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Under the Surface: Recent Histories of the Earth and the History of Science

This is the final peer-reviewed author's accepted manuscript (postprint) of the following publication:

*Published Version:*

azzolini, m. (2023). Under the Surface: Recent Histories of the Earth and the History of Science. NUNCIUS, 38(2), 445-463 [10.1163/18253911-03802005].

*Availability:*

This version is available at: <https://hdl.handle.net/11585/956089> since: 2024-03-02

*Published:*

DOI: <http://doi.org/10.1163/18253911-03802005>

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## ***Under the Surface: Recent Histories of the Earth and the History of Science***

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Rienk Vermij, *Thinking on Earthquakes in Early Modern Europe: Firm Beliefs on Shaky Ground*.

London and New York: Routledge, 2021, 266pp., 39.96 \$, ISBN: 9780367492182.

*Strata: William Smith's Geological Maps*, edited by the Oxford Museum of Natural History, with an introduction by Douglas Palmer and with a Foreword by Robert Macfarlane, with 811 illustrations, London: Thames and Hudson, 2020, 256pp., 500 color plates, 65 \$, ISBN: 9780500252475.

### **1. Looking Under**

The opening page of Ulisse Aldrovandi's *Musaeum Metallicum* (1648) asserts that “no part of philosophy about natural particulars and related to the sensible world is more arduous than that which includes *res metallicas*,” adding that, “owing to the confused generation of these, this history is plagued with no small difficulty in distinguishing the *fossilia* from one another.”<sup>1</sup> In Aldrovandi's time, the word *fossilia* generally denoted anything that could be found under the earth's surface: gems, stones, minerals, or fossils in present-day usage.<sup>2</sup> Exploration of what lay beneath the surface of the earth was indeed arduous: observation was difficult and classical sources were lacking in detail when it came to the origin and formation of these natural specimens as well as their differences.

Pliny's *Natural History* soon became the main point of reference for lapidaries and other works related to gems and stones. But Pliny's work was hardly systematic and did not deal with causality. The final pages of Aristotle's Book III of the *Meteorology* and the bulk of Book IV famously departed from meteorology proper to explain the formation of metals and minerals as the result of the action of Aristotle's dual exhalations underneath the surface of the earth but offered only a summary treatment of the formation of ‘homoeomerous’ (i.e. homogeneous) substances out of the four elements, which included minerals and stones. There was no attempt, moreover, to classify *fossilia* according to

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<sup>1</sup> Ulisse Aldrovandi, *Musaeum Metallicum in Libros 4 distributum*, Bartholomaeus Ambrosinus...labore et studio composuit cum indice copiosissimus (Bononiae: Marcus Antonius Bernia, 1648), 1.

<sup>2</sup> Aristotle's *Meteorologica*, trans. H.D.P. Lee (Cambridge Mass. and London, Harvard University Press, 1952), III, iv, 378a12-378b5.

their genus and characteristics.<sup>3</sup> Aristotle's exploration of minerals, stones, and fossils, thus, was not sufficiently robust to provide an exhaustive and authoritative source on the theory of mineral and stone formation, let alone fossils.

Book II of the *Meteorology* treated other aspects related to the Earth such as earthquakes, which the Stagirite explained as the result of the interaction of the dual exhalations much like all other celestial meteorological phenomena. As noted, for Aristotle stones and minerals – like earthquakes – were fashioned by exhalations. If rain and hail were considered *meteorae aqueae*, metals and stones were *meteorae terreae*. In particular, metals were the product of the watery exhalation, which, once compressed into the bowels of the Earth, congealed into metals. This explained why metals could change from solid to liquid when heat is applied.<sup>4</sup> However, Book IV and its more practical approach left many readers unsure about its place and function in the overall Aristotelian corpus.<sup>5</sup> As scholars have noted, while different aspects of what we would now call 'geology' appeared in the same Aristotelian treatise, Books III and IV diverged enough in the causal approach to phenomena to cast doubt on the place of the last book within the overarching plan of Aristotle's meteorology.<sup>6</sup> Parallel to the learned tradition of Aristotle's commentaries, moreover, another developed that integrated Aristotle's *Meteorology* IV into alchemy, concentrating on theories of generation and the transmutation of metals.<sup>7</sup>

In the Middle Ages, Avicenna's *De mineralibus* sometimes circulated as an appendix to *Meteorology* IV and was initially attributed to Aristotle. The merit of this text was to add a basic division of the Earth's material into four different species: stones, fusible substances, sulfur, and salt. It denied, however, that transmutation was possible.

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<sup>3</sup> Ibid., IV, viii-xii; On debates about this text's authenticity, and the state of play regarding this issue, see the analysis in Craig Martin, *Interpretation and Utility: The Renaissance Commentary Tradition on Aristotle's "Meteorologica IV"* (PhD Diss., Harvard University, 2002), 103-108.

<sup>4</sup> *Meteorologica*, III, iv, 378a25-378b4. Craig Martin, "Alchemy and the Renaissance Commentary Tradition on *Meteorologica* IV," *Ambix*, 51, no. 3 (2004): 245-262.

<sup>5</sup> Craig Martin, *Renaissance Meteorology: Pomponazzi to Descartes* (Baltimore and London: The Johns Hopkins University Press, 2011), 9-11.

<sup>6</sup> *Interpretation and Utility* (cit. note 3), 109-114.

<sup>7</sup> Martin, "Alchemy and the Renaissance Commentary Tradition," 246-249 and bibliography cited there.

Moreover, according to Albertus Magnus (and others following him, like Agostino Nifo in the Renaissance), it was the influence of the stars in specific locations that created the conditions for forming different metals.<sup>8</sup>

Pliny, Aristotle, Avicenna and Albertus Magnus, medieval alchemical treatises, together with classical pharmacopeias like that of Dioscorides represented the raw material out of which a ‘new science of the underground’ emerged in Europe in the sixteenth century. Lack of consensus, however, abounded. Essentially, medieval and renaissance authors who wished to know more about what lies under the surface, or indeed, present new hypotheses about rock and mineral formation and the structure and functioning of the Earth, had ample opportunities to propose new theories and forge new paths. It is in this vein that Renaissance authors as diverse as Georg Agricola, Vannoccio Biringuccio, Athanasius Kircher, Girolamo Cardano, Andrea Cesalpino, Gabriele Falloppia, Ulisse Aldrovandi, and Michele Mercati (to name a few) tried to launch their explorations into the underground. In doing so, they produced highly original and complex works, which, as a group, still await systematic study.

In this period, what we now call geology, mineralogy, paleontology, and seismology did not exist as separate disciplines, and as much as we now use these terms as convenient categories, we should resist dividing our study of these works along nineteenth-century disciplinary classifications. Those contemporaries simply did not, associating instead various areas of the study of the underground to natural philosophy and its cognate sixteenth-century discipline, natural history.<sup>9</sup> It is also essential to remember that the study of the underground was deeply connected to theology and

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<sup>8</sup> Albertus Magnus, *Book of Minerals*, ed. by Dorothy Wichhoff (Oxford, Clarendon Press, 1967). In discussing earthquakes, Nifo attributed their causes to planetary forces. The same was true of floods. See Agostino Nifo, *In Libris Aristotelis Meteorologicis commentaria* (Venetiis: Octavianus Scotus, 1560), 392-400. For astrology and the history of the Earth, see now Ivano Dal Prete, *On the Edge of Eternity: The Antiquity of the Earth in Medieval and Early Modern Europe* (New York: Oxford University Press, 2022), 36-58.

<sup>9</sup> A fine example of how these matters were seen as interrelated is the Jesuit commentary produced at the University of Coimbra: *Collegium Conimbricense, In quatuor libros de Coelo, Meteorologicos, & Parva Naturalia, Aristotelis Stagiritae* (Coloniae: Lazarus Zetznerus, 1603).

religion on the one hand, and medicine on the other.<sup>10</sup> From the sixteenth century, moreover, explorations of the underground were increasingly linked to growing economies of trade and extraction, warfare, and artistic and artisanal practices.<sup>11</sup> For the historian, there is, therefore, an enviable opportunity to research early modern sources exploring the underground from a truly comparative perspective.

A note on terminology is, at this point, necessary. Geology itself, of course, is a relatively young scientific discipline. Most historians of science would place its institutional birth in the mid-nineteenth century with the establishment of the first university chairs in geology across Europe, and the publication of Charles Lyell's *Principles of Geology* (1830-1832), arguably the first extensive work dedicated to the discipline in its modern configuration. The origin of the study of the Earth – its antiquity, its formation, its composition – was, however, much older, and has its cultural and institutional roots in the broader growth of the discipline of natural history in the sixteenth century. Seemingly, the first naturalist to use the word *giologia* to indicate ‘stuff’ of the underground (modelled on the Latin cognates *zoologia* and *botanologia*) was the Bolognese Ulisse Aldrovandi, who expressly used the term in his 1603 testament. What Aldrovandi meant, and what the term meant for nearly two centuries, was the study and description of *fossilia* and *res metallica*, namely everything that grows in the bowels of the Earth.<sup>12</sup> The Earth's conformation and transformation under the surface would remain

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<sup>10</sup> Martin, *Renaissance Meteorology*; id., “Francisco Vallés and the Renaissance Reinterpretation of Aristotle's Meteorologica IV as a Medical Text,” *Early Science and Medicine*, 7, no. 2 (2002): 1-30; id., “Alchemy and Meteorologica IV,” 254, in relation to the influential Paduan professor Francesco Piccolomini.

<sup>11</sup> The literature is extensive, but see the classic work of Pamela H. Smith, *The Business of Alchemy: Science and Culture in the Holy Roman Empire* (Princeton, NJ: Princeton University Press, 1994); Bruce Moran, “German Prince-Practitioners: Aspects in the Development of Courtly Science, Technology, and Procedures in the Renaissance,” *Technology and Culture*, 22, no. 2 (1981): 253-274; and *The Cultural and Material Worlds of Mining in Early Modern Europe*, ed. Tina Asmussen, special issue, *Renaissance Studies*, 34, n.1 (2022): 1-148.

<sup>12</sup> Gian Battista Vai, “Aldrovandi's Will: Introducing the term ‘Geology’ in 1603/Il Testamento di Ulisse Aldrovandi e l'introduzione della parola ‘Geologia’ nel 1603,” in *Four Centuries of the Word Geology: Ulisse Aldrovandi 1603 in Bologna* ed. Gian Battista Vai and William Cavazza (Bologna: Minerva Edizioni, 2003), 69-73.

obscure for centuries, and geology would remain a multifarious and complex discipline with ill-defined disciplinary boundaries and multidisciplinary competencies for much longer. As Pratik Chakrabarti reminds us right at the start of his illuminating book, *Inscriptions of Nature*, even in the nineteenth century, geology was not a unified discipline.<sup>13</sup> This justifies amply, in my view, the choice to review two very different books in this broad field. They both showcase specific approaches to the history of the Earth and they do so by looking at very different sources and presenting different methodological and historiographical approaches. They both speak, however, to the ever-growing interest in the history of the earth sciences among historians and historians of science. They also reveal the richness of the documentation and its potential for further exploration.

As I prepared this essay review centred around Rienk Vermij's *Thinking on Earthquakes in Early Modern Europe* and *Strata. William Smith's Geological Maps*, one more book appeared in the same field, Ivano Dal Prete's much-awaited, *On the Edge of Eternity. The Antiquity of the Earth in Medieval and Early Modern Europe* (Oxford University Press, 2022). Lydia Barnett's *After the Flood: Imagining the Global Environment in Early Modern Europe* (Johns Hopkins University Press, 2019), and Pratik Chakrabarti's *Inscriptions of Nature: Geology and the Naturalization of Antiquity* (Johns Hopkins University Press, 2020), appeared in the last four years. A fascinating collection of essays on geology and medicine came out in 2017, and an edition of selected correspondence by the influential Swiss naturalist Jakob Scheuchzer (1672-1733) was published in 2019. In 2020 the British writer Robert Macfarlane, who also wrote the foreword for *Strata*, offered a powerful exploration of the Earth's underground in his fascinating account of his personal explorations in *Underland: A Deep Time Journey* (W.W. Norton & Co., 2019). Finally, only a few years ago this journal housed an excellent suite of articles on the visual representation in the earth sciences edited by Luca Ciancio e Domenico Laurenza.<sup>14</sup>

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<sup>13</sup> Pratik Chakrabarti, *Inscriptions of Nature: Geology and the Naturalization of Antiquity* (Baltimore: Johns Hopkins University Press, 2020), 1.

<sup>14</sup> Christopher J. Duffin, Christopher Gardner-Thorpe, R.T.J. Moody, eds., *Geology and Medicine: Historical Connections* (London: The Geological Society of London, 2017); Simona Boscani Leoni, ed., "Un glaubliche Bergwunder." *Johann Jakob Scheuchzer und Graubünden. Ausgewählte Briefe*

Of course, my list does not wish to be comprehensive: I am aware it is just scratching the surface and it mentions only major works in English, predominantly published by international university presses. Many more titles could be added to this list by looking at other languages and journal outputs. This short list, however, is a small indication of something bigger: the underground and the history of the Earth are receiving renewed attention, they are expanding in new (and often surprising) directions, and they are approached from novel perspectives (cultural and colonial history being only two). Importantly, they are slowly but steadily moving back chronologically, as Vermij's book demonstrates, leaving aside the grand narratives of the nineteenth century and recovering an earlier period. In short, it seems that the history of "geology" broadly construed is undergoing a Renaissance within the field of the history of science and cultural and intellectual history at large. This revival, moreover, is expanding the traditional confines of the discipline, which like many other historical fields, has been traditionally formed around great theories and great men of science. All these studies are either going beyond great names and theories to explore areas that had been largely neglected or – like Dal Prete, Chakrabarti, and Macfarlane (albeit in very different ways) – are offering revisionist approaches to Martin Rudwick's influential narrative about the 'discovery' of deep time. Thus the two books that I will analyse here represent additional examples of some of the new scholarly trends that are bringing the history of the earth, its formation, and its functioning, to bear on other historical and cultural fields.

## **2. Earthquakes: A History of Ideas Approach**

Within this framework, the study of what caused earthquakes, with its mix of philosophical and religious explanations, came to intersect with questions about the form and formation of minerals and stones under the Earth's surface. As noted, earthquakes were originally studied under the umbrella of Aristotelian meteorology. As major catastrophic natural events which destroyed early modern lives, earthquakes produced a significant amount of historical documentation. It is to earthquakes, therefore, that Rienk Vermij turns his attention in *Thinking on Earthquakes in Early Modern Europe*, the first book to be discussed here. As Vermij states, historically earthquakes worked at the

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1699–1707 (Chur: Bündner Monatsblatt/Cultura Alpina, 2019); *Visual Representation in Earth Sciences*, ed. Luca Ciancio and Domenico Laurenza, special issue, *Nuncius: Journal of the Material and Visual History of Science*, 33, no.3 (2018): 397-536.

crossroads between religion and science: to varying degrees, and in different cultures, they have often been interpreted as supernatural events; because of their extraordinary nature, they were linked from very early on with the divine. Vermij's study takes 1755, the year of the devastating Lisbon earthquake, as its endpoint. While the 1755 earthquake has received ample attention from historians of philosophy and science alike, much less attention has been paid to earthquakes of an earlier era and particularly those that happened in the famed period that is traditionally referred to as the 'scientific revolution'. Vermij traces this lack of attention to earthly phenomena back to an older tradition in the history of science that emphasized scientific innovation and a teleological narrative of scientific progress, thus valuing precursors and the 'correct' interpretations of nineteenth-century scientists over an earlier tradition that was still imbued in religiosity and lacked understanding of the actual causes of earthquakes. To this explanation, he rightly adds the general lack of appreciation for the significance of Aristotle's *Meteorology* in the Renaissance, something that has only changed in recent years thanks to Craig Martin's ground-breaking study, *Renaissance Meteorology* (2011), the first major work to address a series of topics around which, as Vermij notes in the case of earthquakes, early moderns wrote abundantly.

Earthquakes, their history, and their causes were central to early modern lives, as can be amply demonstrated by looking at the book's copious bibliography of primary sources. Even without digging into the archives and into manuscript sources (something on which I shall return), the list of printed documents – pamphlets, student disputations, treatises, philosophical, theological, and historical works – is remarkably rich. The emphasis on printed sources is justified by the author's intention of providing a "history of ideas" (p. 11) of the science of earthquakes, something that Vermij accomplishes by dividing the book into three parts: the first, in four chapters, outlining the scientific, philosophical and religious traditions that shaped the idea of earthquakes up to the Renaissance; the second, in seven chapters, which investigates the religious and naturalistic meanings and interpretations of earthquakes and other natural disasters in a confessionalized Europe up to the seventeenth century; and a third part, in four chapters, which traces the rise of modern empiricism.

The first chapter situates earthquakes within the history of emotions – fear, piety, curiosity – providing a general context to what follows. Vermij sketches this essential context by employing selective anecdotes from a variety of sources to write a



thick description of the emotional, cultural, and socio-political connotations that these events acquire as they unfold. For example, the case of the devastating earthquake hitting Calabria, in southern Italy, in 1638 is deployed to illustrate how prophecy, a deeply rooted cultural and intellectual practice in medieval and early modern society, is put to the service of earthquake prediction, highlighting the potentially disruptive nature of prophecy (p. 14-15). An astrologer in Venice, so we are told, had predicted that countries ruled by Leo would be hit by disaster upon the Sun entering the sign on 23 July. The news reached as far as Poland, also believed to be ruled by Leo, where people feared something terrible would befall them too, sending Prague into a frenzy. Another physician and astrologer, this time in Cosenza, had also predicted the event. Predictions were linked to earlier ones by the twelfth-century visionary Joachim da Fiore; reports of weeping statues were interpreted as confirmation that the disaster was imminent. Unrest unfolded. The astrologer from Cosenza, Pietro Paolo Sassonio, was summoned by the Neapolitan authorities and sent to the galleys with the accusation of fanning social unrest. Astrologers were not new to this fate: in part, it came with the job. Unhappy predictions which were seen as fuelling fear and social upheaval were often met with strong disapproval by political authorities, and sometimes led to harsh punishment.<sup>15</sup> Prophecies, of course, were not only issued by astrologers, but also by preachers and other members of the religious orders: earthquakes were part of a variety of more traditional disasters associated with the Four Horsemen of the Apocalypse – war, famine, and pestilence – and as such, as we have seen, were often interpreted as manifestations of God’s wrath.<sup>16</sup>

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<sup>15</sup> For examples of how astrological predictions could gain political value, see my article, “The Political Uses of Astrology: Predicting the Illness and Death of Princes, Kings and Popes in the Renaissance,” in “Stars, Spirits, Signs: Astrology 1000-1800,” ed. Rob Ralley and Lauren Kassell, special issue, *Studies in History and Philosophy of Biological and Biomedical Sciences*, 41, no. 2 (2010): 135-145.

<sup>16</sup> John Aberth, *From the Brink of the Apocalypse: Confronting Famine, War, Plague and Death in the Later Middle Ages* (London and New York: Routledge, 2001); Andrew Cunningham and Ole Peter Grell, *The Four Horsemen of the Apocalypse: Religion, War, Famine and Death in Reformation Europe* (Cambridge: Cambridge University Press, 2000); Michael Matheus, Gabriella Piccinni, Giuliano Pinto, Gian Maria Varanini, eds., *Le calamità ambientali nel tardo medioevo europeo: realtà, percezioni, reazioni* (Florence: Firenze University Press, 2010).

As other historians have noted, priests invariably lamented that people need to repent and change their ways: processions were organized and cults revitalised.<sup>17</sup> New saint cults emerged to fulfil the intercessory role required to abate God's rage.<sup>18</sup> These catastrophes, moreover, could be easily manipulated by political parties, and in general, they often made evident social and political tensions that were brought to the surface by the earthquake (and are thus more richly documented). It is significant that Grégory Quenet's monumental study of earthquakes in early modern France – one of the most accomplished explorations of earthquakes in one specific national context, certainly the most heavily documented – opens with an example that beautifully encapsulates this issue. As Quenet argued, a disaster is always “a discourse of the aftermath which is inserted into a narrative, because there is no catastrophe perceived as such at the moment when it happens.”<sup>19</sup> This narrative unfolds in the hours and days after the event; it is shaped by the intellectual, social, cultural, political, and scientific contexts in which the disaster takes place; at the same time, however, it reshapes relationships, produces new cultural artefacts, prompts new theories, generates a wealth of documents.

Vermij's third chapter focuses on this written production, particularly newsletters, pamphlets, and chronicles. While very informative, this is a rather short chapter and focuses almost exclusively on printed sources (pamphlets and histories). Vermij declared at the start that the book was a project in the “history of ideas”, and yet it is important to

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<sup>17</sup> The intercession of the Virgin Mary or local saints was ubiquitous. Processions served the function of restoring both faith and order. They can be traced back to late antiquity and continue to this day. The three new Peruvian saints Santo Toribio, San Francisco Solano, and Santa Rosa all had significant associations with miraculous intercessions during earthquakes. See Charles Walker, *Shaky Colonialism: The 1746 Earthquake-Tsunami in Lima, Peru, and Its Long Aftermath* (Durham: Duke University Press, 2008), 10.

<sup>18</sup> See Monica Azzolini, “Coping with Catastrophe: St Filippo Neri as Patron Saint of Earthquakes,” *Quaderni Storici*, 52, no. 3, (2017): 727–750; ead., “The Making of a Transnational Disaster Saint: Francisco Borja, Patron Saint of Earthquakes from the Andes to Europe,” in Ovanes Akopyan and David Rosental, eds., *Disaster in the Early Modern World: Examinations, Representations, Interventions* (London: Routledge, in press); and Milena Viceconte, Gennaro Schiano, Domenico Cecere, eds., *Heroes in Dark Times. Saints and Officials Tackling Disaster (16th-17th Centuries)* (Rome: Viella, 2023).

<sup>19</sup> Grégory Quenet, *Les Tremblements de terre aux dix-septième et dix-huitième siècles. La naissance d'un risque* (Seyssel: Champ Vallon, 2005), 227.

stress here that there is much more that historians could explore. Quenet's work reminds us of the variety of cultural and intellectual artefacts generated by earthquakes – private letters, legal and institutional documents, but also visual and material sources. Like with any book, choices had to be made, but it is worth remembering, moreover, that these events had a substantial impact on the art of the time, both in representing devastated areas, and in sustaining the veneration of individual saints. The ERC research project “DISCOMPOSE - Disasters, Communication and Politics in Southwestern Europe: The Making of Emergency Response Policies in the Early Modern Age” (Grant Agreement N°759829) led by Domenico Cecere at the Università di Napoli Federico II is focusing on a rich variety of documents, including visual sources. For example, Cecere's collaboration with Philine Helas and Elisabetta Scirocco of the Bibliotheca Hertziana in Rome has produced a valuable online exhibition dedicated to the visual documentation produced in the wake of volcanic eruptions in the South of Italy.<sup>20</sup> Besides art, archives are equally important, as Quenet's and Charles Walker's studies richly demonstrate. Utilizing the tools of “incident analysis” first pioneered by historians like Robert Darnton, Charles Walker used the 1746 Lima earthquake and tsunami that ripped apart the city of Lima to explore the city's culture and its social fabric before and after the event. The focus on manuscripts and archival documents is complementary to Vermij's intellectual history approach, and in some cases, it may yield a more fine-grained reconstruction of the events than limiting the analysis to printed sources.

Vermij's fourth chapter explores the significant conjunction of humanism, antiquarianism and natural philosophy. Starting with Giannozzo Manetti's famous treatise on the Campania earthquake of 1456, this chapter explores how humanists, often informed by Seneca's stoic approach in the *Quaestiones Naturales*, tended to address these phenomena by offering naturalistic rather than religious explanations. Learned physicians, around the same time, started to focus more and more on finding the reason for hot springs and their healing qualities. Despite being unable to directly observe the

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<sup>20</sup> *Paper Eruptions. Four Centuries of Volcanoes in Print from the Library's Rara Collection*. An online exhibition by the Bibliotheca Hertziana – Max Planck Institute for Art History in collaboration with DisComPoSe (Disasters, Communication and Politics in Southwestern Europe: The Making of Emergency Response Policies in the Early Modern Age), curated by Elisabetta Scirocco, Philine Helas e Hanna Sophie Stegemann. See <https://galerie.biblherz.it/it/eruzioni/>, accessed January 28, 2023.

underground, they noticed changes in the hydrography of areas affected by earthquakes and started to propose the existence of subterranean fires that would warm up thermal waters and give them their specific properties. Some, like the physician Giovanni Dondi, went even further, comparing the eruptions under the surface of the earth to the working of bombards. Reflecting on the components of gunpowder and the phenomenon of ignition, they thus started to explain earthquakes as the action of Aristotle's dry exhalation on sulphurous or nitric substances within the bowels of the earth.

Another essential figure in this narrative was the humanist Georg Agricola, who after training in medicine in Italy and Germany, went on to become the town physician of the mining town of Chemnitz. Agricola wrote some of the most comprehensive humanist works of the late Renaissance related to the origins and causes of subterranean phenomena, including his influential *De re metallica* (1556), which was soon translated into German (1557) and Italian (1563). His work said little that was new about earthquakes but, importantly, it challenged Aristotle's opinion that they happened more often at specific times of the day. Other new approaches to the underground were offered by the polymath Girolamo Cardano in his *De subtilitate* (1550) and the *De rerum varietate* (1559). All these authors accepted the theory that the Earth had burning fires within its core and proposed alternative or complementary explanations regarding the substances burning within the bowels of the Earth: nitre, sulphur, bitumen, and saltpetre were all possible candidates. These combustions were the causes of earthquakes, and Cardano even speculated that "some mountains were inflated by repeated earthquakes, like a bladder" (p. 58). As Vermij notes, the eclecticism of these humanist approaches is important in understanding the transformation of Aristotelianism from within, leading some of the most daring authors, like Cardano, to attempt to propose a new, full-blown philosophy of nature.

The second part of the book will speak more to cultural historians and historians of religion. Focusing on alternative explanations about the causes of earthquakes, Chapters 5-9 explore how early moderns often chose to read them as portents. In Chapter 5, Vermij argues that unlike intellectuals north of the Alps who tended to interpret the same phenomena as portents of an impending end, Italian authors were "reluctant to attribute to earthquakes any prophetic significance" (p.67). While it may be true that the reading of portents among Catholics tended to be less apocalyptic, it is important to stress that a rich culture of religious practices developed among Catholics

for all sorts of natural disasters. For earthquakes, together with local cults, the Virgin Mary was often the default intercessory figure to be prayed for forgiveness. This reading of prodigies as calamities sent by God was ubiquitous in the Catholic world. The strong earthquake that hit Rome in 1703 is a good example of Catholic responses to earthquakes. Among the varied outputs of the Roman printer-turned-author Luca Antonio Chracas are a series of works dedicated to the 1703 earthquake, including his own lengthy *Racconto istorico de terremoti sentiti in Roma e in parte dello Stato Pontificio* which, in over 200 pages, collected information about “everything that was implemented during the recent earthquake, both about governmental efforts in support of the population that was hit by such a catastrophe (*flagello*), and all the works of piety deployed both in Rome and outside of the city to sedate the rightful wrath of God”.<sup>21</sup> Vermij’s discussion of the works of the Catholic Friedericus Nausea, Franciscus Torreblanca, Cornelius Gemma, Valentinus Fabricius, Cesare Baronio (pp. 86-87), Pierre de La Primaudeaye (pp. 104-105), Franciscus Resta (p. 111), and the example of the earthquake in Vienna reported by both Catholic and Protestant sources (pp. 123-124) all seem to suggest that the interpretative distance between Catholics and Protestants, even with their specific differences, may be more nuanced and case-specific than Vermij has maintained.<sup>22</sup>

The third and final part moves away from “confessionalized philosophy” and the view that irregular and rare natural phenomena could be interpreted as a form of divine punishment to look at alternative views of the world that emerged. In this section, Vermij connects the rise of a new metaphysics – a new view of nature with its immutable laws – to a new way of interpreting earthquakes among the intellectual elites. The chapters in this section describe the decline of confessionalized philosophy and try to locate the engines of change that brought about its demise. Vermij identifies new ways of communication that promoted and supported a “new empiricism” and a widening world as two significant factors. Disasters overseas, according to Vermij, were not recounted

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<sup>21</sup> Luca Antonio Chracas, *Racconto istorico de terremoti sentiti in Roma, e in parte dello Stato Ecclesiastico e in altri luoghi la sera de’ 14 di Gennajo, e la mattina de 2 di Febbrajo dell’anno 1703* (Rome: G. de Martijs, nella stamp. di G.F. Chracas, 1704), 2. Translation mine.

<sup>22</sup> This is certainly true of Protestant Anglicans and their approach to prodigies and natural disasters. See Alexandra Walsham, *Providence in Early Modern England* (Oxford: Oxford University Press, 1999), 167–224. Cf. Vermij, 120-123.

the same way as the local, European ones. Merchants and seafarers recounted these events more “objectively” (Vermij connects his interpretation to Harold Cook’s argument that Dutch merchants who went overseas were attracted to “objective” knowledge) and were more concerned with the economic consequences of these events, leaving aside religious considerations. The examples he brings forward certainly support his argument; it would be interesting, however, to see if similar concerns were shared by Portuguese and Spanish merchants, and what would emerge from private, rather than business correspondence.

A new, exciting source of information regarding disastrous events was certainly the birth of the gazette. The appearance of regular newspapers enhanced the frequency of circulation of news and broadened their audience. So, the famous earthquake of Jamaica in June 1692 was reported by news magazines like the *Europische Mercurius*, but was also discussed in the *Philosophical Transactions*, where the Royal Society collected several accounts of the same earthquake. Both these publications, Vermij argues, were focused on the factual events surrounding the disaster. Neither of these gave in to religious explanations. What emerged, therefore, was a “non-confessional investigation of nature” (p. 167). In Vermij’s opinion, it was a new empiricism that led the way to a new philosophy and not the other way around. In this sense, Vermij rightly situates the study of the formation and functioning of the Earth and the observational approach linked with it within the realm of the so-called seventeenth-century “scientific revolution”. In other words, the new empiricism of earthquake observation and reporting was one of the elements that brought about a different metaphysics: the “debunking of prodigies became heavily associated with mechanical, in particular Cartesian philosophy, but it had a much wider appeal” (p. 168). And it was this attention to the functioning of the Earth that led some intellectuals to rethink the structure of our planet, postulate the existence of subterranean conducts, investigate the motion of the Earth, the direction of the tremors, the change in air pressure, and introduce the use of instruments such as the barometer and the pendulum. This led some seventeenth-century intellectuals to promote new theories for the cause of earthquakes. The most interesting and innovative explanations, however, did not come from mechanical philosophers, but from chemists like Nicolas Léméry.

Chapters 14 and 15 return to the examination of the intersection of religious and naturalistic discourse. Here Vermij notes that the distance between Protestants and

Catholics was eventually reduced and merged into the “physico-theology” of the eighteenth century. Cartesianism, with its refusal to discuss God’s intentions in natural philosophy, was leaving its mark, especially in Protestant countries. The reading of the functioning of the Earth as an example of God’s glory and power took over the idea of disastrous events as the result of God’s wrath. At the end of the seventeenth century, even Catholic authors like Domenico Bottone shied away from interpreting eruptions and earthquakes as divine manifestations and prodigies. Even in texts as diverse as Thomas Burnet’s *Telluris theoria sacra* (1681-1689) and John Ray’s *Three physico-theological discourses* (published posthumously in 1713), Vermij sees above all a factual, empirical approach to the Biblical truth. Chapter 15, however, demonstrates similarly that a religious reading of disastrous phenomena remained strong. Here Vermij focuses on the cult of the saints on the one hand, and physicians’ interpretations on the other. He identifies Giorgio Baglivi, the Roman physician, as representative of the latter trend in a city that had always made devotional practices the core of its cultural discourse. What emerges from these final pages is that the reading of earthquakes as divine punishments did not disappear. It may have become less dominant, but it is still present in the eighteenth century. Indeed, as Vermij states, “it was still dominant in the reactions to the Lisbon earthquake of 1755” (p. 271).

Vermij’s book is a tour de force: it analyses hundreds of different sources and tries to examine very different authors and different cultural and geo-political contexts. Inevitably, Vermij tries to create order in what is a complex set of materials. Occasionally, therefore, I felt that a more nuanced argumentation and depth of analysis were needed. But I also realise that a book of this sort is very hard to write given the breadth and diversity of languages and genres. Vermij’s work is a fundamental point of departure for anybody working on earthquakes, and indeed wanting to approach the history of science from below (meaning from geology rather than astronomy, as it has been often the case).

### **3. Layered Material Histories: *Strata***

The second book reviewed here is *Strata: William Smith’s Geological Map*, edited collaboratively by the Oxford Museum of Natural History. It contains an introduction by Douglas Palmer, a Foreword by Robert Macfarlane, and a series of essays by curators, palaeontologists, and geologists with a solid historical background. This is a superb

book: it is lavishly produced and rich in layers of content that go well beyond Smith's Map of 1815. While at the core of this publication is the first large-scale stratigraphic map of the Earth ever produced, the volume contains high-quality colour images of Smith's personal fossil collection (which he was forced to sell to the British Museum in 1818), some of Smith's additional publications, tables and notes produced and published by Smith to help geologists and engineers identify each rock type by their associated fossils, and images of the covers of his working diaries and notes. In all these pages, we acquire precious evidence of the 'material history' of Smith's life.

Robert Macfarlane's Foreword situates Smith's work in a larger cultural and historical context that takes us to the present: a history of the underground. As Macfarlane summarises elegantly, "the Earth's skin stops sight short" (p. 16), and so our knowledge of the invisible dominion that is our planet remains forbidden to our senses and, to an extent, to our comprehension. Macfarlane's rendering of Smith's enterprise provides us with a glimpse of the man, stressing the pioneering aspects just enough to give us a sense of the Map's importance as a cultural milestone, but not indulging in a heroic narrative. Macfarlane is right to emphasize that Smith achieved something nobody achieved before, but he also stresses the how and why. Smith walked and rode the landscape in person over decades and decades collecting first-hand local data. Macfarlane reminds us of how these searches were born chiefly "of a pragmatic urgency to exploit the Earth's resources" (p.17). And yet the result of Smith's work is, in his words, a mix between artwork, dreamwork, and data set. Macfarlane speaks also of the contemporary relevance of Smith's work. He reminds us that in 2009, the International Commission on Stratigraphy established an Anthropocene Working Group to assess the legacy of *Homo Sapiens* in the rock record. Smith's Map speaks of the past, but also of the present and of the future of our planet.

The rest of the book is divided into four parts: 1. Borders and the North; 2. Wales and Central England; 3. East Anglia and the South East; 4. The West. Each of these sections is accompanied by one or more thematic essays, all interspersed with beautiful colour illustrations from Smith's Map, images of fossils, and other published material from Smith's time. Douglas Palmer's *Introduction* focuses first on the map and then on the man. The first section of the essay provides the reader with a detailed description of the Map's size, its features (twenty-three different tints to distinguish the various rock types), cost, and the socio-political context of its production. Then he gives us a brief



sketch of Smith's life: he rightly situates Smith in that veritable cohort of 'artisan-practitioners' (to use Pamela O. Long's apt term) who learned by doing and in doing, transformed earlier knowledge. The observation of fossils in strata became key to Smith's research; arranging them in order of occurrence enabled him to identify and correlate strata and fossils across the country. Palmer capably sets Smith in his historical context, discussing the influence on Smith of the geologist, topographer, and Fellow of the Royal Society, John Strachey, but also earlier theories of the Earth and the use of geological maps before Smith. He also stresses how some of Smith's theories, modelled on those of intellectuals before him, were an "accident of place" as they were guided by a hypothesis (that the planet's rotation had deflected all strata to decline and curve from west to east) that fitted well the south of England but would not work equally well for the rest of Britain or elsewhere around the globe.

By the early nineteenth century fossils were no longer mere curiosities but served a different purpose. Smith arrived at the same conclusions reached in the same years by French geologists, but as Palmer rightly stresses, with fewer personal resources (Smith ended up bankrupt twice and in 1819 he was imprisoned for debt). Palmer's elegant essay also provides some precious information about the larger economic forces at play both in nineteenth-century Britain and in the rest of Europe and beyond. Smith's expertise in geology was equally coveted by people such as Emperor Alexander I of Russia and Scottish businessmen in North America. Thus, Smith becomes one example among many of the complex relationship existing between the fields of academic geology, agriculture, land reclamation, and industrialization. In Britain and elsewhere in Europe, these relationships were being forged and were constantly renegotiated during the late eighteenth century and nineteenth century. The intersection of these areas, as Lissa Roberts and Joppe van Driel argued in a penetrating article on eighteenth-century France, England, and Scotland encourages us to investigate the development and transformation of modern-day taxonomies of the underground and rethink the shifting identity of natural resources and their history.<sup>23</sup> Smith is certainly part of this history.

The second essay in the book, by Peter Wigley, explores Smith's career as a mineral prospector. Smith learned quickly of coal seams and their associated strata as he started working as a land surveyor for Lady Elizabeth Jones (1741-1800). Smith built on

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<sup>23</sup> "The Case of Coal," in *Compound Histories: Materials, Governance, and Production, 1760-1840*, ed. Lissa Roberts and Simon Werrett (Leiden: Brill, 2018), 57-84.

John Strachey's astute insights on Britain's coal beds to extend his knowledge of the Mearns Colliery and better understand strata, their 'attitude' (dip and strike) and the importance of faulting (pp. 102-103). His early experience in search of coal served him well: "his understanding of the order of strata and the distinctive fossils they contained gave him a considerable advantage when asked for an opinion on a trial for coal" (p. 107). Soon after, Smith's expertise was sought to locate lead, antimony, copper, alum, and salt. As Wigley highlights, this was a time when agriculture and mining met each other in the form of county surveys, which Smith used to integrate his personal experience.

In the third essay, Dave Williams examines Smith's fieldwork: once again the emphasis from the very beginning is on land improvement and increased crop production. This is an important point. All too often, we equate mining with industry, forgetting that extractive practices also served agriculture. The Enclosure Act of 1801 changed the scale of the British economy and promoted mechanization and the agricultural revolution. Smith's knowledge of strata and draining and irrigation techniques was coveted by the gentry, industrialists, and agriculturalists such as the Duke of Bedford and the agriculturalist Thomas Coke of Holkham Hall.

The fourth essay focuses on Smith as a cartographer. Tom Sharpe provides a concise but effective account of the amount of work Smith put into his geological map: how he was assisted in this by his famous patron Joseph Banks; how he resorted to the help of the most preeminent publisher of his time, John Cary, a specialist in maps; how he personally guided Cary's team of colourists through the process of colouring twenty-three strata in different colours and shades on the map. Smith was supported and encouraged by friends: among them, Smith counted Banks, to whom the map is dedicated. We are told how Banks may have told his French visitor, Étienne Coquebert de Montbret, the editor of the *Annales des Mines*, of Smith's use of fossils to distinguish strata, and that Coquebert may have told his son-in-law Alexandre Brongniart, who began to work on mapping the geology of the Paris Basin with the famous naturalist Georges Cuvier. Their map was published in 1811, well before Smith's (p. 157). Smith had financed the publication through a form of subscription, by the time the map was printed, ten of those who had subscribed had died and the severe recession that hit Britain at the end of the Napoleonic Wars seriously compromised his sales. Sharpe draws attention to Smith's uneasy relationship with the Geological Society, where he

never found either support or full recognition, and yet when the Society issued a map, they had to base themselves also on Smith's data. This led one of Smith's friends to accuse the Society's President at the time, George Greenough, of plagiarism (p. 170).

The poor sales of Smith's map seem to have sealed his future: indebted, he had to sell his fossil collection and lost all property, books, and papers. It was only with a change of stewardship at the head of the Society, under Adam Sedgwick's presidency, that things started to improve for Smith. Sedgwick awarded the newly instituted Wollaston Prize to Smith in recognition of his achievements. This helped Smith produce a smaller geological map and with the help of his nephew, new maps that were sold as part of a *New Geological Atlas of England and Wales*.

One of my favourite essays is the fifth one, on Smith as a fossil collector, jointly authored by Jill Darrell & Diana Clements. Smith's interest in fossils went back to his childhood in Oxfordshire, where 'poundstones' – fossilised flat sea urchins – were common. The local children played a form of marbles with these brachiopods, while dairywomen used them to weigh out the butter (p. 184). Smith started to connect fossils to stratigraphy when working for the Somersetshire Coal Canal. Smith's fossil collection became central to his preoccupations and evolved together with his maps and his theory. Indeed, when he moved to London, he displayed his maps and his collections next to one another in his private museum. The order and regularity of their appearance in the soil's strata were driving his research. We have seen how Smith had fashioned himself as a drainage expert in a country that had had a water problem for centuries and where landowners wanted to reclaim as much land as possible for agriculture.<sup>24</sup> As he travelled around the country to offer his expertise, Smith never missed a chance to collect fossils. His *Stata Identified by Organized Fossils*, a series of seven volumes of which only four were finally published, was Smith's other major achievement. Aided by James Sowerby, the most famous fossil illustrator of the day, Smith and Sowerby produced some beautiful illustrations of mostly marine invertebrates. When Smith, in need of money to resolve his financial troubles, decided to sell his collection, it was his friend and supporter, Sir Joseph Banks, who acted as an intermediary with the British Museum. That also proved to be a disappointing experience for Smith as the Museum representatives seemed

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<sup>24</sup> A wonderful study of an earlier period is Eric H. Ash, *The Draining of the Fens: Projectors, Popular Politics, and State Building in Early Modern England* (Baltimore: Johns Hopkins University Press, 2017).

unconvinced of the importance of the specimens and the necessity of displaying the collection arranged by strata (p. 194). Assisted by his nephew, John Phillips, Smith devised a unique cataloguing system and gave detailed instructions about the way they ought to be displayed, but when the collection was transferred to the British Museum it remained unpacked for years. It was only in the 1880s that the collection's fortune changed when they were transferred to the newly built Natural History Museum in South Kensington. But we must wait until 1976 to see the collection gain pre-eminence and be displayed in a newly opened east wing of the museum dedicated to palaeontological collections, where they remain today, displayed in Smith's stratigraphical order.

The sixth essay by John Mather, entitled *Well Sinker*, reconnects us with the theme of water. As theories about the Earth's structure multiplied in the seventeenth century, so did theories about water formation and water flow across the Earth. Water dowsing was not an uncommon technique for locating water in Smith's days, and we need to credit Smith for providing an alternative explanation about the origin of springs and deeper groundwaters. Once again, Smith's hypothesis had practical applications. For Smith and his pupils finding water fast became a significant part of their professional practice and income. Once more we see how hydrology and geology were (and are) deeply interlinked, something that was recognised by many sixteenth-century natural philosophers who addressed one topic, the other, and sometimes both.<sup>25</sup> These early modern authors did not have Smith's understanding of strata, and they did not have the same chances to explore and observe that he had, but they had already hypothesized how rocks, minerals and waters were the basic constituents of the underground and the quality of the former determined the nature of the latter. Smith's knowledge was employed both in Bath and in Harrogate, where sulphuric water was discovered in the 1770s (p. 229).

The final essay, by John Henry (for this journal's readers, not the famed historian of science, but an independent consulting geologist), is dedicated to Smith as a mentor.

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<sup>25</sup> Works as different as Athanasius Kircher's *Mundus Subterraneus*, and Gabriele Falloppia's *De medicatis aquis* discussed both the origins and qualities of spring waters and that of fossils. See Athanasus Kircher, *Mundus Subterraneus* (Amstelodami: apud Joannem Janssonium & Elizeum Weyerstraten, 1664-1665); Gabriele Falloppia, *De medicatis aquis, atque de fossilibus tractatus pulcherrimus, ac maxime utilis* (Venetiis: ex officina Stellae, Iordanis Ziletti, 1564).

He picks up where most other essays stopped, with Smith's final financial collapse and his last stint in prison in 1819. From then on Smith worked mostly in the north of England settling in Yorkshire and living a partly secluded life. At some point he was asked to lecture at the Yorkshire Philosophical Society; he accepted gladly and showed up with coloured maps and borrowed fossils to illustrate eight lectures delivered in four weeks. Smith's success led to more invitations and more lectures, and at some point, his nephew took over some of the lectures, and eventually the whole series. Phillips went on to become an accomplished geologist and at one point he even became the President of the Geological Society, the same institution that had snubbed his uncle.

Smith's significance for the history of geology has been remarked on numerous times: he features prominently in the histories of geology of Martin Rudwick, in Jack Morell's recent book on Smith's nephew, Phillips, in Brenda Maddox's *Reading the Rocks*, he has a cameo appearance in Robert Huxley's *The Great Naturalists*, we can even follow some of his steps thanks to John L. Morton's biography and its useful Appendix retracing the William Smith Trail.<sup>26</sup> Even with its emphasis on the early nineteenth century, this book departs in significant ways from other works on Smith by promoting a synergic reading of the essays and the images (and thus, by proxy, also the objects): it thus attempts to bring together the map and the fossils as Smith had intended, and in giving us concise but insightful glimpses of Smith the man avoiding as carefully as possible to make him out as a hero and as a man ahead of his times.

In this sense, both books present original approaches to the historical material. In their diversity, these approaches highlight for the historian not only the richness of the sources dealing with the underground, but also how this approach allows us to form new

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<sup>26</sup> Martin J.S. Rudwick, *The Meaning of Fossils: Episodes in the History of Palaeontology* (Chicago: The University of Chicago Press, 1985); id., *Bursting the Limits of Time: The Reconstruction of Geohistory in the Age of Revolution* (Chicago: The University of Chicago Press, 2005), id., *Earth's Deep History: How it was Discovered and Why it Matters*, Chicago: University of Chicago Press 2014; Jack Morrell, *John Phillips and the Business of Victorian Science* (Aldershot, Hants.: Ashgate, 2005), Brenda Maddox, *Reading the Rocks: How Victorian Geologists Discovered the Secret of Life* (London: Bloomsbury, 2017); Robert Huxley, *The Great Naturalists* (London: Thames & Hudson, 2007); John L. Morton, *Strata: How William Smith Drew the First Map of the Earth in 1801 and Inspired the Science of Geology* (Stroud, Gloucestershire: Tempus, 2001).

narratives that integrate more fully the history of geology to its social, political, economic, visual, and material contexts. Looking down has never felt more exciting.