astronomical subjects, including the use of the spheres (illustrated with two plates) and comets (including discussion of Halley's comet).

For Demers, teaching science was a passion. He did research, constructed instruments, and in 1806 with the

help of Father Félix Gatueb established a "Museum" (the Cabinet de Physique). Demers offered laboratory work in physics and chemistry to his students. His Cabinet de Physique is one of the most complete in North America containing about a hundred instruments, and a number of pieces from such contemporary London makers as George Adam and W. & S. Jones. The priests at the Séminaire, on their trips abroad, purchased most of the apparatus from such manufacturers as Bretons and Frières Karl Rudoph Koenig in Paris. There are tools for observing (optical instruments), measuring (chemical and hydrostatic balances), and understanding (electrostatic machines). He is author of "Les Institutiones Philosophicœ" (Québec, 1835), a first philosophical manual.

By 1835, the authorities of the Séminaire decided that chemistry should be taught independently of philosophy. Demers's student Louis-Jacques Casault was the first professor of physics at the Séminaire and afterwards the first Rector of Université Laval.

A year later, Father Jean Holmes, a priest at the Séminaire, was sent to France and England to study the functioning of teachers' training colleges in order to set them up in Québec. Holmes also obtained scientific instruments for Demers's Cabinet de Physique. He brought books and minerals that enriched the geological and mineralogical museum created by Father Philippe-Jean Louis Desjardins from his private collection: "... a box of mineral samples arranged under the supervision of the renowned Father René Just Haüy (1743 - 1822)."

Father Jean Holmes (1799-1852), born at Windsor, Vermont, the son of Protestant parents, converted to the Roman Catholic Church, studied theology, and was ordained as a priest on October 5, 1823. Subsequently appointed Vicar of Berthier and Montréal, and then missionary at Drummondville, Professor of Physics and Prefect of Studies at the Québec Séminaire from 1830 until 1849, he devoted his life to education. Realizing the weakness of the educational system at the Séminaire, he introduced Greek, French, English, Geography and History in the program. He prepared and produced, with the help of Father Demers, numerous handbooks of "History of Canada" (1838). He also initiated the students in music and theater. In 1852, in memory of his contribution to education in the Province of Québec, the Séminaire had his name inscribed on the list of the foundation of Laval University.

Science teaching did not prosper in the classical colleges of Québec in the early 19th century because the Catholic colleges preferred to remain loyal to tradition. However, Father Thomas Hamel proceeded to Paris to study "mathematics and the sciences". When he returned he gathered a number of instructors and organized a course leading to the degree of Master of Science. Québec journalism was lively during the 1820s and 1830s, with nearly a dozen periodicals in print. News of societies and items of general interest on science, agriculture, and technology appeared in such major papers as the "Gazette" or "Le Canadien," "Official Gazette," "The Québec Star," "Bibaud's Bibliothéque Canadienne," "La Minerve," "The Canadian Magazine" and William Evan's "Journal d'Agriculture," which carried scientific articles. Also Dr. J. B. Meilleur, co-founder of College de l'Assomption, wrote a textbook on chemistry entitled "Cours Abrégé de Lleçons de Chymie," printed in Montréal in 1833.

Teaching Mineralogy and Geology at Laval University, 1856-1910

Probably the best known teacher was Dr. Thomas Sterry Hunt, who served as Professor of Chemistry and Mineralogy at Laval University from 1856 until 1862. Dr. Hunt studied under the great Yale mineralogist, Benjamin Silliman, the younger, and came to Canada to join the Geological Survey of Canada. In 1864-1865 Dr. Hunt was relieved from his teaching duties to reorganize the Geology and Mineralogy Museum. He donated some 2,000 samples of rocks and minerals from the Survey to the Mineralogy and Geology Museum. Dr. Hunt authored "Canada at the Universal Exhibition of 1855; Esquisse Géologique du Canada pour Servir à L'intelligence de la Carte Géologique et de la Collec..."; A New Basis for Chemistry, A Chemical Philosophy (1887); Un Systéme Chimique Nouveau, Traduit de L'anglais (2e Cd. Americaine 1889).

Hunt's contemporary, William Edmond Logan, contributed greatly to Canadian geology. He was born in

Montréal of Scotch parents, studied in Montréal and continued in London. In 1841, he presented his theory concerning the accumulation of coal to the Geological Society of London. In 1842, on the recommendation of this Society, Logan founded the Geological Survey of Canada. He received many honors from the Royal Society of London and Geological Association of Canada. He was awarded a number of medals for his participation in World Fairs in London in 1851 and in Paris 1855. He was also responsible for building a large collection of minerals.

His principal works were: "Reports of the Canadian Geological Survey: Geology of Canada," embracing the result of all explorations between 1858-1863; "Atlas and Map to Accompany the Geology of Canada," (1863); "Esquisse Géologique du Canada. Pour Servir a L'intelligence de la Carte Géologique et de la Collections des Minéraux Envoyés à l'Exposition Universelle de Paris," (1855). He published numerous articles in the Canadian Journal, Le Canadian Naturalist and the Transactions of the Geological Society (London).

Bishop Joseph-Clovis-Kemner Laflamme (1849-1910)

Bishop Joseph-Clovis K. Laflamme (1849-1910) has been called the father of Québec geology. Born in Dorchester on September 18, 1849, he studied at Séminaire and was ordained priest on October 6, 1872. In 1870, he taught courses in geology and mineralogy, plus botany and physics, at the Faculty of Arts at Laval University. In 1875, he held the Geology and Mineralogy chair. In 1877, he continued his studies at the summer School of Geology at Harvard and from 1891 to 1909, he was appointed Dean of the Faculty of Arts at Laval University where he stayed until his death. He was honored with membership in the Royal Society of Canada. He was an active collaborator of the Geological Survey of Canada. The results of his research were published in the annual reports of the Geological Survey and the Royal Society of Canada. He published: "L'Age de la Chute de Montmorency," (1873); "Eléments de Minéralogie et de Géologie Québec," (1881); "Le Canada D'autrefois : Esquisse Géologique Québec; Notes sur la Géologique du Lac Saint Jean," (1883); "Notes sur les Contacts de Forme Palézoique et Archéenne de la Prov. de Québec et Le Saguenay : Essai de Géographie Physique," (1886); Le Gaz Naturel de la Province de Québec, Mémoires de S.RC," (1888); "Notions sur L'électricité et le Magnétisme Québec," (1893); "Eléments de Minéralogie, de Géologie, de Paléontologie," Québec, (1898); "Modifications Causées à la Riviére Ste-Anne par L'éboulement," (Québec, 1900); "Jacques-Phil. Cornuti, Mémoire S.RC.,"(1901); "Minéralogie, Géologie, Botanique," (Québec, 1907).

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