Scholars and Miners

Dowsing and the Freiberg Mining Academy

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In 1780, the Göttingen Academy of Sciences sought to generate further research on an important topic by publicizing the following essay contest: "How was mining conducted in prior centuries? Can we learn something of benefit to present-day mining and smelting by comparison?" The prize-offer remained open until 1783, when five contestants, among them Christian Hieronymus Lommer, submitted papers. Lommer was the first professor of mine engineering (*Bergbaukunde*) and mineralogy at the Freiberg Mining Academy in Saxony. Although he did not win, the contest afforded Lommer an opportunity to demonstrate to his distinguished Göttingen colleagues that Freiberg was fast becoming an internationally recognized center of earth science. Lommer's response also showed how Freiberg scholars invoked the dowsing rod to distinguish academy science from mining tradition.[1]

Lommer cited numerous examples of a mining culture he claimed was in decline. Contemporary mining science at Freiberg was, he said, grounded on reason and a combination of different theoretical and practical branches, including chemical mineralogy, natural history, physics, geology (*Lagerstättekunde*), mine surveying, mechanics, hydraulics, and hydrostatics. Lommer pitted these fields against mining sciences "in the time of [Georg] Agricola,"

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1. *Göttingische Anzeigen von gelehrten Sachen* 202 (1783): 2027–28. The original offer was repeated in 1781 and 1782; in 1783, the society awarded a prize of fifty ducats, to be shared by two of five contestants; see Christian Hieronymus Lommer, *Bergmännischer Beytrag zu der von der Königlichen Großbrittannischen Societät der Wissenschaften, auf das Jahr 1781 ausgestellten Preißfrage: Wie waren die Bergwerke bey den Alten eigentlich beschaffen und eingerichtet? Und läßt sich nicht nach angestellter Vergleichung derselben, mit den unsrigen, zum Vortheil des Bergbaues, und Hüttenwerke in unsern Zeiten, etwas von den Alten lernen?* (Freiberg, 1785).

which, he argued, were suggestive but misguided inquiries grounded in tradition and superstition rather than reason. Miners had attributed healing and supernatural qualities to minerals, a "childish fairy tale" that was now replaced by "system and knowledge."[2] Prior to the 1749 publication of a textbook by the joint-founder of the academy, Friedrich Wilhelm von Oppel, mine surveying was "Devil's work." Moreover, before appropriate concepts and labels were applied to natural phenomena, "so-called miner language" (*Bergsprache*) dominated in practice—a vernacular terminology that lacked the simplicity and clarity of the enlightened concepts that Lommer was promoting.[3] In the absence of proper reason and experiment, he explained, the miners imagined that the stars and planets had an effect on mineralogical phenomena, that mineral veins originated in the molten center of the earth, and that the dowsing rod (*Wünschelrute*) provided reliable information. The rod was the epitome of all this nonsense, a powerful dream among "so-called knowers of mining" (*Bergverständige*) that even misguided scholars, which lasted into the eighteenth century.[4] The miner of his own day, Lommer alleged, was embarrassed by the continued use of the dowsing rod and instead relied on "natural observations and sound reason."[5]

Lommer's statements indicate that early academy professors distinguished themselves from the *Bergverständiger* by marginalizing prospecting technologies such as dowsing and identifying with the international republic of letters and new ideal of *Wissenschaft*. Historians of geology have echoed Lommer by stressing paradigmatic change at Freiberg. Rachel Laudan cites Freiberg professor Abraham Werner as the first to distinguish *historical geology* from *mineralogy*.[6] David Oldroyd invokes Thomas Kuhn's theory of paradigm change: "The Wernerian radiation gave the study of the

2. Ibid., 12.

3. Ibid., 15.

4. Ibid. *Berg* = mountain; *verständigen* = to inform or advise. The term *Bergverständiger*, which Lommer derided, referred to a man with great experience on the mountain. The dowsing or divining rod was most commonly a forked hazelwood branch. Farmers and treasure hunters used the rod to locate water sources and other hidden or lost objects, whereas miners dowsed primarily for mineral resources. In the *Dictionary of German Superstitions*, Eduard Hoffmann-Krayer and Hanns Bächtold-Stäubli include a lengthy entry for *Wünschelrute*, noting that the majority of tales come from German mining regions, where it was also known as *Visierrute*, *Schlagrute*, *Fragerute*, *Wickerode*, and *Wickerraue*. In France, it was the *baton de Jacob* or *baguette divinatoire*; in Holland, the *Toverstaf* or *Wichelstuk*; and in England and America, both divining or dowsing rod and witch stick, as in "water-witching." See Hoffmann-Krayer and Bächtold-Stäubli, *Handwörterbuch des deutschen Aberglaubens* (Berlin, 1927–42), s.v. *Wünschelrute*.

5. Lommer, 36.

6. Rachel Laudan, *From Mineralogy to Geology: The Foundations of a Science, 1650–1830* (Chicago, 1987), 104–5. Werner, a professor at the Freiberg Mining Academy from 1775 to 1817, advanced the study of rock stratifications or formations (*Gebirgsformation*), which he made central to geology, or what he termed *Geognosy*. He also developed the Neptunist theory of geology.

earth its first paradigm, marking a separation from mineralogy. It was the means of escape from a pre-paradigm condition."[7] Martin Rudwick also notes the epochal influence of Werner in the emergence of *geology* as distinct from *mineralogy* or *natural history*.[8]

Economic and mining historians have similarly presented Freiberg innovations as a watershed in mine engineering. Johann Friedrich Mende, "founder of a new age" of machines at Freiberg, was a graduate of the academy.[9] Freiberg ingenuity contributed to the application in mining of Thomas Newcomen's improved steam-powered engine. Another academy graduate, Christoph Friedrich Brendel, studied this technology in England and introduced it to Freiberg in 1808. The mining administration spearheaded construction of a major steam-powered machine in 1817, and in 1829, Brendel oversaw the construction of underground rails for hauling ore that perhaps represented the "first [iron] railroad in Germany."[10] James Watt and George Stephenson sent their sons to study at Freiberg, where Werner lectured on coal mining.[11]

But there was another, longer-standing language in mining towns like Freiberg, and that was the language of the *Bergverständiger* himself. From the sixteenth century onward, mining books, mining-town sermons, patronage documents, and even academic works had developed the image of the simple though experienced miner, a humble man of pick and axe who possessed a tacit knowledge of the mountain and how to locate mineral ore. He read the signs of ore on the landscape, the effects of supposed mineral fumes on vegetation and trees, and he used the dowsing rod. The mining-town preacher Johann Mathesius summarized these techniques in a 1562 collection of sermons titled *Sermons on the Mount*. The independent prospector, Mathesius said, "needs . . . reason and the advice of loyal and experienced people, keeps his eyes open . . . follows veins and rifts with the dowsing rod [*Ruthe*], minds the mineral vapors, pebbles, rocks, and trees, assays often to be sure, and digs and climbs down in the name and by the

7. David Oldroyd, *Thinking about the Earth: A History of Ideas in Geology* (Cambridge, Mass., 1996), 103. See also William R. Albury and David R. Oldroyd, "From Renaissance Mineral Studies to Historical Geology, in the Light of Michel Foucault's *The Order of Things*," *British Journal for the History of Science* 10 (1977): 187–215.

8. Martin J. S. Rudwick, "Minerals, Strata and Fossils," in *Cultures of Natural History*, ed. N. Jardine, J. A. Secord, and E. C. Spary (Cambridge, 1996), 266–86.

9. Hans Baumgärtel, *Bergbau und Absolutismus: Der sächsische Bergbau in der zweiten Hälfte des 18. Jahrhunderts und Maßnahmen zu seiner Verbesserung nach dem Siebenjährigen Kriege* (Leipzig, 1963), 54. Mende (d.1798) became a director of engineering (*Maschinendirektor*) and an inventor of extraction machines and water pumps.

10. Hanns-Heinz Kasper and Eberhard Wächtler, eds., *Geschichte der Bergstadt Freiberg* (Weimar, 1986), 186.

11. Eberhard Wächtler, "Bergbaureviere als Vorreiter technischer Entwicklungen des 18. und 19. Jahrhunderts unter besonderer Berücksichtigung Sachsens," in *Vom Bergbau zum Industrierevier*, ed. Ekkehard Westermann (Stuttgart, 1995), 363–78.

word of Jesus Christ."[12] Hans Uttman, a metalsmith and mining official, added in his 1601 manual that mountain springs originated in mineral veins, and that expert diggers (*Schürfer*) looked for a "sulfuric fatness" and a vitriolic or otherwise sharp taste in waters.[13]

The legacy of the *Bergverständige* continued into Lommer's day and beyond, although he himself failed to acknowledge their contribution. Historians of geology have recognized mining as an important motivation behind geological knowledge, but they tend to relegate folk-knowledge to the pre-modern era.[14] This article argues that Freiberg became a site for the integration of new science and prospecting tradition, notwithstanding Enlightenment sentiments to the contrary. Freiberg professors and mining officials after Lommer could offer few alternatives to traditional prospecting practices, and they assimilated mining books filled with mining lore and age-old digging and dowsing techniques into the curriculum. In addition, they followed the latest scientific research into dowsing. Animal magnetism and galvanism suggested an enlightened science of dowsing—or rather, a romantic science based in *Naturphilosophie*. The famous Freiberg physicist Ferdinand Reich rejected this notion, but in the 1840s, the Central Mining Office nonetheless asked him to examine a mine surveyor who claimed to experience "galvanic excitement" with a dowsing rod.[15] The

12. Johann Mathesius, *Berg-Postilla oder Sarepta: Darinnen von allerley Bergwerck und Metallen, was ihre Eigenschafft und Natur, und wie sie zu Nutz und gut gemacht, guter Bericht gegeben* (Freiberg, 1679), 847. Mathesius was a preacher in the mining town of Joachimstal on the Bohemian side of the Ore Mountains.

13. Hans Uttman, *Bericht, von denen Ertz-Gebürgen, Streichenderer Gänge, Stöcke, Flöze, Klüffte, Ertze, Berg Arthen und allen Metallen, auch von Schürffen, Seiffenwercken und andern Arthen der Bergwercken*, 1601, Hauptstaatsarchiv Dresden (hereafter DHSA), Loc. 36070, 2b. Little is known about this head overseer (*Oberbergmeister*) at Annaberg, who may have been related to Christoph Uttman, head of the famous Grünthal liquation works.

14. Theodore Porter, "The Promotion of Mining and the Advancement of Science: The Chemical Revolution of Mineralogy," *Annals of Science* 38 (1981): 543–70; Laudan (n. 6 above); Claudine Cohen, "Leibniz's *Protogaea*: Patronage, Mining, and Evidence for a History of the Earth," in *Proof and Persuasion: Essays on Authority, Objectivity, and Evidence*, ed. Suzanne Marchand and Elizabeth Lunbeck (Turnhout, 1996), 124–43; Ernst P. Hamm, "Knowledge from Underground: Leibniz Mines the Enlightenment," *Earth Sciences History* 16 (1997): 77–99; Otfried Wagenbreth, *Geschichte der Geologie in Deutschland* (Stuttgart, 1999); Walter Kertz, *Geschichte der Geophysik* (New York, 1999); Ezio Vaccari, "Mining and Knowledge of the Earth in Eighteenth-Century Italy," *Annals of Science* 57 (2000): 163–80; Hugh Torrens, *The Practice of British Geology* (Burlington, Vt., 2002).

15. Ferdinand Reich was joint-discoverer of the element indium and one of the earliest geophysicists. See Constantin Täschner, "Ferdinand Reich, 1799–1884: Ein Beitrag zur Freiberger Gelehrten- und Akademiegeschichte," *Mitteilungen des Freiberger Altertumvereins* 51 (1916): 23–61. See also *Allgemeine Deutsche Biographie*, s.v. "Reich, Ferdinand." The Saxon Central Mining Office (*Oberbergamt*) dates to 1554, when the elector of Saxony created a head overseer of all mine managers. By the eighteenth century, the administration had expanded to encompass juridical, police, and fiscal functions in mining. The Freiberg Mining Academy of 1765 was an arm of the office.

dowser could appropriate a theory of galvanism also embraced by the physics community.

PREV

Dowsing and other means of locating mineral ore constituted a tacit knowledge that defied articulation and codification into rules.[16] Sketching and working with mineralogical and sectional maps in light of Werner's theory of rock formations may have served as an exemplar among his students at Freiberg and abroad. But tacit knowledge does not flow only from the top downward through a hierarchy of power, and information about treasure hunting, digging, and dowsing was not confined to the mining administration or the metallurgist's shop. Instead, this knowledge dispersed horizontally among unlettered wanderers and farmers, as well as skilled miners and metallurgists. While historians of science have exposed the artisanal associations of the sciences from the fifteenth century, and especially the improving status of *ars* among statesmen and natural philosophers, they have been slower to analyze tacit knowledge of this sort.[17]

I will begin with the Freiberg Mining Academy to trace not only how the *Bergverständiger* became the antithesis of the enlightened specialist, but also how prospecting defied the early Enlightenment agenda. Key academy texts are compared to more descriptive sources, such as patronage documents and the diary of a high official. I then turn to the place dowsing found among physicists and chemists, in particular the work of the German physicist and *Naturphilosoph* at the Munich Academy of Sciences, Johann Ritter. When Professor Reich at Freiberg examined a local mine surveyor and dowser with an electrometer and galvanometer, he was testing Ritter's latest theory. The case illustrates how a dowser could synthesize learned theory and folk-knowledge during the Age of Enlightenment.

The School on the Mountain

The Freiberg Mining Academy, founded in 1765 to train high-ranking officials, was the culmination of a long-term effort to bring Saxon mining under state management. Dresden redoubled its efforts after the Thirty Years' War, when production had halted. The elector reformed juridical and

16. Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy* (Chicago, 1958).

17. Alan Gabbey, "Between *Ars* and *Philosophia Naturalis*: Reflections on the Historiography of Early Modern Mechanics," in *Renaissance and Revolution: Humanists, Scholars, Craftsmen, and Natural Philosophers in Early Modern Europe*, ed. J. V. Field and Frank A. J. L. James (Cambridge, Mass., 1993), 133–45; William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, N.J., 1994); Pamela Long, "Power, Patronage, and the Authorship of *Ars*: From Mechanical Know-how to Mechanical Knowledge in the Last Scribal Age," *Isis* 88 (1997): 1–41; Pamela Smith and Paula Findlan, eds., *Merchants & Marvels: Commerce, Science, and Art in Early Modern Europe* (New York, 2002); Pamela Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago, 2006).

police functions in mining, provided more financial support, reenacted mining privileges, and appointed new officials. In 1670, Johann George II created the office of Head Administrator of Mines (*Oberberghauptman*) to direct the thirteen Saxon mining jurisdictions from Freiberg. A revived interest in the structures and properties of the earth accompanied these bureaucratic developments, and Freiberg developed into an international center for mining-related inquiries.

Freiberg scholars and officials had long imagined an institutionalized mining science to replace miner beliefs and customs. In 1702, head administrator Abraham von Schönberg secured funding from the elector to instruct in mining crafts. The resolution made a distinction between "mining sciences, smelting, and mine surveying" and the digging expeditions (*Schürfe*) it also funded.[18] In 1712, Schönberg also issued the first formal proposal for a school, but the most developed came in 1746 from the chemist and chief superintendent of mines (*Bergkommisar*) Karl Friedrich Zimmerman. He described a break with the *Bergverständige*:

> Since the time that we relied on digging and the dowsing rod alone, we have become rather removed from inspecting the land, mineral vapors, temperature of air, and position against the stars. The old knowers of the mountain, those who first established the local regions, looked to these things and even named the strike of veins accordingly. We retain the expressions of these old fathers in the Mineral Kingdom, but we are ever more removed from an original understanding of the matter itself.[19]

Zimmerman cited Uttman's 1601 *Report on Mining* (printed 1732), which was full of such expressions; rather than repeat them, the new mining science (*Bergwissenschaft*) should speak the language of enlightened thought.

The Seven Years' War devastated Saxony once again and triggered a second wave of fiscal and administrative reforms. Superintendent of Mines Friedrich Anton von Heynitz secured state funding for the academy and headed a reform committee in 1766 to undertake a thorough examination of all mining and smelting operations and administration. In 1767, the committee issued a comprehensive report that cited numerous problems,

18. "Resolution wegen Abstell-und Remedirung derer in Bergwercks-Sachen vorgekommenen und angemerckten Mängel und Gebrechen, sonderlich die Freybergische Revier betreffend, den 7. Januar Anno 1709," in *Codex Saxonicus: Chronologische Sammlung der gesammten praktisch-gültigen Königlich Sächsischen Gesetze von den ältesten Zeiten, vom Jahre 1255 an bis zum Schlusse des Jahre 1840*, ed. W. M. Schaffrath (Leipzig, 1842), 496.

19. Christoph Friedrich Zimmerman, *Obersächsisches Berg-Academie, in welcher die Bergwercks-Wissenschaften nach ihrem Zusammenhang entworffen werden* (Leipzig, 1746), 102. A student of the Stahlian chemist at Freiberg, Friedrich Henckel, Zimmerman became superintendent of mines shortly before his death in 1747.

from the lack of mining experience of Dresden bureaucrats, to widespread neglect, incompetence, and mismanagement in the field, to the inevitable effects of war. Like Zimmerman before him, Heynitz mentioned the poor state of mining science, and he attacked dowsers in this regard. The presence of iron ore was an adequate indication of nearby silver- or copper-bearing deposits, he maintained, and he called for the "banishment" of dowsing and a renewed commitment to "natural knowledge."[20] Mining was not a form of "gambling."[21]

Heynitz brought an ideal of knowledge to mining that was otherwise spreading through German universities such as at Göttingen. The new *Wissenschaft* held that a scientific inquiry was one that a rational thinker could reduce to a small number of basic and logically ordered statements that were more fundamental and universal than mere technical precepts or empirical observations. Based on Friedrich Gottlob Klopstock's *The German Republic of Scholars* (1774) and Immanuel Kant's epistemology, such later scholars as Friedrich Wilhelm Joseph von Schelling and Wilhelm von Humboldt added the romantic belief that all university inquiries would synthesize into a larger unity, and that the pursuit of knowledge was also a process of self-discovery. Although the Kantian and romantic perspectives often conflicted, individual departments might hire representatives from either camp.[22] Both sides called for character or "cultivation" (*Bildung*) among university scholars and distinguished *Wissenschaft* from technical or vocational knowledge. Around 1800, possessing *Wissenschaft* indicated high status and integrated the educated upper middle-class with the nobility.[23] This new ideal extended to scientific institutions, where there was a growing rift between *learned* and *craft* knowledge. The Munich Academy of Sciences was hostile to the optics technician and prospective member Joseph von Fraunhofer because he lacked university training.[24] The Freiberg academy drew more from Kant than Schelling, but it identified with the larger university reform, and a tension between learned and craft knowledge was visible there as well.

20. "Diese ganz kurz gefaßten, mehr zuverläßigen Erfahrungen zeigen, theil die Nothwendigkeit immer fortzusenzender Untersuchungen der Landes-Gegenden . . . theils geben sie die Möglichkeit an Hand, wie man mit Verbannung der Wünschelruthe . . . sich weit edler und nüzlicher, mit Erweiterung der Natur-Kenntniße, beschäfftigen könne," in Baumgärtel (n. 9 above), 139.

21. Ibid., 135.

22. Frederick Gregory, "Kant, Schelling, and the Administration of Science in the Romantic Era," *Osiris* 5 (1989): 16–35.

23. Thomas Broman, "University Reform in Medical Thought at the End of the Eighteenth Century," *Osiris* 5 (1989): 36–53; Charles E. McClelland, *The German Experience of Professionalization: Modern Learned Professions and Their Organizations from the Early Nineteenth Century to the Hitler Era* (New York, 1991).

24. Myles W. Jackson, *Spectrum of Belief: Joseph von Fraunhofer and the Craft of Precision Optics* (Cambridge, Mass., 2000).

Early academy texts upheld a *Wissenschaft* that ridiculed miner language and techniques. The first professor of metallurgical chemistry, Johann Friedrich Wilhelm von Charpentier, expressed frustration with miners in a 1799 piece on geology (*Geognosy*). He was proud of the mining tradition at Freiberg though confident in a more scientific approach to metallurgical phenomena. Suggesting that earth science could satisfy an ideal of mathematical clarity, Charpentier began with praise for Galileo, Kepler, and Newton.[25] Then, the "common miner" emerged as a source of ambiguity for Charpentier. So long as mineral veins were described in *Bergsprache*, he felt, the subject would be shrouded in ignorance.[26] The majority of common miners did not adequately distinguish mineral veins from surrounding earths. A proper account required a more sophisticated understanding of the ore.[27] Charpentier repeatedly contrasted the clear language of natural science with the prejudiced views and expressions of miners: "I have described what I have seen, and nothing else . . . and just as it would appear to anybody with no preconceived notion."[28]

The title page of Charpentier's 1778 *Mineralogical Geography of the Saxon Lands* is significant here for its depiction of the dowsing rod (fig. 1). A muse holds an official letter. To the right, the bust of the elector sits atop a Roman column. To the left, blindfolded Prejudice stumbles as an angel breaks his dowsing rod. Charpentier's message is clear: "Enlightened management over mineral resources overcomes blind superstition in Saxon mining." Heynitz's reform committee had given Charpentier the assignment of creating a mineralogical map of Saxony. The emblem echoed Heynitz's call to banish dowsing and to ground prospecting in a more systematic understanding of visible geological characteristics. Heynitz had proposed iron-bearing earth to be the telltale sign of nobler ore, and Charpentier was equally confident that better knowledge of the earth would prevent unnecessary digging and expense.[29]

The most authoritative and renowned voice at Freiberg was that of Abraham Werner (1750–1817), whose *Wissenschaft* both Enlightenment scholars and *Naturphilosophen* esteemed. Werner's central theory—that

25. Johann Friedrich Wilhelm von Charpentier, *Beobachtungen über die Lagerstätte der Erze, Haupsächlich aus den Sächsischen Gebirgen* (Leipzig, 1799), ii.

26. Ibid., 38.

27. Ibid., 49.

28. Ibid., vi.

29. "Die genauere Kenntnis der Steinarten, woraus die Gebürge bestehen, das Verhalten der Gänge und anderer Lagerstätte der Erze, ja die Beschaffenheit der Erze selbst, macht uns wenigstens behutsam, und lehrt uns, nicht überall und in jeder Steinart Erz zu suchen und sich einzubilden, da viel zu finden, wo nichts oder wenig zu finden ist," in Martin Guntau, *Die Genesis der Geologie als Wissenschaft: Studie zu den kognitiven Prozessen und gesellschaftlichen Bedingungen bei der Herausbildung der Geologie als Naturwissenschaftliche Disziplin an der Wende vom 18. zum 19. Jahrhundert* (Berlin, 1984), 48.

FIG. 1 An angel breaks the dowsing rod in the title image to Johann Friedrich Wilhelm von Charpentier's *Mineralogische Geographie der Chursächsischen Lande* (1778), showing the triumph of reason over superstition. (Reproduced courtesy of the Universitätsbibliothek Leipzig [Signatur: I 13399].)

rocks lay in expansive and distinct formations deposited through a process of successive sedimentation—generated a flurry of field research in Saxony and abroad.[30] Not surprisingly, such a progressive thinker could be dismissive of miner beliefs. His *New Theory on the Origin of Mineral Veins* (1791) listed all major contributions to the subject of mineral generation—from Pliny, to Agricola, to Johann Becher, to Charpentier—and placed their theories in four categories: those proposing 1) that mineral veins originated with creation; 2) that they were branches of an enormous mineral tree;

30. On Werner, see Andre Wakefield, "Abraham Gottlob Werner and the Cameralist Tradition in Freiberg," *Freiberger Forschungshefte* D207 (September 2002): 379–88; Walther Herrmann, "Die Zeit Abraham Werners in Freiberg," *Freiberger Forschungshefte* D2 (Berlin, 1953): 43–60; and Hans Jürgen Rösler, ed., "Abraham Gottlob Werner: Gedenkschrift aus Anlaß der Wiederkehr seines Todestages nach 150 Jahren am 30. Juni 1967," *Freiberger Forschungshefte* C223 (Leipzig, 1967).

3) that they were hollow passages that filled with mineral substance; and 4) that they developed from the earthly material that surrounded them. Werner settled on a synthesis, believing that hollow passages filled with contiguous materials that chemically modified over time. He explicitly excluded the works of Uttman, mine-manager Georg Engelhard von Löhneiß (1617), and other miner books since Agricola from the discussion: "What they offer is too unimportant to deserve mention." Werner meant in particular that they gave too much causal significance to the stars.[31] He denied that astrology and dowsing still had currency at his contemporary Freiberg:

> The entire old belief of the influence of the sun and planets on mineral veins belongs, together with the now rather forgotten dowsing rod, to the astrological mysticism of old times . . . and hardly deserves mention, the name of theory, and certainly not refutation; because the claims are totally inconsequential and incoherent, and this superstitious belief is long forgotten.[32]

Charpentier's and Werner's statements, like those of Lommer and Heynitz, were in accord with other scholarly and popular remarks on miners made across Europe. Enlightenment thinking was disseminated through mining towns by locally published pamphlets and calendars, among them the *Harzmagazin* in the Harz Mountains, and the Marienberg *Bergwerkscalendar* in the Ore Mountains. A short 1775 essay in the Marienberg calendar titled "On the Superstitions of the Miner" even summarized major beliefs and practices that fell under this category, including astrology, mining spirits, treasure-hunting manuals, and the dowsing rod.[33]

But did institutionalized *Wissenschaft* really displace the *Bergverständiger* as Werner claimed? The fields taught at the new academy included pure and applied mathematics, land and mine surveying, mine engineering, natural history of minerals, chemical mineralogy, and smelting.[34] Some of these subjects—among them chemical mineralogy and mine surveying—were new or highly progressive, but at least one major practice remained steeped in mining lore and tradition: prospecting (*Schürfen*), the search for the "natural signs" of mineral ore that would facilitate its discovery. Agricola, Mathesius, Uttman, and other sixteenth-century authorities had treated the subject in depth, and their treatment included dowsing.[35]

31. "Sie sezzen insgesamt den Hauptgrund der Veredlung der Gänge, theils auf die Lage des Gebirges gegen die Sonne, theils auf den Einflus der Gestirne"; see Abraham Werner, *Neue Theorie von der Entstehung der Gänge, mit Anwendung auf den Bergbau, besonders den freibergischen* (Freiberg, 1791), 16.

32. Ibid., 170.

33. "Würde wohl die Wünschelruthe . . . die Bergleute so lange getäuschet haben, wenn sie hierbey nicht so leichtgläubig gewesen wären?" Gotha Forschungbibliothek (GFB), Math 8° 1260/2, year 1775.

34. Walter Hoffman, *Bergakademie Freiberg* (Frankfurt am Main, 1959), 43.

35. Georg Agricola, *Zwölf Bücher vom Berg- und Hüttenwesen* (Munich, 1994), chap. 2.

Schürfen would find a place within the academy curriculum, which meant tolerating or reevaluating the rod and its bearers.

In fact, Freiberg had a long history of experimentation with dowsing for mineral ore. This was most obvious in the decades just prior to the founding of the academy, when the Central Mining Office formally and publicly patronized dowsers. Two high-profile examples were Christoph Dietrich and Tobias Häusler. Dietrich, a foreman as well as dowser, defended his practice in a 1738 letter to the office. Referring exclusively to the rod (*Ruthe*) rather than the more derogatory "divining rod" (*Wünschelruthe*), he and a fellow practitioner affirmed their legitimacy. They recalled having taken an oath as dowsers (*Ruthen Gänger*) in which they swore to remain "obedient" and "honorable" miners, and sealed it with a handshake before the Central Mining Office itself. They complained that certain individuals of little mining experience (*Bergwerksohnerfahrene*) would make unfounded claims and steal their business. "Were they miners, it would be tolerable," said the dowsers, but the region was riddled with questionable characters from all walks of life. The authors were "poor miners," and their practice was grounded in nature and mining experience: "Our rods dip by nature, and the techniques [*Wissenschaften*] come from mining practice."[36] The *Wissenschaft* of dowsing was a function of mining experience. The office considered the complaint justified and nine days later ordered local shaft managers to favor the formally employed dowsers over their unauthorized competitors.

Tobias Häusler also found widespread employment in Saxon mining, though his practice came under increasing scrutiny and he eventually lost favor with the mining authorities in Dresden and Freiberg. In 1739, the Central Mining Office drafted an eight-point contract for Häusler to follow, a code of conduct titled "Provisional Sketch of Instructions for Dowser Tobias Häusler." Item 2 was especially revealing for distinguishing between superstitious and legitimate practice:

> Because God the Almighty is to thank for the blessed gift that the dowsing rod dips for him and is used toward the exposure of crevices, mineral veins, branches, and other such things that are hidden to human eyes under the earth; so should he in no way misuse it to the harm of his neighbor, and much less perform superstitious things with it, but rather operate it as a natural means of exposing crevices, mineral veins, and branches.[37]

36. "Unser Ruthen schlagen aus der Natur, und die Wissenschafften von einem bergmännischen Exercitio haben," in August Friedrich Wappler, "Alte sächsische Wünschelruten-Geschichten," *Mitteilungen des Freiberger Altertumsvereins* 43 (1907): 64. We know little about these dowsers beyond their letter stating that Dietrich had been a miner for twenty-one years, and his companion for nineteen years.

37. "Da er Gott dem Allmachtigen die Gnaden Gabe daß ihm die Wundschel Ruthe

The office humbly credited the Creator for granting miners the ability to dowse. The true dowser did not abuse his powers by applying the rod toward ends beyond his God-given capacity to expose hidden veins. He did not deceive his fellow miners with strange incantations and prophecies; rather, he trusted in a natural correspondence between rod and underground materials, though the contract did not explain the theory. The next item continued with the moral conduct of the dowser, specifying that when Häusler offered his services to others, he should call on God's help and behave "sober and moderately" rather than make extraordinary claims. By 1743, the office had cancelled the contract and thoroughly discredited the would-be official dowser, Häusler. In that year's report to Dresden, signed by none other than the joint-founder and future joint-head of the mining academy Friedrich Wilhelm von Oppel, among other Freiberg luminaries, the office concluded that Häusler engaged in magic and made numerous bold and unreliable claims.[38]

These documents prove that the Central Mining Office consulted dowsers during the decades that preceded the founding of the Freiberg Mining Academy. Contemporary mine surveyors like Balthasar Rößler and Augustus Beyer presented dowsing as an important part of *Schürfen* in their mining books, bringing additional legitimacy to a contested technique.[39] The new academy, which was formally a branch of the Central Mining Office, then incorporated *Schürfen* as a component of *Bergbaukunde* more broadly—a field that also included *Lagerstättekunde*, boring, and mine construction and mechanics (hydraulics and ventilation).[40] Werner and others lectured on *Bergbaukunde*, though it never received the same treatment as more progressive areas.[41]

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schlagt, zu dancken hat, selbige aber zu Ausgehung Klüffte, Gänge, Thrümer, und dergleichen, so denen menschlichen Augen unter der Erden verborgen sind, hauptsächlich gebraucht wird: so soll er solche in Keiner Wege zum Nachtheil des Nechsten mißbrauchen vielweniger damit abergläubische Dinge vornehmen, sondern sich derselben, als eines natürlichen Mittels zum Ausgehen der Klüffte, Gänge, und Thrümer bedienen." DHSA, Loc. 36263, 5b.

38. Ibid., 18–24.

39. Balthasar Rößler, *Speculum Metallurgiae Politissimum, Oder Hell-polierter Berg-Bau-Spiegel* (Dresden, 1700); Augustus Beyer, *Gründlicher Unterricht vom Bergau, nach Anleitung der Marckscheiderkünst* (Schneeberg, 1749).

40. Lommer, who taught the subject until 1771, when Werner took over, defined the field as follows: "Lehre vom Gebrauch des Grubenkompasses, Bestimmung des Streichens und Fallens des mineralogischen Lagerstätte, die Lehre von der Beurteilung der Bauwürdigkeit ganzer Reviere und ganzer Gebirge, die Lehre von der Aufsuchung sowohl unerschrotener und noch unbekannter, als auch bekannter, desgleichen auch verlorner metallischer Lagerstätten, wohin ich zugleich die Aufsuchung und Beurteilung der Geschiebe, des Schürfen und Übberröschen und den Gebrauch des Erdbohrers erklärt habe, ferner die Lehre von der Veranstaltung eines neu angehenden Grubenbaues"; see Joachim Wrana, ed., *Bergakademie Freiberg: Festschrift zu ihrer Zweihundertjahrfeier am 13. November 1965* (Leipzig, 1965), 1:118.

41. Ibid., 120.

The textbook from which Werner lectured exposed this weakness in the curriculum. Johann Gottlieb Kern's *Report on Mining* (1772) was intended to replace prior mining books, as Oppel explained in the preface. He cited three authorities of old: Agricola's *Twelve Books on Mining and Metalworking* (1556), Georg Löhneiß's *Report on Mining* (1617), and Balthasar Rößler's *Mining Mirror* (1700). All included substantial sections on *Schürfen* and dowsing. Oppel argued that they were important stepping-stones, but not a comprehensive doctrine.[42] When Kern turned to *Schürfen*, however, his text lost its enlightened tone and resorted to the tacit knowledge of old. In keeping with academy rhetoric he excluded the dowsing rod, but what remained was little different from that explained in Agricola and repeated in Uttman, Löhneiß, and Rößler. According to Kern, *Schürfen* was the study of alluvial mineral fragments (*Geschiebe*) embedded in topsoils and the inspection of earths and grasses, particular herbs, and warm springs, which one examined for a salty or vitriolic taste and an oily fattiness. He also referenced the age-old belief that patches of evaporated dew or melted snow revealed the presence of mineral vapors and the minerals from which they came, though he considered that a dubious sign.[43] This knowledge was the product of centuries of experience in locating mineral ore.

The debt to miner beliefs and practices was more openly acknowledged in other academy texts. Like Kern, Friedrich Wilhelm Heinrich von Trebra (1740–1819), the first academy graduate and head administrator of Saxon mining after 1801, advanced the Freiberg agenda, but he admitted the limits of new science and reason in the case of prospecting. Trebra adopted the official rhetoric, which included praising the introduction of higher learning into what had otherwise been a mere craft: "Mining had never been acknowledged as a scientific [*Wissenschaftlichen*] enterprise, but rather disregarded as a craft, or at best an art, to which . . . other than miners, only a few scientific men wished to contribute. The Mining Academy . . . remedied this evil."[44] We know, however, that Trebra used the mining sermons of Mathesius (1562), the chronicles of Saxon mining of Peter Albinus (1590), and the mining books of Rößler (1700) and Christoph Herttwig (1710) in the classroom, all of which not only described miner lore and digging knowledge, but included detailed explanations of dowsing as well.[45]

Trebra's first major publication, *Experience of the Interior of Mountains, as Gathered through Observations*, treated the problem of *Schürfen* head-on. Trebra expressed a certain amount of frustration with learned works on the matter. To present the subject adequately, he claimed, he would have to employ miner language and explain its terminology to the reader.[46] Miners

42. Johann Gottlieb Kern, *Bericht vom Bergbau* (Leipzig, 1772), a2.

43. Ibid., 29.

44. Baumgärtel (n. 9 above), 98.

45. Walther Herrmann, *Goethe und Trebra: Freundschaft und Austausch zwischen Weimar und Freiberg* (Berlin, 1955), 15.

46. "Ich habe mich oft der Sprache des Bergmanns bedienen müssen . . . diese und

had hundreds of special terms and expressions that contemporaries referred to collectively as *Bergsprache*. Rather than ridicule this language or dialect, as had Lommer, Trebra acknowledged its importance for his learned audience. Moreover, there would be no discussion of the origin of veins or similar theoretical issues in his text: the amount of experience gathered thus far did not warrant it, nor would that serve the immediate needs of miners.[47] Because *Schürfen* passed orally "from father to son," Trebra wished first to bring more order to the subject and replace popular wisdom with reliable or "scientific" knowledge.[48] His basic rule of prospecting was that mineral veins shared their origins with water sources, and that miners might therefore look for wet crevices and other damp regions.[49] He credited his renowned success at locating silver veins at Marienberg to following that simple rule.[50] But on the other hand, he appealed to classic miner beliefs in natural signs as presented in Mathesius or Rößler: fallen trees that revealed mineral ore; alluvial mineral fragments that could lead to veins; and particular earths known to lie contiguous with ore.

Trebra's dual commitment to academy knowledge and miner experience explains his ambiguous statements on the dowsing rod. He echoed fellow academy scholars Charpentier and Werner by presenting the practice as the epitome of popular superstition in mining. He even included a map of veins charted by a dowser in 1709, and he interpreted the great number of charted veins as evidence of the absurdity of the practice.[51] He also criticized learned men who entertained dowsing merely out of desperation with a failing venture.[52] Yet, Trebra's explanation of dowsing was surprisingly detailed given his negative comments, and he clearly drew from Rößler. From Trebra's diary for 1767–79, when he was *Bergmeister* at Schneeberg, we also see that he was more open-minded than his later *Experience* would suggest.

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der Zusammenhang des Ganzen, sollen hoffentlich dem aufmerksamen Leser nirgends Unverständlichkeit übrig lassen, wenn er auch gleich kein Bergmann ist"; see Friedrich Wilhelm Heinrich von Trebra, *Erfahrung vom Innern der Gebirge, nach Beobachtungen gesammlet* (Leipzig, 1785), iii.

47. Ibid., iv: "Vor der möglichen ersten Entstehung ganzer Gebirge, ihrer Form sowohl, als ihrer Felsmasse nach, bin ich allenthalben scheu vorüber gegangen. Die Summe unserer Erfahrungen scheint mir beyweiten noch nicht gross, und allgemein gnug zu seyn, um etwas Befriedigendes und fest Bleibendes hierüber sagen zu können."

48. Ibid., 5: "Es ging hier, wie es mit blossen Sagen allemal gehet, sie pflanzen sich wohl fort, vererben sich von Vater auf Sohn, werden aber selten ganz gründlich durchgedacht, erprüft, und berichtiget."

49. Ibid., 9.

50. Ibid., 188.

51. Ibid., 67: "Wo haben wir jemals ein Gebirge so besäet mit Gängen gefunden? Ich sage kein Wort mehr hierüber, das frappant Unwahre fällt allzusehr sogleich in die Augen."

52. Ibid., 4: "Es sey alles schwankende, unzuverlässige Spekulation . . . meynten auch Leute von Ansehen . . . und nahmen in Fällen, wo sie sich nun eben nicht weiter zu helfen wusten, heimlich oder öffentlich, ihre Zuflucht zur noch weit anzuverlässigern Ruthe."

For example, he once fined a foreman and "old magician" a week's wages for having failed to dowse an area that Trebra knew to be promising. The man had claimed that the effort would be in vain. Duly censured, the man continued his work in Trebra's company until they discovered traces of galena (*Bleiglanz*) and, ultimately, silver. *Now* the rod dipped strongly, Trebra noted sarcastically. More concerned with the man's negligence than with his dowsing per se, Trebra had considered him stubborn or difficult, but now he was a "good old man."[53] On another occasion, an otherwise "trustworthy and hard-working" digger was caught with a piece of stolen mineral earth. His only defense was that he intended merely to use the piece in dowsing. He had actually been witnessed holding the ore beside an extended rod, attempting to increase its affinity for the earth below. The digger was fired. That Trebra spoke highly of the man and stressed the small size of the stolen piece, intended only for dowsing, suggested sympathy for the poor *Hauer*.[54] Trebra also exposed his familiarity with the practice by referring here to the "rod" (*Rute*), as had Dietrich and Häusler, rather than to the more derogatory "divining" or "wishing" rod (*Wünschelrute*), the term used by Werner.

An appendix to his diary devoted to *Schürfen* helps explain why the skeptic Trebra tolerated dowsing in the late 1770s: recognition that the academy could not claim that prospecting was a science. Mining was otherwise a *Wissenschaft*, Trebra began, one that drew on Christian Gellert's metallurgical chemistry and Johann Suckow's and Johann Krüger's physics (*Naturlehre*), among other new sciences. But digging was an accumulation and combination of tacit knowledge and scholarly insights—collective wisdom that Trebra classified into five branches: studying the general landscape and rock formations; examining the local vegetation; surveying the layout of mountains; the reading of old and new authors; and consulting the "still living experts" in the field.[55] More than Werner, Trebra acknowledged the gap between new theory and practice at the academy, particularly in the case of prospecting.

53. "Ich fand weiter hin nie solche Widerspänstigkeit mehr, bey diesem übrigens guten alten Manne, die ich doch wohl auch dießmal, mehr der bisher gewohnten allgemeinen Verwilderung, als seiner Ruthengeherey zuschreiben konnte"; see Friedrich Wilhelm Heinrich von Trebra, *Bergmeister-Leben und Wirken in Marienberg, vom 1. Decbr. 1767 bis Augusti 1779* (1818; reprint, Leipzig, 1990), 183–85. See also August Friedrich Wappler, "Oberberghauptmann von Trebra und die drei ersten sächsischen Kunstmeister, Mende, Baldauf, und Brendel," *Mitteilungen des Freiberger Altertumsvereins* 41 (1905): 76.

54. Trebra, *Bergmeister-Leben*, 356: "Er kam sogleich in Untersuchung, und ob gleich das Corpus delicti sehr klein war, und er vollen Beweis dafür beybrachte, daß er das Stüffchen nur weggenommen habe, um es beym Ruthengehen zu gebrauchen, denn dabey hatte man ihn mit dem Stüffchen in der Hand neben der Ruthe betroffen, so half ihm dieses doch nicht."

55. Ibid., 585.

Academy scholars did not accord *Schürfen* in general or dowsing in particular any prominence or even treat them sympathetically, and *Bergbaukunde* remained a neglected subject. They certainly expected the light of science and progress to shine through the earth's strata and render the knowledge of dowsers obsolete. As Trebra put it, "Perhaps I will find some enlightenment [*Aufklärung*] in the fogs that continue to surround this science with a curtain impenetrable to many eyes."[56] In the meantime, they continued to consult standard mining books and others more expert on the mountain than themselves—which might include dowsers.

The Electric Rod

Laudan rightly contends that geological knowledge at the new Freiberg Academy had little bearing on mining practice. She cites prospecting in particular as an area still based on "time-honored methods," including dowsing.[57] Hugh Torrens similarly argues that "scientific prospecting" in coal mining based on the stratigraphic column was a British accomplishment of around 1805, though he acknowledges that this remained a gentlemanly and scholarly pursuit: "The practical men did not want to know."[58] However, Freiberg scholars also investigated electricity and galvanism, which suggested a science of prospecting insofar as a number of prominent French, Italian, and German physicists began experimenting with pendulums and dowsing rods to detect the electrical, and then electromagnetic, potential of mineral earth. When physicist Reich discredited a dowser during the 1840s, he did so with an electrometer. The electrical theory of dowsing synthesized new science and *Schürfen* in a way Lommer never recognized.

Germany inherited the new dowsing theory from France and Italy. It originated with French physician and Royal Inspector of Mineral Waters Pierre Thouvenel (1747–1815). Aided by Barthelemy Bléton, a peasant dowser who experienced seizures near mineral and water sources, Thouvenel discovered mineral waters near Contrexéville at about the same time that Anton Mesmer's "magnetized" water baths were gaining attention in Paris.[59] Thouvenel published his findings in a 1781 text, in which he replaced earlier

56. Ibid., 586.

57. Laudan (n. 6 above), 54: "Prospectors relied on the time-honored methods of following surface deposits underground, examining hillsides after rain to see if unusual deposits had been exposed, tasting spring water for unusual metallic tastes, running trial sinkings and borings, and (most dubiously) using the divining rod."

58. Hugh Torrens, "Some Thoughts on the Complex and Forgotten History of Mineral Exploration," *Journal of the Open University Geological Society* 17 (1997): 20.

59. Michael R. Lynn, "Divining the Enlightenment: Public Opinion and Popular Science in Old Regime France," *Isis* 92 (2001): 34–54. On popular interest in electricity during the Enlightenment, see Oliver Hochadel, *Öffentliche Wissenschaft: Elektrizität in der deutschen Aufklärung* (Göttingen, 2003), and Robert Darnton, *Mesmerism and the End of the Enlightenment in France* (Cambridge, Mass., 1968).

theories of dowsing (mineral vapors, occult qualities, corpuscularism) with a theory of "subterranean electricity," an expression of the more fundamental animal magnetism Mesmer discussed.[60] Bléton's attacks, Thouvenel argued, were qualitatively similar to the medical crises Mesmer witnessed in his magnetized baths, and the movements of the dowsing rod—which spiraled clockwise or counterclockwise in apparent obedience to natural law—suggested the polar action (positive or negative charge) of electricity. In 1782, a commission—which included such students of electricity and Enlightenment thought as Benjamin Franklin, the chemist Claude von Berthollet, the Baron d'Holbach, and the physician Joseph-Ignace Guillotin—was appointed to investigate these claims. A flurry of opinions followed, and by the time Thouvenel and Bléton migrated to Italy, the dowser had been questioned by Condorcet, Bossuet, and Diderot.

In Italy, Thouvenel discovered yet another French dowser, Joseph Pennet, and found an audience with the famous biologist Lazzaro Spallanzani. Inspired finally by Luigi Galvani's 1786 demonstrations of an animal electricity (galvanism) in frog legs, Thouvenel associated this biological or chemical reaction with the subterranean electricity he himself hypothesized. According to him, animal electricity (demonstrated with frogs) and mineral electricity (demonstrated with dowsers) seemed to "explain [one another] and to confirm [one another] mutually."[61] The contraction of frog legs paralleled the tremors and convulsions experienced by the dowser. Echoing Galvani, Thouvenel began calling his dowsers "electrometers."

The physicist Johann Wilhelm Ritter (1776–1810) developed Thouvenel's theory; with Ritter, we transition back to the intellectual contexts of Weimar, Jena, Halle, Leipzig, and Freiberg. Ritter is best-known in the history of physics as the discoverer of ultraviolet light, for improving on Volta's pile of copper/zinc plates (or battery), and for using it to measure chemical change, or electrolysis. Strongly influenced by Schelling's *Naturphilosophie* and the romantic critique of Newtonian mechanics, moreover, Ritter also believed that physics engaged the spirit, reconciled man with nature, and provided an understanding of unity and harmony in nature. In his effort to prove that a galvanic force pervaded all organic and inorganic matter, Ritter invoked such themes from Schelling's philosophy as dualism, polarity, periodicity, and a vital and developmental spirit in nature, and also the microcosm/macrocosm distinction.[62]

60. Pierre Thouvenel, *Mémoire physique et médicinal montrant des rapports évidents entre les phénomènes de la baguette divinatoire, du magnétisme animale et de l'électricité* (Paris, 1781).

61. Quoted in Walter Bernardi, "The Controversy on Animal Electricity in Eighteenth-Century Italy: Galvani, Volta, and Others," *Nova Voltiana: Studies on Volta and His Times* 1 (2000): 113. See also Lucia De Frenza, *I sonnambuli delle miniere: Amoretti, Fortis, Spallanzani e il dibattito sull'elettrometria organica e minerale in Italia* (1790–1816) (Florence, 2005).

62. For a succinct introduction to Schelling's philosophy and its influence in the sci-

Ritter's interest in *Naturphilosophie* continued to increase. In 1806, for example, he was correlating the rhythms of the voltaic pile with astronomical events. That was also the year when, newly installed at the Munich academy, Ritter heard from his colleague, mineralogist and crystallographer (and former Werner student) Christian Samuel Weiß, that a twenty-one-year-old farmer who had learned his art from none other than Thouvenel and Pennet had successfully used a dowsing rod to locate hidden coins. Always looking for new ways to demonstrate the qualitative similarity between physical and biological electricity and the unity of man with nature, Ritter asked the academy for a travel stipend.

So began two years of intensive experiments with the dowser Campetti, who returned to Munich with Ritter. These began with the pendulum. The instrument consisted of a rock of pyrite (*Schwefelkies*) on a string of human hair or raw silk, suspended over magnetite (lodestone) or another mineral or metal. Receptivity was demonstrated by the "water-feeler" (*Wasserfühler*), "metal-feeler" (*Metalfühler*), or "electrometer" (as Ritter called his subjects) when the pendulum oscillated. According to Ritter, the subject conducted a force between the suspended and stationary objects that was otherwise neutralized in nature. Ritter carried out hundreds of such experiments, believing to observe oscillations of predictable regularity, as had Thouvenel. Ritter concluded that he was working with a natural force coursing through Campetti's body that was qualitatively similar to galvanism. He called his force "siderism" (*sidus*, or star), maintaining that it resembled the gravity of planetary bodies. The movements of the dowsing rod or pendulum (as well as metal rods balanced on fingertips) were equivalent at a microcosmic level to what occurred in the universe at a macrocosmic level.[63] Ritter described his interest in Thouvenel's work, his entire experience with Campetti, and the theory of siderism in his *Der Siderismus* (1808).[64]

Did Freiberg scholars know about Ritter's research? While Ritter never

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ences, see Nicholas Jardine, "*Naturphilosophie* and the Kingdoms of Nature," in *Cultures of Natural History* (n. 8 above), 230–45. See also Robert J. Richards, *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe* (Chicago, 2002). On Ritter's physics, see Walter D. Wetzels, "Johann Wilhelm Ritter: Romantic Physics in Germany," in *Romanticism and the Sciences*, ed. Andrew Cunningham and Nicholas Jardine (New York, 1990), 199–212.

63. "Siderismus bleibt sein Name, denn wirklich ist es nur der Sternenlauf, der sich in allen jenen sonderbaren Bewegungen von Baguetta, Pendel, Degen, Früchten, Magneten, Metallen, usw. wiederholt, indem jeder Körper der anorganischen Natur, in Conflict mit dem vollendetsten Microcosmus, dem Menschen, selbst zu einer, um was immer für ein Centrum als Sonne, laufenden und sich drehenden Erde zu werden sucht" (Ritter to Karl von Hardenberg, brother to the author Novalis), in Armin Hermann, *Die Begründung der Elektrochemie und Entdeckung der Ultravioletten Strahlen von Johann Wilhelm Ritter* (Frankfurt am Main, 1968), 18.

64. Johann Wilhelm Ritter, ed., *Der Siderismus* (Tübingen, 1808).

visited the Mining Academy nor corresponded with Werner, Trebra, or Reich, his influence clearly extended to the very doors of the academy. None of the Freiberg professors was himself a *Naturphilosoph*, but a number of Werner's famous students were. The romantic author Friedrich von Hardenberg (Novalis) left Jena in 1797 to study under Werner at the advice of Ritter.[65] The physician Gotthilf Heinrich von Schubert also came to Freiberg after exposure to Schelling and Ritter at Jena. Schubert referenced Ritter's work in a text on *Geognosy* and mining: discussing *Schürfen*, the author mentioned the "old experiences" concerning melted snows, evaporated dews, and discolored and disfigured vegetation and trees, as well as the latest research on metal-feelers, which he found very promising.[66] The geologist Henrich Steffens studied under Werner from 1799 to 1802 and synthesized his *Geognosy* with Schelling's thought. Steffens was a more outspoken (if also critical) admirer of Ritter.[67] Alexander von Humboldt studied under Werner in 1791 and served in various bureaucratic capacities in Saxon mining. Humboldt corresponded with both Schelling and Ritter, and Humboldt's call for a "terrestrial physics" also inspired Reich. In a 1797 work, Humboldt claimed to have attempted Thouvenel's pendulum experiments to little effect.[68] The philosopher Franx Xaver von Baader studied for three years under Werner before turning to *Naturphilosophie*. After taking positions in mining and metal works in Bavaria and Bohemia, Baader became a philosophy professor at Munich. It was he who helped Ritter secure an appointment at the Academy of Sciences in 1805. Finally, the physicist Weiß was also a student of Werner's and his lifelong correspondent and friend;[69]

65. "Der Jenaer Physiker Ritter wies ihn auf Werner hin" (Bernd Klengel, "Ultaviolette Strahlen und Ladungssäule: Zur Rezeption von Entdeckungen Johann Wilhelm Ritters in Frankreich," in *Naturwissenschaften um 1800: Wissenschaftskultur in Jena-Weimar*, ed. Olaf Breidbach and Paul Ziche [Weimar, 2001], 52). See also Alexander M. Ospovat, "Romanticism and German Geology: Five Students of Abraham Gottlob Werner," *Eighteenth-Century Life* 7 (1981–82): 105–17.

66. "Was jene Arten der Aufsuchung metallischer Gänge und Lager betrifft, wobei die Nähe der Metalle mittelst eines krankhaft gereizten Nervensystems empfunden, oder durch das leise Zucken der gewaltsamen gespannten Fingermuskeln, bei einer natürlichen Reizbarkeit für Metalle merklich wird, mit andern Worten das sogenannte Metallfühlen und Wünschelruthen-Schlagen, so dürfen die Erfahrungen, auf welche sie sich gründen, seit der Bekanntschaft mit dem Galvanismus und den Phänomenen des thierischen Magnetismus, freilich nicht ganz bezweifelt werden"; see Gotthilf Henrich von Schubert, *Handbuch der Geognosie und Bergbaukunde* (Nuremberg, 1813), 332.

67. "Er [Ritter] war ein junger Mann von großem Talent, in der Chymie, auch in der Geschichte derselben wohl bewandert, und Kenntnisse, die ihm etwa noch fehlten, erwarb er sich mit Leichtigkeit"; see Henrich Steffens, *Was ich erlebte: aus der Erinnerung niedergeschrieben* (reprint, Stuttgart, 1995), 4:88.

68. Alexander von Humboldt, *Versuche über die gereizte Muskel- und Nervenfaser, nebst Vermuthungen über den Chemischen Process des Lebens in der Thier- und Pflanzenwelt* (Berlin, 1797), 1:470.

69. *Allgemeine Deutsche Biographie*, s.v. "Weiß, Christian Samuel."

it was Weiß who first informed Ritter of the dowser Campetti. Weiß also promoted Ritter's work in Paris.[70]

That Freiberg knew of Ritter's work is confirmed in the work of the professor of *Bergbaukunst*, Moritz Ferdinand Gaetzschmann (1800–1895). A former academy student and instructor of mine surveying, Gaetzschmann's textbook addressed both the most cutting-edge earth science and long-standing tacit knowledge, as the author, not unlike Trebra before him, exposed a dual commitment to academy and *Bergverständiger*. As Gaetzschmann explained, the first step in establishing a mine was prospecting. That included the "[natural] signs and methods" in the discovery of minerals.[71] A thorough knowledge of rock formations, mineralogy, mineralogical chemistry, and physics formed the basis of prospecting for Professor Gaetzschmann. However, this *Wissenschaft* was compatible with a due appreciation for chance discovery and *Schürfen*. Gaetzschmann incorporated these beliefs and techniques as well, referencing Mathesius, Agricola, Georg Löhneiß, and Rößler. The independent miner analyzed the color of earths, springs, and streams, he looked for particular herbs and plants, stunted growth and singed leaves, and other effects of warm mists and vapors from underground.[72]

Gaetzschmann then devoted some ten pages to the problem of dowsing, complete with visual depiction and a literature review. Like Trebra, he remained skeptical but open-minded. "In earlier times," he recounted, "the *Wünschelruthe* stood in high esteem, and to some extent still today . . . it even found official application when dowsers [*Ruthengängern*] were paid, according to their claims."[73] Gaetzschmann included the latest on electricity and galvanism: professional physicists balanced metal rods on the fingertips of "receptive" individuals or hung pendulums from their fingers. A new language of electricity had come to replace the "sympathy of the old."[74] Gaetzschmann did remain skeptical: How could galvanic current from a mineral vein transfer to the human body through a wooden stick, "even if the dowser, following the proposal of one adept of about ten years ago, covered the soles of his feet and body with gold leaf?"[75] That man was undoubtedly one Karl Schmidt, whom Reich examined in the 1840s. Still, Gaetzschmann allowed that dowsers possessed an inexplicable tacit knowledge of the mountain, and he recalled the older view that dowsers detected mineral fumes: "It cannot be denied that many individuals of this sort, assisted by

70. Klengel, 256.

71. Moritz Ferdinand Gaetzschmann, *Einleitung zur Bergbaukunst*, pt. 1 (Freiberg, 1856), 253.

72. Ibid., 287.

73. Ibid., 295.

74. Ibid., 305.

75. Ibid., 306.

natural acumen, good powers of observation, even a peculiar physical receptivity to the action of moist vapors, have great value in their trade."[76]

Ferdinand Reich and the Schneeberg Dowser

Freiberg continued to show a formal interest in dowsing in Gaetzschmann's day, as dowsers could synthesize new science with *Schürfen* knowledge. Reich's investigation of Karl Wilhelm Schmidt has remained a quaint reference in the history of physics and Saxon mining, though it was a logical extension of Freiberg's broader interest in electrical theory.[77] When the Central Mining Office contacted Reich about Schmidt, the electromagnetic properties of mineral earth was one of the foremost problems in physics. In 1830, Robert Fox had demonstrated this for copper ore using a Schweigger multiplier (or galvanometer).[78] Shortly afterward, the office asked Reich to examine earth with this new instrument, in part to determine whether it had any practical application in mining.[79] Following Fox's procedure, Reich confirmed the galvanic property of mineral rock, which he attributed to the interaction of fluid and minerals. As for its mining implications, Reich insisted that that determination had to await further examination.[80]

Schmidt positioned his practice within the language of galvanism, and the physicist would use an electrometer and galvanometer to test the dow-

76. Ibid., 334: "Es kann nicht in Abrede gestellt werden, dass manche Personenn dieser Art, unterstützt durch natürlichen Scharfsinn, gute Beobachtungsgabe und wohl selbst eine eigenthümliche körperliche Empfindlichkeit für Einwirkung feuchter Dünste, grosse Uebung in ihrem Gewerbe haben."

77. No *Naturphilosoph* or supporter of Ritter, Reich worked with Ludwig Wilhelm Gilbert in 1815 at Leipzig on determining the density of the earth. Gilbert, an outspoken opponent of Ritter and *Naturphilosophie*, published his opinion of Ritter in "Einige Kritische Aufsätze über die in München wieder erneuerten Versuche mit Schwefelkies-Pendeln, Wünschelruthen, u.d.m.," *Annalen der Physik* 2 (1807): 369–449. See also Otfried Wagenbreth, *Die Technische Universität Bergakademie Freiberg und ihre Geschichte* (Leipzig, 1994), 88.

78. Robert Were Fox, "On the Electromagnetic Properties of Metalliferous Veins in the Mines of Cornwall," *Philosophical Transactions of the Royal Society* 120 (1830): 399–414. See also Heinz Balmer, *Beiträge zur Geschichte der Erkenntnis des Erdmagnetismus* (Aarau, 1956).

79. Ferdinand Reich, "Ueber electrische Stöme auf Erzgängen," *Jahrbuch für den Berg- und Hüttenmann* (Freiberg, 1840), 1. Reich would use two instruments with Schmidt. The electrometer contained two identical gold leaves suspended in a jar; since like charges repelled, the leaves separated when the experimenter introduced an electric charge. In 1820, Johann Schweigger devised the *Multiplikator* (multiplier, or galvanometer), which was also used by Reich. Wire loops in a magnetic field increase the turning force of a current, observed by the deflection of a magnetized needle.

80. Ibid., 2: "[S]o bleibt die genauere Ermittlung dieses für den Bergmann wichtigsten Umstandes noch weitern Versuchen vorbehalten."

ser, even if Reich a priori rejected dowsing theory. Schmidt was an academy graduate (both he and Reich were enrolled in 1816, which suggests some prior acquaintance),[81] and a mine surveyor and shaft manager at Schneeberg since at least 1827. He recounted his experiences with the dowsing rod in a local mining journal in 1842, in which the elderly author, invoking Thouvenel's and Ritter's work, spoke of "galvanic" responses and "electrical currents." A self-described *Geognost*, or student of Werner's *Geognosy*, Schmidt evidently considered his dowsing practice to complement his earlier study at the academy. He explained that misuse and deception had disgraced the otherwise valid practice of an "experienced [*Wissenschaftlichen*] miner."[82] Like Freiberg dowsers before him, Schmidt referred exclusively to the "rod" (*Rute, Rutenschlag, Rutenschläger*), rather than "divining" or "wishing rod" (*Wünschelrute*). He claimed that he was a disbeliever until becoming a mine surveyor, which brought him into contact with *Schürfen* and therefore with dowsing. Schmidt added that his own body was "receptive."

Schmidt's self-experimentation led to two curious observations: that whenever he held the rod in the classic palm-up style, he felt "galvanic excitement," and that bulbous tree trunks seemed to grow exclusively above mineral earth. That claim was rooted in the longer-standing belief that mineral vapors affected growth aboveground, a notion common to mining books from the sixteenth century onward. The telltale bulbs did not parallel underground veins exactly, Schmidt conceded, but tended to follow their trajectory, and dense groupings indicated an intersection of veins.

Schmidt described a systematic dowsing method that closely resembled the practice as Rößler had explained and depicted it in 1700. Having prepared stakes of various sizes, Schmidt proceeded to a prospective field and walked with his dowsing rod in straight lines, charting evenly spaced and parallel paths. Wherever the rod responded, an assistant would hammer in a stake. Schmidt then crisscrossed the parallel lines at right angles with new lines, forming a grid. The assistant hammered in new stakes. Then Schmidt intersected the angles by pacing diagonal paths. Once the entire region was thus staked, he zeroed in on highly staked-out regions in a more circular fashion in order to rule out "false impulses." The entire process was physically exhausting, supposedly because the strength of electrical currents increased over time.[83]

81. *Festschrift zum hundertjährigen Jubiläum der Königl. Sächs. Bergakademie zu Freiberg am 30. Juli 1866* (Dresden, 1866), 248.

82. "Haben Mißbrauch und Betrug den Ruthenschlag gleichsam infam und aller nähern Untersuchung als eines wissenschaftlichen Bergmannes unwürdig, lächerlich gemacht, so muß der Wahrheit doch die Ehre gegeben werden" ("Notizen über den Rutenschlag," in Wappler, "Alte sächsische Wünschelruten-Geschichten" [n. 36 above], 77).

83. Ibid., 78: "Läuft ein Ruthengänger aber gleich anfänglich continuirlich auf einer Gangregion fort, so impulsiren die elekrischen Ströme seinen Körper nach und nach so steigend, daß seine Schritte endlich unzuverlässig werden und das kleinste übersetzende Klüftchen ihn auf Abwege führt."

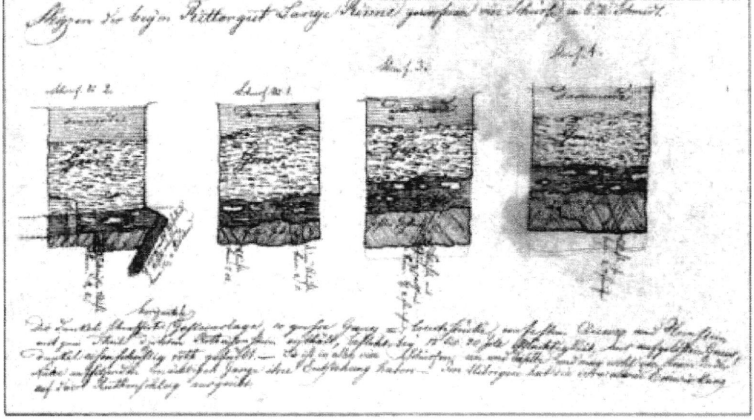

FIG. 2 The dowser Karl Schmidt's sketch of four digs (*Schürfe*). The dark band containing chunks of mineral rock "exerted a strong effect on the rod's dip [*Ruthenschlag*]." (Reproduced courtesy of the Sächsisches Staatsarchiv, Bergarchiv Freiberg.)

The Central Mining Office invited Schmidt to Freiberg for examination by Professor Reich. The first trial took place on 12 October 1843. According to Reich's report, the men walked to a pre-selected area next to a stable that was unfamiliar to Schmidt. He then proceeded to dowse the region in exactly the same manner he had outlined in his article. He walked with "small steps slowly forward," carrying the instrument Reich termed his *Wünschelruthe* before him, an apparatus consisting of intertwined iron wires fixed into a metal cap, fitted with brass grips, and covered in a mesh of copper wire. That Schmidt also coated his shoes in gold leaf (as Gaetzschmann later recalled) underscores how central an electrical or galvanic theory was to these experiments, as the metallic rod and the gold-leafed shoes were intended to conduct mineral current. That the dowser had another rod made of fish bone and wooden grips suggests, however, that his own theory was more expansive than that of the physicists.

Schmidt claimed to have identified four veins that day, the presumed intersections of which marked four later digs. Mine surveyor Leschner laid the string and used his compass to chart the direction, strike, and intersections of Schmidt's claims. Excavation of the four sites took place on 20 October. The first dig (fig. 2) passed through topsoil (*Dammerde*), then a rough layer packed with sharp stones, and then a thin band of iron-bearing earth containing large fragments of quartz and bloodstone (*Roteisenstein*). At the bottom was a harder metamorphic rock (gneiss) with fissures (*Klüfte*). The second dig, which required that the diggers leave a buffer (*Strosse*) against encroaching waters, resembled the first dig in all respects

except the base. There, the diggers recognized thin branches (*Trümmer*) running through the gneiss in addition to fissures, and at the corner, a larger muddy vein of iron-bearing gneiss rock. The third and fourth digs produced a similar stratification, with thin quartz-bearing branches appearing in the third. Schmidt supposed that the dark iron-bearing layer with large fragments (the third layer down) originated from a large mineral vein nearby, from which the vein discovered in Dig 2 also derived. In his sketches, he accordingly placed Dig 2 to the side of the other three columns and stated in the caption that the iron earth "may well have originated from a nearby, rich vein." He stressed that this earth had a "strong effect" on the rod. Reich reported Schmidt's interpretation, but he specified in his footnotes that the party had not found the supposed veins or intersections about which Schmidt had originally spoken.[84]

Reich was inclined to discount the dowser, and further experiments on 20 October seemed to confirm the skepticism. Schmidt was asked to dowse along a pathway (labeled as *Bauergasse* at left on Leschner's map [fig. 3]; today, *Hainichener Strasse*) under which veins were known to pass. The spots at which Schmidt's rod dipped strongly are labeled as "No. 1" and "No. 2" and so on. Reich considered the results to be strong proof against Schmidt, since he did not locate either the Priestly Felicitation (*Priesterliche Glückwunsch*) or the Maria and Max veins, both marked on the map as red lines crossing *Bauergasse*. Schmidt explained this oversight in a letter of 21 October. Addressing the "Dowsing Committee," he claimed that had he paced the region more thoroughly, he would certainly have experienced the effects of these veins.[85] He also referred to his published essay that the committee had read (and obviously valued), in which he conceded that the dowsing rod often dipped in "various" and "inexplicable" ways.[86] This was evidence of the delicacy of the art rather than its dubiousness.

But Schmidt had a more sophisticated defense. As Leschner's map shows, miners had discovered any number of offshoots from the Jonas, Esselstollen, and Michaelis veins shown at right. These branches are labeled with "A," "B," "C," and so forth. The final letter, "H," appears to the left, beside a group of branches off of Priestly Felicitation. Schmidt believed that these tributary veins crisscrossed the area according to the light dotted lines indicated on the map. In particular, he claimed that the spots along the

84. Ibid., 82.

85. Freiberg Bergarchiv (hereafter BAF), Nr. 2249, 20: "[D]ie hochverehrlich Deputation wird . . . aber sich gewisslich nicht entscheidend dafür aussprechen, daß mir bey weiterer Begehung, das heisst, mehr und oftmaliger Uberschritung dieser Gange in ihrer Längen erstreckung nicht Punkte vorgekommen seyn werden, worinen Einwirkung sich herausgestellt und die zwei Gang regionen zweifels ohne sich nach und nach markirt hätten."

86. Ibid., 20b: "[B]ey dem Ruthenschlag Vorkommnisse stattfinden, die örtlich vielseitig und unerklärbar sich gestalten."

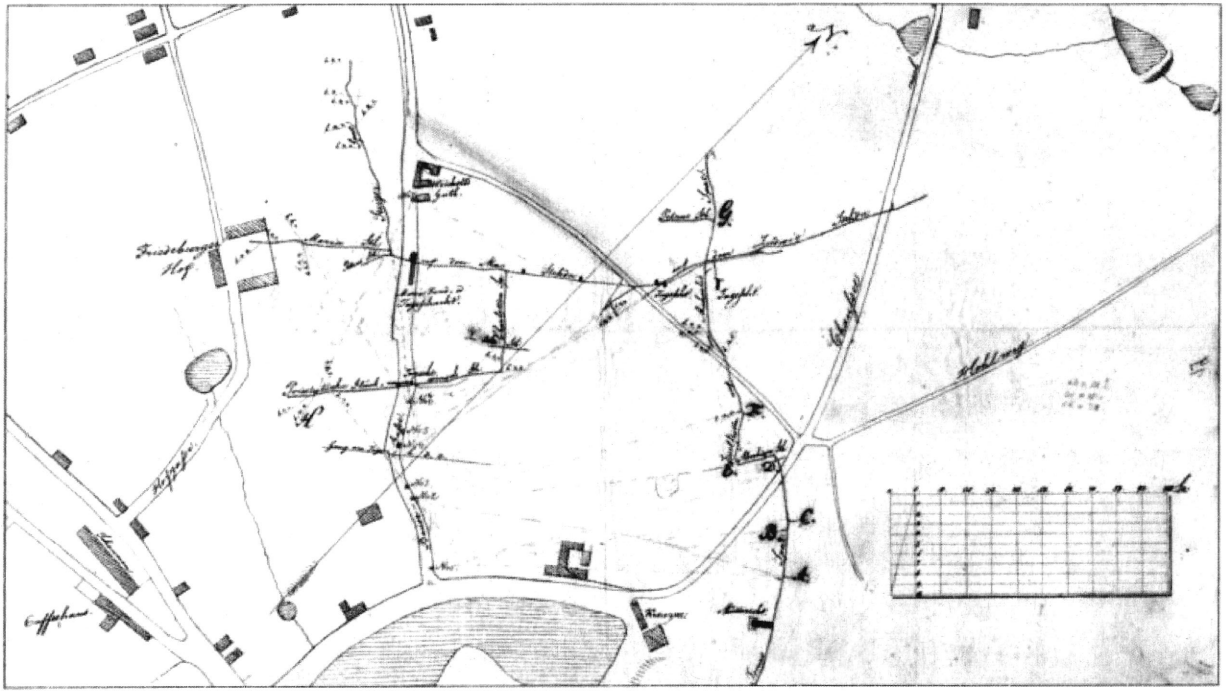

FIG. 3 The mine surveyor produced a map (*Riss*) of mineral veins, pathways, and structures on land dowsed by Karl Schmidt. The dotted lines represent uncharted veins, according to the dowser. (Reproduced courtesy of the Sächsisches Staatsarchiv, Bergarchiv Freiberg.)

pathway over which his dowsing rod dipped (proof for Reich against Schmidt) were the places at which several of these uncharted veins continued below, or intersected with others. So, for example, a small branch off the Esselstollen vein, labeled with "F" to the right, crossed the land and reached the pathway at No. 2, where Schmidt had placed a stake. Another vein from "A" also intersected at No. 2, as did a third from Priestly Felicitation above. Schmidt apologized for not making these deductions the day before. Had he been privy to Leschner's chart, the dowser explained, he would have realized that the rod, while it failed to locate two major veins, dipped to important sources nevertheless. The correspondences between stakes and veins was "most likely," he believed, and "it would be difficult not to acknowledge this most decisive evidence."[87] These remarks did not survive into Reich's official report.[88]

More damning still, Schmidt's practice did not lend credence to the electrical theory of dowsing, notwithstanding his golden shoes and metallic rod. When he stood above a (presumed) triple intersection of mineral veins where the electrical charge should have been strong, the investigators approached his dowsing rod with a gold leaf electrometer. The leaves in the jar did not separate. The multiplier was then placed in contact with Schmidt's rod, and it too showed nothing. When tested on copper and zinc pieces wedged into the ground, however, it showed a small charge as expected. At stake No. 5 along *Bauergasse*, wire from the multiplier was literally wrapped around Schmidt's rod and observed. But the needle only deflected when the instrument was again brought into contact with damp metal pieces placed in the ground. Also, Schmidt could not locate hidden metal coins with his dowsing rod. The men brought Schmidt inside the academy complex itself (sketched to the bottom-right of *Bauergasse* on the map) to conduct the classic coin test that brought Campetti to Ritter's attention back in 1805. The party laid numerous chests on the floor and filled one secretly with coins. Schmidt failed to locate the coins on two trial runs.

Reich's report concluded that there was "not a single fact" to suggest indubitably that Schmidt's rod determined the location of mineral veins, although he felt "obliged" to add that the dowser remained convinced. Schmidt and his examiners, predisposed toward opposing interpretations, had a great difference of opinion when observing complex data. Schmidt vaunted the subtlety of his art and formed explanations in part post hoc, whereas Reich looked for unambiguous experimental results. Schmidt possessed a dowsing practice that synthesized scientific theory and his tacit knowledge, and Reich upheld an electrical theory that excluded the experience and interpretations of the dowser. In 1846, Schmidt reported new

87. Ibid., 21: "[E]s wohl schwer seyn möchte diesen bescheid etlichst ausgesprechenen Nachweis nicht anerkennen zu wollen."

88. Wappler, "Alte sächsische Wünschelruten-Geschichten" (n. 36 above), 83.

experiences with his dowsing rod to the Central Mining Office, but this time Reich refused to investigate.[89] Others would. The archival record shows that Freiberg continued to conduct such experiments well into the twentieth century.[90]

Concluding Remarks

The Freiberg Mining Academy marked great progress in the history of mine engineering and geology, but the transition from pre-modern to modern knowledge systems was subtler than historians often recognize. The academy sought to realize a new ideal in mining that was hostile to mining culture, but prospecting defied Enlightenment, much to the chagrin of such men as Lommer, Werner, and Reich. *Schürfen* was an accumulation of centuries-old miner experience presented in well-worn mining books, and it still included dowsing. The Central Mining Office formally employed dowsers at least into the 1740s, after which time practitioners may have adopted the new scientific theory. Trebra's and Gaetzschmann's statements and the case of Karl Schmidt demonstrate continued interest after 1800 in the tacit knowledge of miners and the ways in which dowsers could appropriate new science. It should be no surprise that a science of dowsing has persisted to the present day.

89. Täschner (n. 15 above), 41.
90. BAF, 40024-16, Nr. 45, "*Wünschelrutenforschungen*," 1920.