‘Among all the different ways that great wealth can be acquired by good and honest means, nothing is more useful than the art of mining.’¹ With this authoritative tone, the physician and investigator of metals and minerals, Georgius Agricola (1494–1555), opens his book on mining, *De re metallica libri XII* (Basel: Froben, 1556). Heavily bolstered with allusions to classical authorities, he defends mining against critical voices who may not agree with the superiority of this ‘art’, and eloquently displays his humanist learning.² He surmises the ways in which critics denounce mining as dirty, risky, and above all, dangerous work. These disparaging voices consider mining to be the principal reason for humanity’s cultural decay, which they see expressed in moral and economic destabilization, self-interest, crime, aggression, and war. But without the benefits of metals, Agricola counters, humanity would culturally degenerate, because it would lack tools, money, and weapons.

A similar tone is taken in a manuscript entitled *Münz und Mineralienbüchlein* (1594/1600), written by the Basel merchant, politician and avid mineral and coin collector Andreas Ryff (1550–1603). Ryff opens his discussion with some lines that praise mining for being the most noble and useful form of employment, which brings immeasurable benefits to the sovereign, his territory, and his subjects:

Firstly, the mines bring great and considerable use to the princes and lords, because at places where the soil is newly dug up, galleries and shafts are constructed (this is mostly done at barren and rough wastelands and remote territories, where nobody lives except wild animals, snakes, toads and other kinds of vermin []); here territories are cleaned up, levelled out, planted and cultivated, inhabited by people and cattle, towns and villages are built, lovely gardens established, and instead of the wild creatures a new world is being created,

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¹ ‘[...] tum omnium rerum, quibus magiae divitiae bona & honesta ratione aquiruntur, nihil est arte metallica utilius’, Georgius Agricola, *De re metallica libri XII* (Basel: Froben 1556), 2r [Epistola dedicatoria], (Asmussen’s translation).

² On Agricola, the humanist tradition and the role of empirical knowledge see: Isabel Fay Barton, ‘Georgius Agricola’s De Re Metallica and Early Modern Scholarship’, *Earth Sciences History*, 35 (2016), 265–85; Owen Hannaway, ‘Georgius Agricola as Humanist’, *Journal of the History of Ideas*, 55 (1992), 553–60.
Mining in early modern Europe

commerce and trade are carried out and also divine worship with churches and schools are highly regarded and supported.³

Very like Agricola, Ryff declares that a future without mining would bring civilized Europe into a state of barbarism.

Whereas Agricola limits his account to the European dimensions of the early modern mining rush, Ryff highlights its global context. From around the middle of the sixteenth century, the tremendous output from the colonial silver mines – most notably from the Bolivian silver boomtown Potosí – had been flooding the European and Asian markets.⁴ For Ryff, a life without metals would lead to an extinction of craft and trade, not to mention the loss of all civilized manners. Heavily influenced by published travel accounts, such as Hans Staden’s Brasilian adventures,⁵ he remarks:

Indeed, it would come to a state where we would eat ourselves, like those poor, miserable and wild Presilians. These people should be a mirror and a warning to us, they do not have one single bread knife in their country, except what is brought to them from Europe across the wild sea.⁶

According to Ryff the ‘Presilians’ do not master the art of mining and metallurgy, they make their living through wars, fishing, and hunting.

³ ‘Erstlich so bringen die angohnden Pergwerck den Fürsten unnd Herren [...] grossen unnd ansehehlichen Nutz in dem, wa [sic.] neiwe Schürpf gemacht, Stoll unnd Schacht recht empfangen werden (wellichs mehrern theil ahn wüesten rouchen Einöden unnd verlegnen Ländern beschicht, da nichts anders wohnt dann wilde thier, schlangen, krotten und annder ungeseufer []), da werden die Länder geraumbt, verebnet, geseubert, pepplantzt und erbauwen mit leuthen und viech besetzt stätt unnd fläcken da aufgericht, wie schöne Lustgärten, zu berereith, an statt der wilden thieren ein neuwe wält erzeuget, gwerb und handtierungen getrieben wie auch der Gottsdienst mit Kürchen und Schuelen alda angesehen und befürdert würdt.’ Andreas Ryff, Münz und Mineralienbüchlein (1594/1600), Iv. Universitätsbibliothek Basel, MS A lambda II 46a. This manuscript contains an inventory of Ryff’s mineral collection, followed by an encyclopedic description of his coin collection. For a short description of the manuscript and its contents see, Georg Koprio, ‘Das Münzbüchlein des Andreas Ryff (Teil I)’, and ‘Das Münzbüchlein des Andreas Ryff (Teil II)’, Der Anschnitt, 12, no 2 (1960), 9–12; and 12, no 3 (1960), 7–13, respectively.

⁴ The fantastic yields of Potosí reached their peak with 193 metric tons of silver being produced in the years 1591 to 1595. The major south German and Central European mining regions produced their greatest output between 1541 and 1545 with an estimated total of 56 metric tons. See John H. Munro, ‘The Monetary Origins of the ‘Price Revolution’: South German Silver Mining, Merchant-Banking, and Venetian Commerce’, in Dennis O. Flynn, Arthuro Giráldez, and Richard von Glahn (eds.), Global Connections and Monetary History, 1470–1800 (Aldershot: Ashgate, 2003), 1–34, here 4. There exists a vast literature on colonial mining at Potosí. Peter Bakewell’s monograph, Miners of the Red Mountain: Indian labor in Potosí, 1545–1650 (Albuquerque: The University of New Mexico Press, 1984) remains a standard reference.

⁵ Hans Staden, Warhaftig Historia und Beschreibung eyner Landschaft der Wilden, Nacketen, Grimmigen, Menschenfresser Leuthen, in der Neuenwelt America gelegen, vor und nach Christi Geburt im Land zu Hessen unbekant [...] (Frankfurt am Main: Wegsagnt Han, 1557); Hans Staden, Dritte Buch Americae, Darinn Brasilia durch Johann Staden von Homberg aus Hessen/ auf eigener Erfahrung auf Teutsch beschrieben [...] (Frankfurt am Main: Theodor de Bry, 1593).

⁶ ‘Ja es käme algemachs dahien dass wir einander selbs frässen, wie die armseeligenn, Ellenden wilden Presilianer thun, dassellig arm volck soll uns wohl ein Spiegel und wahrnung seyn, Sie haben nit ein einzig Brodtmesser im Landt dann was man ihnen aus Europa über das wilde mehr dahien füehrt.’ Ryff, Münz und Mineralienbüchlein, Ov.
Nevertheless, God has provided them with immeasurable mineral resources, which they cannot use because of their lack of understanding: ‘therefore the peoples of Europe must bring them the necessary [tools and weapons], in exchange for metals and other victuals’.

These examples of sixteenth-century German print and manuscript culture show how mining was regarded with particular ambivalence. Firstly, it was seen as a noble undertaking, rich with promise. It opened vast networks of exchange on a local and global scale and its achievements were perceived as having civilizing effects. Secondly, the desire for abundant riches set imaginations, hopes, and fears in motion, which circulated in Europe through a variety of media and in various material forms. And thirdly, these practices and conceptualizations of mining not only came with promises of wealth and affluence, they also constituted a zone where power relations, social conflict, violence, and exploitation were very much in operation.

This special issue of Renaissance Studies takes up this ambivalence and is dedicated to the cultural values and impacts of early modern mining and metallurgy and some of the enterprises and practices that surrounded them. The contributions enquire into how mining and metallurgy became a key sector in early modern European society, not only in terms of economic prosperity with its utilitarian connotations, but as a sociocultural phenomenon, whose materials and products affected, or even enabled, many areas of life and rulership. The authors’ contributions focus on places, materials, and processes, and assess how historical actors engaged with metallic materials, both under and above the ground. They analyse human engagement with mined materials not simply from an economic perspective, but also as an administrative and legal praxis, a technological challenge, an environmental problem, a spiritual engagement, and an affective experience. These essays range from the subterranean to the sub-oceanic (the latter in Philippa Hellawell’s study of submarine diving for ore-laden sunken ships). Most focus on the early modern period, but one – by Sebastian Felten – shows how more recent cultural and political movements from the eighteenth to twentieth centuries have shaped both archives and collections of artefacts through which historians study the earlier period. These studies, taken as a whole, significantly broaden the subject areas encompassed by early modern European mining and metallurgical practices.

7 ‘Deshalben müessen inen die Völcker auß Europa, gegen abholung irer Metalen unnd anderer Victualien, ir notturfrit bringen [...]’. Ibid, Pr. For global histories of mining, see Jack Goody, Metals, Culture and Capitalism. An Essay on the Origins of the Modern World (Cambridge: Cambridge University Press, 2012); and Dennis O. Flynn and Arturo Giráldez (eds.), Metals and Monies in an Emerging Global Economy. (Aldershot: Ashgate, 1997).

8 Among the broad range of literature on the social history of colonial mining we want to refer to a recent study, which adds a new perspective connecting economic, social and intellectual history of colonial mining: Orlando Bentancor, The Matter of Empire: Metaphysics and Mining in Colonial Peru (Pittsburgh: University of Pittsburgh Press, 2017).
Mining in early modern Europe

HISTORIOGRAPHIC BACKGROUND

The history of mining and metallurgy in general can be said to have been written from two major points of view. The first is from the vantage point of the history of technology and economic history. The second originated from folklore studies [Volkskunde].

The history of mining written from the perspective of technological and economic history has often emphasized innovation, or development, or both. Such approaches have led to a rich repository of scholarship that forms an essential foundation for further investigations. However, they have also created conceptual structures that might be called teleological – directed toward a goal, such as understanding the growth of capitalism or investigating technological ‘progress.’ Such frameworks tend to ignore or minimize the multifarious ways in which mining and metallurgical practices came to be ingrained in the societies in which they were carried out.

In the second major approach, folklore studies have seen how the confluence of heterogeneous groups of people within mining towns gave rise to a particular mining culture that was instrumental in keeping the peace and creating a sense of community. The recent long-term surveys of the mining historians Rainer Slotta and Angelika Westermann pay credit to a long-standing and well-established mining history research tradition, which originated from Volkskunde [folklore studies] on the one hand and the history of economy and technology on the other.

Since the late nineteenth century, these disciplinary fields have published innumerable contributions which have enriched our knowledge of places, actors, techniques, modes of production, and objects of early modern mining. They have brought to light a huge variety of printed and manuscript

9 For a recent handbook on early modern mining in the German territories, which sums up most of this research tradition, see: Christoph Bartels and Rainer Slotta (eds.), Der alteuropäische Bergbau: Von den Anfängen bis zur Mitte des 18. Jahrhunderts, Geschichte des Deutschen Bergbaus, vol. 1., (Münster: Aschendorf, 2012). The following is a selection of the most essential publications on early modern mining: Christoph Bartels and Marcus Denzel (eds.), Konjunkturen im Europäischen Bergbau in vorindustrieller Zeit: Festschrift für Ekkehard Westermann zum 60. Geburtstag (Stuttgart: Steiner, 2000); Angelika Westermann, Die vorderösterreichischen Montanregionen in der Frühen Neuzeit (Stuttgart: Steiner, 2009); and Christoph Bartels, Vom frühneuzeitlichen Montangewerbe zur Bergbauintustrie. Erzbergbau im Oberharz 1635–1866 (Bochum: Dt. Bergbau-Museum, 1992).

10 Rainer Slotta, ‘Der (Silber-)Bergbau als Kunstkatalysator’, in Bartels and Slotta (eds.), Der alteuropäische Bergbau, 591–618; Angelika Westermann, ‘Bergstadt und Montankultur, 1350–1850’, in Wolfhard Weber and Jens Adamski (eds.), Salze, Erze und Kohlen: Der Aufbruch in die Moderne im 18. und frühen 19. Jahrhundert, Geschichte des Deutschen Bergbaus, Vol. 2 (Münster: Aschendorff Verlag, 2015), 409–560.
sources, including archival documents and visual evidence. They have also undertaken the study of material objects. Whereas the history of economy and technology is mostly aligned with the development of progressive technologies and the economic cycles that were to become crucial in the industrial revolution, the Volkskundler analysed the cultural heritage of mining as transmitted in mining songs, legends, prayers, theatre plays, processions, and two- as well as three-dimensional works of art with a focus on tradition and cultural heritage.\footnote{Gerhard Heilfurth, \textit{Bergbau und Bergmann in der deutschsprachigen Sagenüberlieferung Mitteleuropas} (Marburg: Elwert, 1967); idem, \textit{Der Bergbau und seine Kultur: Eine Welt zwischen Dunkel und Licht} (Zürich: Atlantis, 1981); Georg Schreiber, \textit{Der Bergbau in Geschichte, Ethos und Sakralkultur} (Wiesbaden: VS Verlag für Sozialwissenschaften, 1962); and Helmut Wilsdorf, \textit{Kulturgeschichte des Bergbaus: Ein illustrierter Streifzug durch Zeiten und Kontinente} (Essen: Verlag Glückauf, 1987). On the writings of Helmut Wilsdorf see Franz Kirnbauer (ed.), \textit{Helmut Wilsdorf: Montangeschichte und Montanethnographie. Eine Bibliographie zu seinem 65. Geburtstag} (Vienna: Montan-Verlag, 1977). For a nuanced historiographical survey on the significance of mining history within the discipline of Volkskunde in former East and West Germany, see Felten’s article in this volume.}

Slotta and Westermann both relate these research traditions to each other and underline the cross-fertilization of culture, industry, and technological innovation that occurred at these mining sites. They have shown how mining formed a unique microcosmic culture that developed a particular identity based on practices, meanings, and representations of \textit{Arbeit} [labour] and \textit{Technik} [technology].\footnote{‘In diesem Zusammenhang wird dann auch die Frage nach der Bedeutung von Montankultur virulent. So kommt ihr z. B. eine Identität bildende und sie festigende Aufgabe zu. Grund hierfür ist das hohe Maß an arbeitsteiliger, außerhäusiger Tätigkeit, verstärkt durch die aufgrund vorläufigen oder tatsächlichen Abbaustillstandes erforderliche Bereitschaft zur Mobilität. Arbeit und Technik sind, wie es Gerhard Heilfurth formuliert, nicht nur zentrale Elemente der Montankultur, sondern ihr Fundament.’ Westermann, ‘Bergstadt und Montankultur’, 414.} Labour and technology, as they underline, were not only central elements of mining culture but its very foundation. Both authors identify the creation of a collective identity as the main function of this mining culture. In a monumental survey, which incorporates different social groups and geographical areas, Westermann uses the idealist philosopher Ernst Cassirer’s ideas on the essential constituents of culture – language, myth, religion, art, science, and history – to distil the essence of mining culture, relying on a rich body of textual, visual, and material artefacts.

Rather than defining the constitutive elements of mining culture (i.e. manual labour in the mines) and their diffusion into the different social milieus of the actors within these mining sites,\footnote{Westermann, ‘Bergstadt und Montankultur’, 230–8.} we understand culture not only as something incorporated and carried passively, but as something that is actively used and which determines specific repertoires of action. Our analytical approach is inspired by recent studies within an interdisciplinarily-oriented history of knowledge, investigating cultures of learning and vernacular knowledge,
artisanal epistemologies, materials, and techniques.\(^\text{14}\) From this methodological background we direct our attention to the questions of how knowledge about mining and mined material is mobilized, appropriated, deployed, and linked to the perceptions of nature, experiences of labour, practices of risk, as well as material desires.

Extracting ores from the ground and processing them were activities that influenced many aspects of life beyond the economic and technological. These included political power and authority; religious life and popular beliefs; the life of objects and their changing significations; costume and dress; the grim daily work life of miners and of some metal workers, which varied according to their specific tasks; the work of mine supervisors; the practices of rulers and other elite actors, including conspicuous consumption and courtly display; and the culture of knowledge, including the values and practices utilized in the investigation of the natural world.

To carry out the complex tasks of metal production required the tacit knowledge involved in mining and metallurgy. Traditional accounts often pass over silently topics such as the ordinary material practices of early modern actors, the meaning of those practices to the individuals who carried them out, and the ways in which contemporary lives were influenced and changed by them. The changing material and economic practices of mining transformed the ambient culture, and profoundly influenced the lives of miners and their families. Changes in material and economic practices influenced cultural norms and beliefs. Mining communities also changed as new families from other locales moved in. These developments in mining broadened the range of people who were either somehow involved or interested in mining, or in closely connected industries such as mints, smelters, glass foundries, dyeworks, or goldsmithing. Mining and metallurgy influenced local cultures but also those far afield. It had ramifications in the global world.\(^\text{15}\)

The studies published here make important contributions, especially because their interdisciplinarity and interest in looking beyond strictly technological and economic realms allows new arenas of cultural practice to come into view. These new perspectives broaden our understanding of the culture of mining including the culture of knowledge that surrounded it.

\(^\text{14}\) Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004); Harold Cook, Pamela H. Smith, and Amy Meyers (eds.), *Ways of Making and Knowing: The Material Culture of Empirical Knowledge* (Ann Arbor: University of Michigan Press, 2014); Pamela O. Long, *Artisan/Practitioners and the Rise of the New Sciences, 1400–1600* (Corvallis, Or.: Oregon State University Press, 2011); and idem, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore: Johns Hopkins University Press, 2011).

\(^\text{15}\) For the global nature of mining and metallurgy, see Flynn and Giráldez, *Metals and Monies*; and Goody, *Metals, Culture and Capitalism*; and for traveling miners (in this case German miners to English copper mines), Eric H. Ash, *Power, Knowledge, and Expertise in Elizabethan England* (Baltimore: Johns Hopkins University Press, 2004), 19–54.
Agricola’s and Ryff’s praise of mining was published during a time when mining was changing in fundamental ways. New, deep mines were being excavated—a far cry from the shallow mines of the medieval centuries in northern Europe—mostly mined seasonally by agricultural families. Deep mines were more profitable, but also more expensive and far more dangerous to the people who mined them. They brought about new economic forms—the selling of shares and companies of shareholders, and wage-earning miners and ore processors. They required complex operations requiring the use of huge pumping and drainage machines to solve the ever-present problem of water removal; and new ore-processing techniques, including the use of large furnaces and smelters.16

Because of these new practices, starting in the 1470s, silver, copper, and lead mining in the districts of the Tyrolean Alps, the Saxon and Bohemian Erzgebirge, the Harz in central Germany, and the mining regions of ‘lower Hungary’ in the Carpathians experienced a remarkable upswing that lasted until the 1540s. The production rate during these years increased almost five-fold.17 This mine boom was very much motivated by technological developments such as improved drainage technology, better equipped ventilation systems, and advanced lifting machines. Exhausted mines, which miners had abandoned during the twelfth and thirteenth centuries, came back to life thanks to the way new technologies enabled the extraction of deeper-lying ore deposits.18

Next to these technological developments a new financial instrument helped to bring much needed capital into the mining regions. By the end of the fifteenth century, the practice of buying mining shares—which were given the name Kux (or the plural form Kuxen) – had taken a legal form via Saxon mining ordinances aimed at guaranteeing the flow of capital for the costly mining enterprises. One Kux guaranteed a share in the profits from the

16 A still useful summary is John U. Nef, ‘Mining and Metallurgy in Medieval Civilisation’ in The Cambridge Economic History of Europe, Vol. 2: Trade and Industry in the Middle Ages, 2nd edn., M. M. Postan and Edward Miller (eds.), assisted by Cynthia Postan (Cambridge: Cambridge University Press, 1987), 691–761.
17 For quantitative data see: Munro, ‘Monetary Origins’; John U. Nef, ‘Silver Production in Central Europe, 1450–1618’, Journal of Political Economy, 49 (1941), 575–91.
18 For mining in the medieval centuries, see also Christoph Bartels, Lothar Klappau, ‘Das Mittelalter. Der Aufschwung des Bergbaus unter den karolingischen und ottonischen Herrschern, die mittelalterliche Blüte und der Abschwung bis zur Mitte des 14. Jahrhunderts’, in Bartels and Slotta (eds.), Der alteuropäische Bergbau, 111–248.
mining of precious and semi-precious ores, but also provided for Zubusse [subsidies] if necessary. 19

With these paper shares a new type of actor entered the mountainous regions: the Gewerke [mining investor]. Theoretically people from anywhere and of any rank could buy mining shares, but most shareholders were princes, nobles, clergymen, merchants, and wealthy burghers, who generally came from the surrounding areas, but also from the upper German regions such as Nuremberg and Augsburg. 20

Among the most remarkable mining towns that emerged during this period were Schwaz in the Tyrol, St Joachimsthal in Bohemia, Schneeberg, Annaberg and Marienberg in Saxony, and Mansfeld in the southern Harz region. 21 Whereas Schwaz and Mansfeld already existed as small villages before the mining boom, Schneeberg, Annaberg, Marienberg, and St Joachimsthal developed entirely from scratch thanks to the rich ores that were found nearby. The Saxon town of Annaberg for instance first began to develop around the Schreckenberg mountain in 1492. By 1509, its population already numbered 8000 and by 1540 it was the second largest town in Saxony, with 12,000 inhabitants. The discovery of silver ore in the Bohemian Erzgebirge Mountains led to a smattering of houses being built there in 1516. By 1534,

19 Each pit was divided into several Kuxen – normally 128 – which investors could buy. For further details on the etymology of Kux and the practices of Kux trade, see: Tina Asmussen, ‘Kux as a Site of Mediation: Economic Practices and Material Desires in the Early Modern German Mining Industry’, in Susanna Burghartz, Lucas Burkart, and Christine Göttler (eds.), Sites of Mediation – Connected Histories of Places, Processes, and Objects, Europe and Beyond, 1450–1650, Intersections. Interdisciplinary Studies in Early Modern Culture 47 (Leiden: Brill, 2017), 139–82.; See also Adolf Zycha, ‘Das Wort Kux’, Zeitschrift für Bergrecht, 62 (1921), 407–12; Ekkehard Westermann ‘Silberproduktion und -handel: Mittel- und Oberdeutsche Wirtschaftsverflechtungen im 15./16. Jahrhundert’, Neues Archiv für sächsische Geschichte, 68 (1997), 47–65, esp. 57–58; Adolf Laube, Studien über den erzgebirgischen Silberbergbau von 1470 bis 1546: Seine Geschichte, seine Produktionsverhältnisse, seine Bedeutung für die gesellschaftlichen Veränderungen und Klassenkämpfe in Sachsen am Beginn der Übergangswoche vom Feudalismus zum Kapitalismus (Berlin: Akademie Verlag, 1974), 56, 82–110; Ekkehard Westermann, ‘Kux’, in Michael North (ed.), Von Aktie bis Zoll: Ein historisches Lexikon des Geldes (Munich: Beck, 1995), 212; and Judy Mendels, ‘Die Etymologie des Wortes Kux’, Modern Language Notes, 76 (1961), 336–41. 20 Richard Dietrich, Untersuchungen zum Frühkapitalismus im mitteldeutschen Erzbergbau und Metallhandel (Hildesheim: Olms, 1991). Dietrich refuted Theodor Gustav Werner’s thesis that investing in mining shares from the Erzgebirge was a large-scale phenomenon while pointing to the importance of the investment from neighboring places; Theodor Gustav Werner, ‘Das fremde Kapital im Annaberger Bergbau und Metallhandel des 16. Jahrhunderts’, Neues Archiv für sächsische Geschichte, 57 (1936), 113-79; idem, ‘Das fremde Kapital im Annaberger Bergbau und Metallhandel des 16. Jahrhunderts’, Neues Archiv für sächsische Geschichte, 58 (1937), 1–47, 135–201. 21 For further reading on aspects of definition and legal implications existent in mining towns see especially Westermann, ‘Bergstadt und Montankultur’, esp. 411–13; Slotta, ‘Der (Silber-)Bergbau als Kunstkatalsator’, esp. 592–9; Karl Heinrich Kaufhold, ‘Stadt und Bergbau – Einführung’, in idem and Wilfried Reininghaus (eds.), Stadt und Bergbau (Cologne: Böhlau, 2004), VII–XI.
the settlement had grown into the mining town of St Joachimsthal (present day Jáchymov), with a population of 18,200.²²

Compared with the average size of other European towns in the sixteenth century, these numbers are impressive. St Joachimsthal was the second largest town in Bohemia next to Prague. Mining towns became not only important sites of economic growth, but also centres of technological innovation, artistic production, and coveted destinations for mineral collectors and their agents.²³ The artisans of St Joachimsthal for instance were renowned for their work as goldsmiths, with their Handsteine (i.e. carved ore specimens the size of a hand) being treated with particular enthusiasm. Various kinds of rare, precious, and common minerals – as well as the artfully crafted Handsteine – circulated among learned groups and the nobility throughout Europe, as Henrike Haug discusses.²⁴

But not all renowned mining sites developed into such vibrant places of commerce and cultural production. The Spanish mining district Almadén, which was the principal mercury mine in western Europe is a fitting counter example. Mercury became increasingly important after the discovery of the patio process in the mid-sixteenth century. This process used mercury amalgamation to recover silver from ore and it became crucial when refining American silver. Almadén along with Huancavelica in Peru served as one of the most important global suppliers of mercury. Contrary to the careers of the Saxon and Bohemian silver boomtowns, producing mercury was a less enviable business. The village of Almadén was small and poor. The dangerous work in the mines and the refining of the poisonous mercury ores was done by forced labourers such as convicts, slaves, and resettled Moriscos. We therefore have to acknowledge that developments of the individual European mining towns, including the organization of work, technical requirements,

²² For Annaberg see Slotta, ‘(Silber-)Bergbau als Kunstkatalysator’, 592; for St Joachimsthal see Christoph Bartels, ‘Strukturwandel in Montanbetrieben des Mittelalters und der frühen Neuzeit in Abhängigkeit von Lagerstättenstrukturen und Technologie: Der Rammelsberg bei Goslar 1300–1470 – St Joachimsthal im böhmischen Erzgebirge um 1580’, in Hans-Jürgen Gerhard (ed.), Struktur und Dimension: Festschrift für Karl Heinrich Kaufhold zum 65. Geburtstag (Stuttgart: Steiner, 1997), 25–70, here 58. For Schwaz see the recent article by Philipp Robinson Rössner, ‘Vom Silbererz zur Münze. Das Tiroler Montanrevier um 1500 als Fallbeispiel’, in Markus A. Denzel, Andrea Bonoldi, Anne Montenach, and Francoise Vannotti (eds.), Oeconomia Alpium I: Wirtschaftsgeschichte des Alpenraums in vorindustrieller Zeit. Forschungsaufriss, -konzepte und -perspektiven (Berlin: De Gruyter, 2017), 249–75.

²³ Manfred Bachmann, Harald Marx, and Eberhard Wächtler (eds.), Der Silberne Boden: Kunst und Bergbau in Sachsen (Stuttgart: Deutsche Verlags-Anstalt, 1990); Rainer Slotta, Christoph Bartels, and Heinz Pollmann (eds.), Meisterwerke bergbaulicher Kunst vom 13. bis 19. Jahrhundert, Veröffentlichungen aus dem Deutschen Bergbau-Museum Bochum 48 (Bochum: Selbstverlag des Deutschen Bergbau-Museums Bochum, 1990); Heinrich Winkelmann, Der Bergbau in der Kunst (Essen: Glückauf, 1971).

²⁴ See Henrike Haug in this volume; idem., ‘Artificial Interventions in the Natural Form of Things: Shared Metallogenetical Concepts of Goldsmiths and Alchemists’, in Sven Dupré (ed.), Laboratories of Art: Alchemy and Art Technology from Antiquity to the 18th Century (Cham, Switzerland: Springer, 2014), 79–105, esp. 92–3; and idem, ‘Wunderbarliche Gewechse. Bergbau und Goldschmiedekunst im 16. Jahrhundert’, Kritische Berichte, 40 (2012), 49–63.
infrastructure, and the industries closely connected with mining differed considerably depending on the type of ore that was mined at each site.

THE LITERATURE OF MINING

In areas where mining and ore processing were important economically, writings on these topics proliferated – in the form of laws, regulations, and instructions both in manuscript and print, and in the form of printed pamphlets, manuals and treatises, some of the latter the focus of Renée Raphael’s study in this volume.

In the context of mining’s growing economic importance and the increased interest in such activity, a specific type of technical literature on mining, metallurgy, and practical alchemy began to appear around 1500. This literature treated mineral generation, described technologies associated with mining and refining, and provided information regarding tools, skills, and the risks taken by miners. Most of these treatises were written by authors who had a personal connection to the mining regions. They came from diverse social backgrounds; some were university-educated scholars, while others were experienced craftsmen or practitioners. Their texts cover a range of subjects, including prospecting, techniques of mining, descriptions of ores, minerals and metals, assaying and smelting techniques, as well as juridical regulations, customs, and prayers. The readership for these texts was unlikely to have been practicing miners; rather, they would have been mine owners, mining officials, investors, and citizens with a broader interest in contemporary economic developments, or knowledge about a very dynamic field of human ingenuity and technē.25

Traditionally historians of technology have used such writings as sources for actual practices. Raphael shows that to do so involves an oversimplification. She compares three printed accounts of mercury processing with archival sources at Almadén, Spain that describe those processes in detail for purposes of actual supervision in the mine. She shows that the written accounts in printed books were often created by the humanist practice of extracting material from previous books (‘commonplacing’) rather than by recording processes personally carried out or witnessed. Her study underscores that the prospective readership for such writings, included not primarily practitioners, but patrons, dukes and princes, mine investors, and interested people of all kinds not actually engaged in the work itself. Indeed, the proliferation of

25 An excellent overview on this literature is given by Ernst Darmstaedter, Berg-, Probir- und Kunstbüchlein (Munich: Verl. d. Münchner Drucke, 1926); Manfred Koch, Geschichte und Entwicklung des bergmännischen Schrifttums (Goslar: Hübener, 1963); and see Pamela O. Long, ‘The Openness of Knowledge: An Ideal and Its Context in 16th-Century Writings on Mining and Metallurgy’, Technology and Culture 32 (1991): 318–55; and idem, Openness, Secrecy, Authorship, 176–91.
pamphlets and books about mining (many illustrated) attests to the broad significance of such practices in the surrounding culture.26

Although mining and metallurgical writings were not necessarily detailed or accurate enough to guide actual practice, there can be no doubt that they were developed in the context of practice. Learned humanists such as Agricola documented their conversations with overseers and other practitioners. They also utilized an extensive array of texts, both contemporary and from the past. Similarly, practitioner authors such as the mine overseer Vannoccio Biringuccio (c.1480–c.1539) availed themselves of practices of writing, including extracting material from previous texts.27

BERGGESCHREY: MINING CULTURE IN ACTION

To signal the transformative effects of mining, contemporaries coined the term Berggeschrey, meaning ‘mountain clamour’.28 Berggeschrey implies the dynamic and multi-layered socio-cultural developments that took place around these mining centres. The concept communicates all the concomitant legal interventions, social inequalities, environmental transformations, ordering processes, technological innovations, material practices and desires, and transmissions across different media that mining involved; an approach that cuts closer to the grain than a narrowly focused history might do.

The following three differentiated layers of Berggeschrey serve as a heuristic approach to unravel the complex entanglements of mining and metal production, thereby illustrating the ways in which contemporaries raised (or questioned) the function of mining as a cultural and moral system of value production. The term aptly describes a process of economic dynamism, with faster cycles of boom and bust and the accelerated pace at which people, knowledge, materials, and money circulated. Accordingly, the industry that the clamour initiated was highly interconnected and heavily dependent on tenacious workers, capable officials, solvent investors, clever projectors, skilled

26 For the practices of “commonplacing” and common place books, see Ann M. Blair, Too Much to Know: Managing Scholarly Information before the Modern Age (New Haven: Yale University Press, 2010), esp. 62–116; and notes 29 and 30 of Raphael’s essay in this volume.
27 See Long, ‘Openness of Knowledge’, 334–46; and for Agricola’s humanism, Hannaway, ‘Georgius Agricola as a Humanist’. For Biringuccio, see esp. Andrea Bernardoni, La conoscenza del fare: Ingegneria, arte, scienza nel De la pirotechnia di Vannoccio Biringuccio (Rome: ‘L’Erma di Bretschneider, 2011).
28 Heinrich Veith, ‘Geschrei’, in idem, Deutsches Bergwörterbuch (Breslau: Verlag von Wilhelm Gottlob Korn, 1870), 230; Wolfgang Ingenhaeff and Johann Bair (eds.), Bergbau und Berggeschrey: zu den Ursprüngen europäischer Bergwerke, 8. Internationaler Montanhistorischer Kongress Schwaz – Sterzing 2009 (Hall in Tyrol: Berenkamp, 2010).
engineers, not to mention sufficient access to wood, water, and lead resources, as well as a fully functioning transport infrastructure.

The meaning of *Berggeschrey* was not solely confined to the material side of industry and its concomitant dynamic nature. Recognizing the clamour’s noise and spontaneity is crucial in our understanding of the developments that took place in early modern mining. Such hubbub reflects the affective and imaginary forces at work in this early modern silver rush, propelled by material desires, and people’s hopes and fears. The clamour’s vibrancy unleashed wishes for wealth and affluence but also created anxieties and unrest. It was nevertheless the case that despite these dynamic and affective aspects, *Berggeschrey* also had a stabilizing function, thanks to the legal implications of the term *Geschrey*, which can mean *clamor*, *fama*, and *rumor*.

In the medieval and early modern German legal tradition, *Geschrey* was not just a noise, it was a performative legal act. In his seminal work on popular culture and village life in early modern south-west Germany, David Sabean has pointed to the qualitative shift from *Geschwätz* [gossip] to *Geschrey* [clamour]. In contrast to gossip, clamour in this context denotes a public rumour with far reaching political and legal effects. Particularly since mining along with minting were highly significant governmental concerns – due to sovereign mineral and minting privileges (i.e. *Bergregal, Münzregal*) – the spread of *Berggeschrey* was tightly linked to the claims of the local magistracies and bore legal implications. To attract workers and investors from foreign territories, the sovereigns granted a civil *Bergfreiheit* [freedom to mine]. The mining

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29 An equally important factor for this boom was the implementation of the process of *Seigerung* [liquation] at the processing sites above ground. It allowed for the extraction of silver from copper ores by adding lead. Mining regions, which mainly produced copper, suddenly became attractive sites for silver mining too. Lothar Suhling, *Der Seigerhüttenprozess: die Technologie des Kupferseigers nach dem frühen metallurgischen Schrifttum* (Stuttgart: Riederer, 1976). For the economic implications of this process see: Ekkehard Westermann, ‘Silbererzeugung, Silberhandel und Wechselgeschichte im Thüringer Saigerhandel von 1460–1620, Tatsachen und Zusammenhänge, Probleme und Aufgaben der Forschung’, *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte*, 70 (1983), 192-214 and idem, ‘Der Mansfelder Kupferschieferbergbau und Thüringer Saigerhandel im Rahmen der mitteldeutschen Montanwirtschaft 1450–1620’, in Werner Kroeker and Ekkehard Westermann (eds.), *Montanwirtschaft Mitteleuropas vom 12. bis 17. Jahrhundert. Stand, Wege und Aufgaben der Forschung* (Bochum: Vereinigung der Freunde von Kunst und Kultur im Bergbau, 1984), 144–7.

30 Ekkehard Westermann (ed.), *Bergbautorfe als Verbraucherzentren im vorindustriellen Europa*, Vierteljahrschrift für Sozial-und Wirtschaftsgeschichte. Beihefte 130 (Stuttgart: Steiner 1997); Angelika Westermann, ‘Zentralität und Funktionalität: Überlegungen zur Bedeutung der Bergbautorfe in den Montanregionen Vorderösterreichs in der Frühen Neuzeit’, in Kaufhold, Reininghaus (eds.), *Stadt und Bergbau*, 73–92.

31 Lemma ‘Geschrei’, in Jacob Grimm and Wilhelm Grimm, *Wörterbuch der Deutschen Sprache*, Vol. 5 (Leipzig: Hirzel 1897), cols. 3963–9; Luis Leonor Hammerich, *Clamor: Eine rechtsgeschichtliche Studie* (Copenhagen: Munksgaard, 1941).

32 ‘As soon as the information circulating in the village rose above common gossip and became ‘rumor’, it was a matter for action [...]’ and its handling obliged the local authorities. David Sabean, *Power in the Blood. Popular Culture and Village Discourse* (Cambridge: Cambridge University Press, 1984), 148ff; For further reading on the interconnections between *Berggeschrey* and mining law see Julia Schreiter, ‘Der Zusammenhang von “Berggeschrey” und Bergrecht im Erzgebirge’, in Ingenhaeff, Bair (eds.), *Bergbau und Berggeschrey*, 241–50; Wilhelm Brauneder, ‘Berggeschrey als Rechtspublizität’, in Ingenhaeff, Bair (eds.), *Bergbau und Berggeschrey*, 59–65.
ordinances for each district declared what the *Bergfreiheit* should mean locally. Generally it meant no fees for travelling on the roads, exemption from duties, free use of wood, the right to fish and hunt, the right to bear arms, and immunity from taxes.  

These privileges theoretically allowed anyone to begin mining, but whoever pursued this activity had to officially register their ore finds and had to follow an officially defined procedure. Such procedures must indeed have been very effective. Over a very short time period, where silver was being discovered in substantial quantities, populations around the mining centres of central Europe began to grow rapidly. As we have seen, settlements of less than one hundred residents transformed into mining towns with populations of many thousands. Official privileges were granted to the new communities. The settlement of a totally new group of people in these rural environments sent existing social structures into a whirl and confronted the sovereigns and town magistrates with considerable challenges when it came to politics, legislation, economy, healthcare, and supply.  

For the miners who climbed or were lowered down into the deep shafts to excavate silver, copper, or iron ores, or to those who processed such dangerous substances as mercury, the new mining practices brought new dangers, new risks, new forms of terror, if also new possibilities for making a living and even the hope of fabulous riches. The mobility generated by the central European mining boom meant that miners moving from one place to another brought their practical and tacit knowledge with them. Objects of mining also travelled, including lamps, tools, precious hand-made objects, and *Handsteine*. Mining lured a large influx of people especially to the Erzgebirge and Harz Mountains and to the Tyrol. Formerly rural areas were transformed into bustling mining towns inhabited by recently-arrived individuals possessing a great diversity of skills and backgrounds. The newcomers who arrived in the burgeoning mining towns faced great uncertainty. Rich veins were difficult to find and difficult and perilous to extract. Competition was fierce.  

The demographic, economic, and environmental developments initiated by the mining industry transformed, if not to say ‘wasted’ nature in particularly visible ways. Such changes in the environment triggered

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33 Hermann Löscher, *Das Erzgebirgische Bergrecht des 15. und 16. Jahrhunderts*, Freiberger Forschungshefte. Reihe D, Kultur und Technik 24 (Berlin: Akademie, 1957); and for the Harz region see Ekkehard Henschke: *Landesherrschaft und Bergbauwirtschaft: zur Wirtschafts- und Verwaltungsgeschichte des Oberharzer Bergbaugebietes im 16. und 17. Jahrhundert* (Berlin: Dunker and Humblot, 1974).

34 Susan C. Karant-Nunn: ‘Between Two Worlds: The Social Position of the Silver Miners of the Erzgebirge, c. 1460–1575’, *Social History*, 14 (1989), 307–22.
reflection by contemporaries on the consequences of their actions from early on.\textsuperscript{35}

The new mining culture had profound symbolic and emotional implications for the individuals who were involved. As one of us (Asmussen) shows in her article, the Wild Man (like all good symbols) was highly malleable and able to be put to multiple and even contradictory uses. On the silver coins of Duke Heinrich the Younger of Braunschweig-Wolfenbüttel, they remained wild, suggestive of the Duke’s conquest of a subterranean wilderness and the acquisition of new wealth thereby. On Heinrich’s son Julius’s coins, the Wild Man has been tamed, subterranean dangers have been expunged, he is the bearer of light.

Yet the Wild Man lived not only on coins but in the mines themselves, protecting the silver ore by causing death and destruction in the dark shafts. Just as deep mining broke the boundaries of solid earth and the underworld, so the Wild Man was a liminal character. A bringer of light, but also representative of destructive power. The mines sheltered other spirits as well, some malevolent and demonic, others benevolent. The changing perceptions of mythical figures reflected the emotions, desires, hopes, and fears of historical persons. They reflected the circumstance that mines represented sources of great wealth, but also delivered terror, injury, and death. For miners themselves, Wild Men and subterranean spirits were real beings lurking in the dark tunnels and crevices. Yet they were also images on coins, and they were changing symbols, the latter extending back into the medieval centuries and, in Early Modern times, across the ocean to the New World.\textsuperscript{36}

\textbf{THE CULTURES OF MINING AND THE CULTURES OF KNOWLEDGE}

Our investigation of the complex semantics of \textit{Berggeschrey} extrapolates mining as a profitable, dynamic, but also highly contingent industry that magistrates tried to restrain by implementing certain structures and regulations. Rich ore finds led to the spontaneous settlement of areas and the emergence of infrastructure, towns, and connected industries. At the same time, when

\textsuperscript{35} The environmental history of early modern mining has received more attention in recent years. Among the vast field of literature, the following contributions are of particular importance for our study: Frank Uekoetter (ed.), \textit{Mining in Central Europe: Perspectives from Environmental History}, Rachel Carson Center Perspectives 10 (2012), online www.environmentandsociety.org/sites/default/files/rcc_layout_issue10_2013_smaller_2.pdf (accessed, December 2018); Peter Anreiter, Gert Goldenberg, Klaus Hanke and Rüdiger Krause (eds.), \textit{Mining in European History and its Impact on Environment and Human Societies} (Innsbruck: Innsbruck University Press, 2010); Daviken Studnicki-Gizbert and David Schecter, ‘The Environmental Dynamics of a Colonial Fuel-Rush: Silver Mining and Deforestation in New Spain, 1522 to 1810’, \textit{Environmental History}, 15 (2010), 94–119; John F. Richards, \textit{The Unending Frontier: An Environmental History of the Early Modern World} (Berkeley: University of California Press, 2003), Ch. 10, Ranching, Mining, and Settlement Frontiers in Colonial Mining, 334–76.

\textsuperscript{36} For medieval wild men, see note 2 of Asmussen’s article in this volume. For Wild Men in the New World, see esp. Surekha Davies, \textit{Renaissance Ethnography and the Invention of the Human: New Worlds, Maps and Monsters} (Cambridge: Cambridge University Press, 2016), esp. 41–2 and 48–182.
metal production declined, population decline followed, as did impoverishment. The sovereigns and their officials aimed to provide for such contingencies and promoted structured processes and workflows, legal protections, and incentives for investors. Due to mining’s essentially unstable nature, these structures always stood on shaky ground. The marked ambivalence between stability and instability, rise and decline, hope and despair shaped the repertoire of action pursued by those people involved in mining, in a practical as well as a discursive sense. Our investigations of the negotiations and exchanges that took place in these mining zones reveal that they were not at all founded on a thoroughly planned, well-ordered, smoothly running system. It was rather a collective endeavour with its foundations in thin, risky, and dangerous interactions, which offered significant space for the articulation of different kinds of interests (i.e. individual, collective, juridical) and claims, daring projects, and wishful thinking.

The dynamic and contingent nature of Berggeschrey with its economic, legal, performative, technological, and emotional implications shifts our attention to the questions of how culture is mobilized, appropriated, deployed, and linked to the perceptions of nature, experiences of labour, practices of risk, as well as material desires. Following this line of enquiry, we want to explore a cultural history of mining that does not assume – or construct – a distinct and total mining culture but rather traces the ways people associate (or dissociate) themselves around certain objects and materials through practices. This approach affords a broader perspective which expands the history of mining beyond the narrow sense of a history of material extraction, one that crosses the borders of the European mining regions and takes activities in urban hubs and on the sea into consideration as well. The entire early modern world was connected through mining and seafaring, in no small part due to the tons of mineral resources (gold, silver, copper, mercury) that were transported by galleons to the markets of Europe and Asia.

We thus juxtapose the subterranean and the submarine sites of extraction as sites of connectivity and mutual influence regarding shared commercial practices or interests. Beyond these economic and logistic considerations, the

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37 Using the example of Saxony, Helmut Bräuer has shown that in silver mining, the social divergences between investors and wage labourers were particularly apparent, see Helmut Bräuer, ‘Armut in den Bergstädten des sächsischen Erzgebirges während der Frühen Neuzeit’, in Kaufhold and Reininghaus, Stadt und Bergbau, 199–238.

38 Andre Wakefield identified the well-ordered mine as the ‘paper-mine of cameralist reveries’. Andre Wakefield, Disordered Police State: German cameralism as science and practice (Chicago: University of Chicago Press, 2009), 30; 46–7

39 Dennis O. Flynn and Arturo Giráldez, ‘Born with a ‘Silver Spoon’: The Origin of World Trade in 1571,’ Journal of World History, 6 (1995), 201–21; Dennis O. Flynn and Arturo Giráldez, ‘Cycles of Silver: Global Economic Unity through the Mid-Eighteenth Century,’ Journal of World History, 13 (2002), 391–427; and Dennis O. Flynn and Arturo Giráldez, ‘Born Again: Globalization’s Sixteenth-Century Origins (Asian/GLOBAL vs. European Dynamics), Pacific Economic Review, 13 (2008), 359–87. And see Goody, Materials, Culture, and Capitalism.
hidden treasures in submarine and the subterranean realms share a concept of natural ‘riches’ that moves beyond economic and utilitarian connotations of productivity, and includes religious, political, learned, and symbolic dimensions. A careful analysis of the complex nature of the mined materials is crucial, as they differ fundamentally from a contemporary idea of non-renewable resources. Just as shells and fishes were perceived to be fruits of the sea, metals were regarded as fruits of the earth, which grew underground in a way similar to plants and were subject to divine providence. The perception of metals as living organisms is a view shared among early natural philosophers, alchemists, and practicing miners. Warren Dym and John Norris recently have discussed the ways in which natural philosophers and alchemists from the sixteenth to the eighteenth centuries adopted an organic conception of minerals, according to which veins of minerals grew like branches, underwent a natural life cycle of generation and decay, and even regenerated years after depletion.40 Metals were thus considered as animated, changeable, and inexhaustible. Mining like agriculture was understood as a kind of cultivation of natural resources. This concept of mineral resources affected the understanding of economic productivity and growth. It also shaped the practices of how these resources were analysed, processed, commodified, displayed, or circulated.

As Haug shows in her essay, both Handsteine and valuable worked metals could function as religious objects and could serve as the focus of theological discussions. They displayed religious themes and were among the luxury items that were discussed in sermons, such as those by the protestant preacher Johannes Mathesius (1504–1565). Mathesius associated gold and other precious metals to metallogenesis – the theory that metals in the earth were God’s work, and that they originated from prime matter undergoing transmutation.41 An analogy to the transmutation of matter was the suffering and salvation of Christ. Yet precious metals used to decorate churches was, in Mathesius’s view, idolatrous. Similarly, he and others condemned the display of such metals by clerics (a protestant reaction to Roman practices).42

40 Alexander Warren Dym, ‘Alchemy and Mining: Metallogenesis and Prospecting in Early Modern Mining Books’, Ambix, 55 (2008), 232–54; and John Norris, ‘Early Theories of Aqueous Mineral Genesis in the Sixteenth Century’, Ambix, 54 (2007), 69–86. See also, Horst Bredekamp, ‘Die Erde als Lebewesen’, Kritische Berichte 9 (1981), 5–37; and Christoph Bartels, ‘Montani und Silvani im Harz. Mittelalterlicher und frühneuzeitlicher Bergbau und seine Einflüsse auf die Umwelt’, in Albrecht Jockenhövel (ed.), Bergbau, Verhüttung und Waldnutzung (Stuttgart: Steiner, 1996), 112–27.

41 See also Pamela H. Smith, ‘The Matter of Ideas in the Working of Metals in Early Modern Europe’, in Christy Anderson, Anne Dunlop, and Pamela H. Smith (eds.), The Matter of Art: Materials, Practices, Cultural Logics, c. 1250–1750 (Manchester: Manchester University Press, 2014), 42–67, for the implications of the notion of metals growing in the earth and the bodily practices of mining and working them.

42 On piety and religious practices of miners in the Erzgebirge see: Bridget Heal, ‘Seeing Christ: Visual Piety in Saxony’s Erzgebirge’, in Jeffrey Chippas Smith (ed.), Visual Acuity and the Arts of Communication in Early Modern Germany (Aldershot: Ashgate, 2014), 43–59; idem. A Magnificent Faith: Art and Identity in Lutheran Germany (Oxford: Oxford University Press, 2017).
Cultures of mining, metal processing, and indeed underwater treasure hunting, shared in creating knowledge about the natural world. If subterranean mineral and ore deposits were sites of divine creation, English explorers for sunken treasure using diving machines also encountered divine mysteries. The deep sea was associated with biblical notions of the abyss and with the Mosaic Flood, with the mysteries of God. Hellawell notes the close connections between English natural history and physico-theology that informed such underwater explorations.

Concerning the latter, Hellawell considers Robert Boyle’s collection of information from divers – especially information concerning the physical effects of diving. Robert Hooke designed underwater machines that aimed to mitigate those effects. Technological experiments and natural investigations were closely interrelated. Knowledge of the plants and animals at the bottom of the sea (and their possible utilitarian value) went hand in hand with the invention of diving machines. Numerous ‘projectors,’ including both gentlemen and the practically skilled, sought patents for diving machines and diving expeditions for specific wrecks. There was a permeable boundary between merchants and gentlemen that contravenes the idea of the ‘disinterested’ gentleman as natural philosopher. Edmund Halley’s experiments with diving machines also display the combination of commercial, technological and epistemic aims.

Pamela H. Smith argues for an embedded understanding of the practices of mining, metalworking, and mineral collecting within a widespread culture of making, which was deeply concerned with questions of metallic generation and material transformation. Her studies show that knowledge does not arise in a disembodied world of ideas, but rather its producers and also the production processes are situated within very concrete social, spatial, material, religious, political, and economic contexts. Analysing the early modern practices of making, artisanal know-how, textual learning, and thinking as connected forms of empirical knowledge blurs the traditional dichotomy of theoretical and practical knowledge. Our investigations of the careers of some of the most well-known actors connected with early modern mining – such as the physician Georgius Agricola, the Catholic priest Alvaro Alonso Barba (1569–1662), and the Lutheran pastor Johannes Mathesius, or the practitioners Vannoccio Biringuccio, Lazarus Ercker (c.1530–1594), Georg Engelhard von Löhneysen (1552–1622), and the mining official Abraham von Schönberg (1640–1711) do not show the emergence of early forms of modern disciplines such as chemistry, mineralogy, geology, or engineering. Rather they bring to light bricolagic characters and the fluid occupations of these

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43 Smith, ‘The Matter of Ideas in the Working of Metals’; idem, ‘The Codification of Vernacular Theories of Metallic Generation in Sixteenth-Century European Mining and Metalworking’, in Matteo Valeriani (ed.), The Structures of Practical Knowledge (Cham, Switzerland: Springer, 2017), 371–92; See also Warren A. Dym, Divining Science. Treasure Hunting and Earth Science in Early Modern Germany (Leiden: Brill, 2011).
early modern actors. Success at the mines in the early modern period required not only mineral expertise or technological skills, but also a profound knowledge regarding the social and cultural codes of the working environments specific to the mines, how to apply this knowledge, and how to translate it into different medial and material forms. We thus locate culture less in the emergence of shared values or in the shared use of cultural symbols but in a plurality of repertoires of actions that were actively exchanged, negotiated, shaped, and re-shaped.

This interest in practices of connectivity and mutual exchanges is particularly inspired by the concept of the trading zone. It responds to the problem of a coordinated exchange across social divides and differing worldviews. Peter Galison coined the concept of the trading zone as a ‘social, material and intellectual mortar binding together the disunified traditions of experimenting, theorizing and instrument building’ regarding twentieth-century quantum physics.44 Galison’s ideas on the exchange processes were influenced by the work of the anthropologist Michael T. Taussig and his investigations into the exchanges between the peasants and the landowning classes in the Cauco Valley of Colombia while ascribing different meanings to the means of exchange (i.e. money).45 Applying the practices of economic exchanges in the Cauco Valley to the epistemic arena of quantum physics proved to be a fruitful endeavour when aiming to demonstrate how scientists and technicians from various disciplines can form communities around certain objects and practices that function as trading zones, enabling a productive collaboration without compromising their professional, epistemic outlooks.46

One of us (Long) has adapted and modified this same concept of the trading zone in order to investigate specific arenas in the early modern world in which groups whose activities had been conducted to a large degree separately (such as artisan/practitioners and learned university-trained persons) increasingly engaged in communication and exchange. Mining was very much one of those arenas. Long suggested areas of mining and metal production as vibrant places of exchange where disparate cultures, practices, and

44 Peter Galison, ‘Trading Zone: Coordinating Action and Belief’, in idem, Image and Logic: A Material Culture of Microphysics (Chicago: University of Chicago Press, 1997), 781–844, here 803.
45 Michael T. Taussig, The Devil and Commodity Fetishism in South America (Chapel Hill: University of North Carolina Press, 1980), 126–42 [Ch. 7].
46 ‘Trade focuses on coordinated, local actions, enabled by the thinness of interpretation rather than the thickness of consensus. Thin description is precisely what makes it possible for the experimentalist and the theorist to communicate, albeit in a register that by no means captures the full world of either, let alone both. Thinness is what makes it possible for the surface chemist to work with the atomic physicist, the virologist with the electric engineer, the computer scientist with the molecular geneticist. […] What they need is consensus in a restricted zone, a zone where coordination is good enough.’ Peter Galison, ‘Trading with the Enemy’, in Michael E. Gorman (ed.), Trading Zones and International Expertise: Creating New Kinds of Collaboration (Cambridge: The MIT Press 2010), 25–52, here 36–7.
knowledge assembled and where ideas and knowledge, as well as practices and skills where mutually translated, adapted, and made appropriate to the specific local environments.\textsuperscript{47}

Illustrated treatises and other writings, courtly festivals, collecting, the carving of pieces of ore, the appropriation and re-use of mythical figures such as Wild-Men, and preaching, all point to the broad cultural significance of mining. Princes, merchants, overseers, physicians, investors, and even preachers, did not actually do the work of mining, but they wanted substantive information on mining and metallurgical practices for a variety of reasons. By writing treatises, practitioners themselves could raise their own status and prospects. The cultures of knowledge, of rulership, and of practice were deeply intertwined.

Germane to these complex interrelationships, recent scholarship in the history of science and technology has investigated the many interconnections and overlapping spheres of practice among technology and technical practices, knowledge, and historical cultures. To name just a few: Lissa Roberts, Simon Schaffer and Peter Dear in \textit{The Mindful Hand} show the artificiality of presupposing a dichotomy between science and technology or theory and practice; Pamela H. Smith in \textit{The Body of the Artisan} and elsewhere has extensively investigated the embodied knowledge of the artisan; while Marcus Popplow has proposed heuristic models of understanding ‘technology-related knowledge’ that appreciate and encompass the complexities of early modern developments.\textsuperscript{48}

The pervasive presence of mining and ore processing in certain areas led to trading zones, in which practitioners communicated substantively with (usually more learned but unskilled) individuals. Another development, which occurred increasingly in the seventeenth and eighteenth centuries, was the emergence of individuals who possessed both practical skill and learning. Such individuals appeared in many areas of endeavour, including mining and metallurgy. In France, Paola Bertucci has investigated such men who called themselves ‘artistes’. For Germany, Ursula Klein has investigated learned practitioners whom she calls ‘hybrid experts’.\textsuperscript{49} Although these studies encompass far-ranging areas of technology and practice, they include mining, ore processing, and metal working among them.

\textsuperscript{47} Pamela O. Long: ‘Trading Zones. Arenas of Exchange during the Late Medieval/Early Modern Transition to the New Empirical Sciences’, \textit{History of Technology}, 31 (2012), 5–25; idem. ‘Trading Zones in Early Modern Europe’, \textit{Isis}, 106 (2015), 840–7.

\textsuperscript{48} Lissa Roberts, Simon Schaffer, and Peter Dear (eds.), \textit{The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation} (Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2007); Smith, \textit{The Body of the Artisan}; Marcus Popplow, ‘Formalization and Interaction: Toward a Comprehensive History of Technology-Related Knowledge in Early Modern Europe’, \textit{Isis}, 106 (2015), 848–56. See also Long, \textit{Artisan/Practitioners}.

\textsuperscript{49} Paola Bertucci, \textit{Artisanal Enlightenment: Science and the Mechanical Arts in Old Regime France} (New Haven: Yale University Press, 2017); and Ursula Klein, ‘Hybrid Experts’, in Valleriani (ed.), \textit{The Structures of Practical Knowledge}, 287–306.
The culture of mining and metallurgy in early modern Europe led to changing values that influenced cultures of investigation and the methodologies that grounded the new sciences of the sixteenth and seventeenth centuries. It helped to bring a new positive valuation of hands-on practice and of individual experience vis-à-vis geology and topography in particular locales. It led to an appreciation of the skills of extraction and ore processing. It brought great admiration for those who could craft beautiful hand-made objects from gold and silver and precious stones. The intense economic, political, and cultural valuation of the skills and practices of mining and metallurgy without doubt contributed to a developing culture of natural inquiry which featured hands-on skill and practice, individual experience, and experiment.

Such broad influence resulted from the ubiquitous presence of mining and metal processing activities and their influence on multiple aspects of life and rulership, as the studies in this volume show. The extensive and complex culture of mining led to wealth and technological innovation but also to pious practices, the authority of rulers, and to the culture of knowledge. Taken together, the merit of these studies is that they address aspects of the complex matrix of economic, political, social, cultural, and epistemological circumstances that emerged from particular mining cultures in early modern Europe. They point to historiographical methodologies that do not ignore technological and economic issues but place them into broader and more complex cultural and epistemological contexts.

The articles within this volume are inspired by this approach. They are particularly interested in how and where different actors (e.g. princes, artisans, humanists, mining officials) associated themselves with mining, and how mining became a distinct system of cultural expression. They investigate who promoted mining and how—whether by printed books and pamphlets, by manuscript writings, by images, by preaching, or by creating luxurious objects. They discuss how the heterogeneous groups in and beyond these mining regions acquired, applied, or displayed mineral or technological knowledge and where such knowledge was exchanged. Only by examining the activities and agencies of practitioners and theorists as interrelated spheres is it possible to understand the ways in which seemingly divergent cultures informed, enriched, and modified each other.50

50 On the blurred boundaries between cultures of ‘hand’ and ‘mind’ see, Lissa Roberts, Simon Shaffer, ‘Preface’, in Roberts, Shaffer and Dear (eds.), The Mindful Hand, XIII–XXVII; Bruce T. Moran, ‘Eloquence in the Marketplace: Erudition and Pragmatic Humanism in the Restoration of Chymia’, Osiris, 29 (2014), 49–62; Popplow, ‘Formalization and Interaction’; Smith, ‘The Matter of Ideas in the Working of Metals’; Pamela O. Long, ‘Multi-tasking “Pre-professional” Architect/Engineers and Other Bricolagic Practitioners as Key Figures in the Elision of Boundaries Between Practice and Learning in Sixteenth-Century Europe: Some Roman Examples’, in Valleriani, The Structures of Practical Knowledge, 223–46.
This volume opens with a contribution from Tina Asmussen on the myth of the Wild Man and the figure's symbolic and emotional significance for the Harz mining industry. From about the sixteenth century onward, the Wild Man became a point of identity in the montane region of the Harz Mountains: mining pits and towns were named after him, he was a prominent character in local festival culture, he was a bearer of the coat of arms for the Welf dynasty – notably for the Dukes of Braunschweig-Wolfenbüttel, and his image came to adorn the reverse of silver coins (named thaler) after the 1530s. By analysing the appropriation and meanings of the Wild Man and his connection to mining in different media, this article stresses the importance of investigating not only material and empirical evidence, but also considering the imaginary and affective implications of mining, such as the promises and expectations of finding metal ores, the materialization of desires, as well as the productivity of hope and fear. The Wild Man, as Asmussen shows, was perceived as benevolent and evil at one and the same time. He was an image of desire, because as a demon he shares nature's secrets and is in possession of arcane and useful knowledge, but he was also an image of ferocity, terror, and punishment. This malleable character made the Wild Man an ideal personification of the uncertain, dangerous, but at the same time promising mining industry. The Wild Man was by no means a secondary or curious product of the Harz mining industry. It is far more the case that he becomes the personification of a complex mining culture, in which economic and technological innovations were intertwined with human life and practices, human emotions, and political and economic power.

Henrike Haug's contribution expands on these political and economic perspectives by pointing to the religious connotations of mineral resources, which she investigates in relation to the Saxon theologian and mineral collector Johannes Mathesius. Surveying the mining activities, artificial practices, and literary production that took place in the Bohemian mining town of St. Joachimsthal, Haug unravels the entangled perceptions of natural resources and mining practices, with respect to ideas of theology, piety, and artifice. The Handsteine serve as a starting point for Haug's investigation of the polyvalent and multivocal semantics of gold and silver. While analysing both material artefacts and literary sources, she points to the ambivalence of raw material and the valuation of the human production of artifacts, which shares parallels with the divine act of creation. At the same time, the sinful connotations of worldly luxury and idolatry must be ever kept in mind. Articulating learned ideas about nature and its resources in a religious framework was, however, not solely the preserve of the mining tradition. Situating the inaccessible and hidden places of the earth in a biblical and symbolic framework connects the subterranean with the submarine realm as well.
Philippa Hellawell’s article takes up these connections and explores how biblical ideas and discourses about the submarine world informed underwater explorations. Using the example of submarine exploration in seventeenth-century England, she problematizes underwater technologies such as diving engines and interprets these inventions as attempts to extend the limits of human experience. Experiments with diving engines blurred the boundaries between commercial and epistemic interests; they were imbued with the promise of gaining new submarine knowledge and the hope of retrieving precious materials from sunken ships at the bottom of the sea. For Hellawell the submarine represented a ‘trading zone’ in which a diverse group of people entertained hopes of gaining vast riches. They both collaborated and competed to find hidden treasure beneath the ocean in the form of sunken ships.

The following article by Renée Raphael takes up a source critical approach to the historical investigation of mining cultures. Raphael analyses accounts of the refining of mercury, in texts from Vannoccio Biringuccio, Georgius Agricola, and Alvaro Alonso Barba, as well as in archival documents related to mercury production at Almadén. Juxtaposing these two genres of source material, she identifies a lack of correspondence between such printed accounts and local practices. Her findings indicate the continuing importance of archival and documentary forms of scholarship in the production of period technical knowledge and the dangers of using such learned treatises as indicators of actual practice.

The final article by Sebastian Felten concludes this special issue with a historiographical analysis of the value and use of mining as a distinct system of cultural expression. Felten’s article encourages cultural historians to shift their attention from the ‘origins’ of early modern mining culture in manual labour to seemingly derivative contexts such as the court, bureaucracy, and heritage collections. The article identifies at least five layers of constitutive and interpretative work: the current, ‘normalized’ scholarship in a reunited Germany; the construction of liberal or socialist traditions in the East and the West after World War II; the resurrection of both a mining State and mining Volk during the Nazi era; the system-building of ethnographers and heritage associations since the early 1800s; and attempts by the mining industry during the seventeenth, eighteenth, and nineteenth centuries to homogenize workers’ dress, rituals, and language for juridical, management, and economic planning purposes. Each layer produced its own archives, on which any investigation of early modern mining culture depends as an empirical base. All of them offered their own attempts to construct a system of cultural expression from the particular stories, archival documents, songs, and dress elements that they collected and arranged. Because Felten examines the origins of archives and collections that early modern historians use to construct their own histories, his study is fundamentally relevant to early modern as well as modern historiography.
These articles taken together explore the cultural history of mining and the search for precious metals, and reveal the ramified, unruly, and resilient world of metal extraction and refining. The authors trace the dynamic relationships between religion, science, and commerce within the complex negotiations that existed among a heterogeneous group of actors, their practices, and the desires that grew up around specific materials. The articles point to new directions in the history of mining and metallurgy that see the culture, society, religion, and politics surrounding mines and mining, and even material culture, not as trivial or derivative but intrinsic to the topic. As a whole, the volume suggests a methodology that richly expands the topic at hand from economic and technological history, and from Volkskunde history, to a range of subjects that embrace as well as expand the purview of these approaches, and underscore the rich diversity of practices and cultures inherent in early modern mining.

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