

Men, methods and materials: exploring the historical connections between geology and medicine

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Historical backdrop

A conference entitled *A History of Geology and Medicine*, convened by the History of Geology Group and held at Burlington House in November 2011, formed the basis of the first known volume dedicated to the historical links between medicine and geology (Duffin *et al.* 2013). Although the meeting was somewhat exploratory in its approach, it was obvious that the themes encountered were worthy of further investigation, which led directly to a second meeting in November 2014, the fruits of which form the core of the present volume.

As independent disciplines, medicine and geology have markedly different origins, but their practical applications intersect very early on in human history. The possible use of bone needles for suturing in the Palaeolithic, and the widespread application of (and survival from) trepanation in the Neolithic, show that elements of medical practice had already been established during the Stone Age. The forsaking of hunter-gatherer lifestyles in favour of settled agricultural existences allowed the development of new medical skills including wound-healing and bone-setting, as well as encouraging the development of written records of medical knowledge, especially in Babylonian (cuneiform) and Egyptian (hieroglyphic) texts. These writings clearly demonstrate the burgeoning connections between medicine and geology, as mineral drugs were incorporated wholesale into the *materia medica*; Campbell Thompson (1936), for example, identified 120 mineral drugs cited in the clay tablets excavated from King Assurbanipal of Assyria's Library at Nineveh, and minerals are significant inclusions in the medicinal recipes detailed in Egyptian medical papyri (Duffin 2013). Whilst many minerals were used as medicinal simples, some were amuletic and their magico-medicinal efficacy supposedly depended on spoken charms or religious liturgies. One papyrus fragment in the Ägyptisches Museum und Papyrussammlung in Berlin (Berlin P.3027), for example, records how a charm should

be spoken over beads of lapis lazuli, jasper and malachite, which were then threaded to form an amuletic necklace for a sick child (Erman 1901, p. 9).

In the Greek and Roman schools there was some intrinsic interest in geological materials (as in the work of Theophrastus, for example, in the third century BC). The greater part of the written legacy preserved for us, however, is associated with the medicinal output of Greek and Roman healers, including Galen of Pergamon (c. 130–c. 210) and Pedanius Dioscorides (first century), and the eclectic writings of Pliny the Elder (23–79), replete with contemporary Roman folklore. The humoral theory of medicine was overlain by emerging notions of the Doctrine of Signatures, which saw geological materials being prescribed for various ailments on the basis of common characters, form and colour; the phallic shapes of fossil cidaroid echinoid spines, for example, initially determined their use in the treatment of urogenital conditions.

With the conquest of Greece by Rome and the subsequent decline of the Roman Empire, the spread of Islam during the seventh and eighth centuries saw a burst of Muslim scholarship characterizing the 'Islamic Golden Age', which lasted well into the thirteenth century. Interest in minerals was, again, primarily associated with their supposed therapeutic virtues as, for example, in the works of Al-Biruni (Abū al-Rayḥān Muḥammad ibn Aḥmad al-Bīrūnī, or Alberonius in Latin: 973–1048) and Ahmad ibn Yusuf al-Tifāḥī (1184–1253). At the same time, a new emphasis on experimentation led to profound changes in scientific methodology which, in turn, resulted in a revitalization of the understanding of medicine in the hands of such luminaries as Muhammad ibn Zakariyā Rāzī (Rhazes: 865–925) and Abū 'Alī al-Ḥusayn ibn 'Abd Allāh ibn Sīnā (Avicenna: c. 980–1037), each of whom also referred to the therapeutic application of geological materials in his writings. At the same time, the rise of alchemy was able to lay the early foundations of chemistry.

Meanwhile, in the Latin West, the centres of higher learning during the early Middle Ages were

From: DUFFIN, C. J., GARDNER-THORPE, C. & MOODY, R. T. J. (eds) 2017. *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**, 1–8.

First published online April 26, 2017, <https://doi.org/10.1144/SP452.19>

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Publishing disclaimer: www.geolsoc.org.uk/pub_ethics

Monastic Schools that preserved the teaching and continuance of science in a strongly religious environment. Prominent characters who incorporated geological materials in their medical writings and in encyclopaedic compilations of knowledge included the Abbess Hildegard von Bingen (1098–1179), Isidore of Seville (Isidorus Hispalensis: c. 560–636) and Rabanus Maurus Magnentius (c. 780–856). During the later Middle Ages, the Monastic Schools gave way to the establishment of medieval universities during the twelfth century. Highly productive interchange between these institutions and the Islamic world meant that previously lost classical texts and those of new Arabic scholarship were made available to the West; a furious programme of translation and copying at dedicated scriptoria ushered in a medieval renaissance. The rise of scholasticism saw the rediscovery of Aristotelianism and the emergence of notable philosophers and encyclopaedists, who, once again, largely combined knowledge of geological materials with their suggested pharmaceutical applications. These scholars included such famous names as Thomas of Cantimpré (1201–72), Bartholomaeus Anglicus (before 1203–72), Vincent de Beauvais (c. 1190–1264), Albertus Magnus (c. 1200–80) and Konrad von Megenberg (1309–74) (see Duffin 2013 for further details).

A pronounced philosophical shift away from Aristotelianism as part of the Northern Renaissance (i.e. in the area north of the Alps, as opposed to the slightly earlier Italian Renaissance) paved the way for a closer focus on the individual sciences. The advent of printing in the mid-fifteenth century then meant that many individual texts could be produced rapidly and relatively cheaply (compared to copying texts by hand), ensuring wide and efficient distribution of classical texts, commentaries and new ideas. It was not long before the ancient and seemingly unassailable authority of classical authors, Galen, Dioscorides Pliny and others, together with the assertions of medieval Arabic and European authors, was being questioned and challenged. Blind reliance on received wisdom and an Aristotelian approach to scientific enquiry (utilizing observation and searching for ‘natural’ circumstances through reasoning) was gradually replaced by empiricism, in response to the establishment of inductive methodologies for scientific inquiry by Francis Bacon (1561–1626). The transition was not always a comfortable one, the case of Philippus Aureolus Theophrastus Bombastus von Hohenheim (Paracelsus: 1493–1541) and the resurgence of alchemy being a case in point; this particular revolution paved the way for the eventual development of iatrochemistry and chemical pharmacology. In medicine, the anatomical precepts of Galen were overturned by the closely observed human dissections

performed by Andreas Vesalius (1514–64) and published in his ground breaking work of 1543 (*De humani corporis fabrica*).

The demand for metals stimulated the taking of great strides in the location, extraction and refinement of ores, the products of which were so crucial to the work of the alchemists. Georg Agricola (1494–1555) famously published his *De Re Metallica* (posthumously) in 1556 (Vesalius 1556). Interest in the natural world during the sixteenth century was also marked by the incorporation of geological, botanical, zoological, historical and ethnographical specimens into cabinets of curiosity. Apothecaries and professors of medicine were among those who made and wrote about their collections, including the Neapolitan Ferrante Imperato (1550–1625), Francesco Calceolari I (1521–1600 or 1522–1606) from Verona, Michel Mercati (1541–93) from the Vatican in Rome, Ole Worm (1588–1654) from Copenhagen and Michael Bernhard Valentini (1657–1729) of Giessen.

Following a period of description of the elements of the natural world, the seventeenth and eighteenth centuries were marked by increasingly successful attempts to rationalize, systematize and produce accessible syntheses of the plant, animal and mineral realms. The establishment of learned societies helped to foster intellectual alliances and the cross-fertilization of ideas, to investigate questions of interest, and to disseminate the research of their members and fellows through their publications.

The rise of geology as an independent scientific discipline is usually traced back to the first use of the word ‘geology’ in its modern sense by Ulisse Aldrovandi in 1603 (Vai & Cavazza 2006). Aldrovandi (1522–1605) had broad interests, which are reflected in a wide set of academic achievements, including a degree in philosophy and medicine from Bologna (1553), and the teaching of medical botany (1556). The evolution of geological enquiry benefited from the same fifteenth–seventeenth century philosophical and technological innovations as did medicine, but its development proceeded at a slower pace. Foundational work was certainly accomplished by a suite of renaissance philosophers, many of whom trained originally in medicine: for example, Conrad Gessner (1516–65), City Physician of Zürich, produced the first systematic treatment of fossils (Gessner 1565), an approach considerably expanded by Anselm Boetius de Boodt (1550–1632: Boodt 1609), Court Physician to Emperor Rudolph II in Prague. The great anatomist, Nicolas Steno (1638–1686), laid the foundations of stratigraphy (Steno 1669), as well as introducing fundamental concepts in crystallography and palaeontology (Steno 1667, 1669).

It was not until the nineteenth century that a geology and/or mineralogy syllabus began to

appear in university curricula, supported by a suitably dedicated professorial staff. This was also true for professional geological positions. The establishment of professional societies in the same century, as well as the rise in education of the middle and lower classes, the popularity and activities of field clubs, and public lectures meant that, once an unseen threshold had been breached, geology enjoyed both a popular and a professional renaissance. The intervening centuries of the early modern period drew its geological innovation and expertise from a variety of polymaths, and established professions including the church and, especially, medicine. Thus, the history of geology is littered with the names of medical and medically trained professionals who made fundamental contributions to the fledgling science.

Men and methods

Otto Sperling (1602–81) studied medicine at Greifswald (1617–18), Leiden (1619–21) and Rostock (1622–23), eventually becoming *Doctor Medicinae* at the University of Padua (1627). In 1641 he was appointed *Stadtphysicus* in Copenhagen, and acted as *Leibarztes* to King Christian IV. This position brought him into close association with the nobleman and statesman Corfitz Ulfeldt (1606–64), who was later to be named the worst traitor in Danish history. Following the death of Christian IV, Ulfeldt was accused of plotting against his successor, Frederick III (1609–70); Sperling fled with Ulfeldt to The Netherlands. Sperling was eventually arrested and held in the infamous Blue Tower (*Blåtårn*), a tower specifically used as a prison at the Royal palace in Copenhagen. Here, Sperling languished for 17 years until his eventual death. While incarcerated, Sperling wrote an autobiography for his children. **Hoch (2017)** uses this autobiography as a means of examining Sperling's interests in medicine and natural history, with special emphasis on fossils and minerals, against the complex backdrop of contemporary Nordic political and intellectual history.

The therapeutic use of mineral waters in the UK saw something of a renaissance, beginning in Elizabethan times and gathering pace in the late seventeenth century. As additions to the well-established Roman centres at thermal springs (at Bath, for example), numerous cold-water bathing spas became popular, as did the drinking spas in and adjacent to London. One of the earliest of the London sources of mineral waters was situated at Shooter's Hill, currently located in the Royal Borough of Greenwich. **Mather & Duffin (2016)** have ascribed the first notice (1673) of the 'Purging waters' of Shooter's Hill, derived from sandy

horizons in the London Clay Formation, to Nathaniel Hodges (1629–88), a London physician who is better known as one of the limited number of medical personnel who remained in the capital to care for the sick during the year of the Great Plague (1665). Once established, use of the Shooter's Hill waters by local people continued for more than 200 years; at one point it enjoyed fame as a more prolific and cheaper source of Epsom salts (magnesium sulphate) than the more established centres of production at Epsom and Acton.

The water theme is continued by **Porro et al. (2016)** in their consideration of the ways in which the complex needs of the Milanese water supply system were addressed at the end of the nineteenth century. Shallow wells provided the Milanese with drinking water of sufficiently good quality to maintain metropolitan health until industrialization of the city took place following the establishment of rail linkages. By the 1870s it was clear that the quality of local drinking water was becoming compromised, so the Cagnola Award was offered by the Lombard Institute in an open competition to undertake a three-component study to address the problem. In addition to possible contamination by industrial products, other potential threats to the water supply included cemetery and hospital wastewater entering the drainage system. Furthermore, the hospitals required access to a non-polluted water supply. The authors trace the historical threads of these problems and the various approaches to their final solution.

Italy has long been acknowledged an important centre for discussion and the generation of geological ideas, especially during the sixteenth and early seventeenth centuries (Vai & Caldwell 2006). **Pantaloni et al. (2017)** present a very useful overview of the contributions to geology of a succession of medically trained Italian scientists from late medieval times to the early twentieth century. They consider the lives and contributions of some of the household names of the early history of geology, including the eminent characters Girolamo Fracastoro (1476–1553), Gerolamo Cardano (1501–76), Niels Stensen (1638–86) and Antonio Vallisneri (1662–1730). This is supplemented by consideration of less well-known (outside Italy) contributors Francesco Serao (1702–83), a pioneer of Vesuvian geology, the geomorphologist and stratigrapher Tommaso Antonio Catullo (1782–1869), the Sicilian geologist Carlo Gemmellaro (1787–1866), and the nineteenth century geologists Leopoldo Pilla (1805–48), Giuseppe Ponzi (1805–85), Giuseppe Arcangelo Scacchi (1811–93), Giuseppe Giovanni Antonio Meneghini (1811–89), Giulio Andrea Pirona (1822–96) and Gaetano Giorgio Gemmellaro (1832–1904).

Georgian London saw a surge of interest in geology, as reflected in the amassing of collections of

specimens for personal *naturalia* cabinets, discussion of questions of interest at scientific bodies at the Royal Society and elsewhere, and the production of semi-popular texts by Emanuel Mendes da Costa (1717–91) and Sir John Hill (1714–75) (Duffin 2017b). **Liston & Alcalá (2017)** consider two prominent late Georgian medical practitioners: William Hunter (1718–83) and James Parkinson (1755–1824). Although sharing a passion for palaeontology, these two great collectors and natural philosophers probably never met; a comparison of their lives and work reveals a good deal of circumstantial overlap, as well as significant differences, against a background of fundamental intellectual upheaval.

Like many medical professionals, the Catalan physician Pau Estorch Siqués (1805–71) was a man of many parts; he was a teacher, poet, translator, businessman and arts correspondent. **Sabaté Casellas & Torres Gallardo (2017)** briefly examine the contribution to public health of this individual who is otherwise now little known outside his home area. He was instrumental in the setting up of public baths in a place and time when accessible drinking water and effective sewage removal were the exception rather than the rule, thereby ensuring hygienic accessibility to clean water by members of the community. Estorch Siqués is also known for his interest in the *pedra escurçonera* (antivenomous stone) which he called his *magnes venenorum*. Having observed its topical use in the treatment of snakebite in rural communities, Estorch Siqués carried out some clinical trials, concluding that the stone was efficacious when used topically and internally against anthrax, rabies, smallpox, plague, pustules and some venereal diseases.

The temporal transition from the nineteenth to the twentieth century was marked not only by considerable changes in the intellectual climate but also, with societal and educational transformations, increasing professionalization and specialization in science. **Carter & Spurgeon (2016)** use the father and son duo of Peter Martin Duncan (1824–91) and Cecil Cooke Duncan (1868–1948) to investigate something of the changing development of the professions, scientific expertise and changes to education taking place over this pivotal time period. Following a medical apprenticeship, Peter Martin Duncan practised medicine in Colchester. His geological interests led to his election as FRS (1868) for his work on fossil corals, and he was able to segue into a new career, becoming Professor of Geology at King's College, London from 1870, and President of the Geological Society from 1876 to 1878. Cecil Cooke Duncan studied chemistry and went on to become a public analyst. Both Duncans were accomplished polymaths with wide-ranging scientific, including geological, interests. They were men of their respective times, however, and

the freedom to cross poorly defined professional boundaries by the father was not compatible with the increasingly stringently defined professional demarcations experienced by the son.

Another nineteenth century polymath, Victor Lemoine (1837–97), is the subject of scrutiny by **Buffetaut (2016)**. A native of Reims, a city in the Champagne Region of the Grand Est area of France, Lemoine studied medicine in Paris before returning to his home town where eventually he rose to become Professor of Medicine at the medical school. Possessed of wide-ranging scientific interests, his publication record includes papers on medicine, radiography, embryology, invertebrate anatomy and botany. His greatest contribution was in the sphere of vertebrate palaeontology, with a long series of papers on the early Tertiary fauna of the Cernay Conglomerate (late Thanetian), cropping out just to the east of the city. Lemoine described various fossil mammals (e.g. *Arctocyon*, *Plesiadapis* and *Neoplagiaulax*), reptiles (champsosaurs) and birds (*Gastornis*). His opinions drew him into conflict with one of the most influential vertebrate palaeontologists of the day, the Belgian Louis Dollo (1857–1931), and also attracted the attention of American palaeontologists Othniel Charles Marsh (1831–99), Edward Drinker Cope (1840–97) and Henry Fairfield Osborn (1857–1935); the latter two visited him in Reims to view his collection. Leaving Reims in 1889 to settle in Paris, Lemoine applied the newly developed X-ray technology to the study of entomology and zoology, and realized its potential in palaeontology; unfortunately, he died before he could expand these investigations further.

Materials

Medicinal earths have been known and exploited since antiquity (Macgregor 2013). Long believed to be useful for their astringent (shrinking or constricting body tissues), alexipharmic (acting as an antidote to poison) and desiccative (drying ability or absorbency) properties, medicinal clays have been exploited from deposits on Greek islands (e.g. Lemnos, Saos, Chios, Kimolos), Malta, Palestine, Armenia, Turkey and various localities in central and western Europe. Probably the most famous is lemnian earth (*terra lemnia*), which was extracted under strict ritual observance in classical times, worked into pastilles or troches, and authenticated by means of embossed stamps to become *terra sigillata* (sealed earths) or Lemnian *sphragides* (Lemnian seals). Using the Hippocratic Corpus (a collection of around 60 Ancient Greek medical works closely associated with Hippocrates and ranging in date from the fifth to the fourth century BC)

and the works of Galen (c. 129–c. 210) and Dioscorides (c. 40–90), **Retzas (2016)** considers the ancient therapeutic uses of *terra lemnia* with reference to the manuscript catalogues of Sir Hans Sloane (1660–1753).

Photos-Jones et al. (2017) subject historical material of Lemnian *sphragides* and samples of sedimentary clays from a variety of depths recovered from Kotsinas (the general area on Lemnos yielding historically important lemnian earths) to mineralogical, chemical and microbiological analysis. Interestingly, they found that the historical *sphragides* samples demonstrated significant antibacterial properties against the Gram-positive pathogenic bacterium *Staphylococcus aureus*, but no such effect against the Gram-negative *Pseudomonas aeruginosa*; the Kotsinas sedimentary clays displayed no such antibacterial effects. The differences between the historical and modern samples may be the consequence of secondary fungal metabolites in the former. Clearly, this is an area worthy of further development.

In addition to medicinal clays, some fabulous stones derived from the bodies of living animals have been claimed to have prophylactic and therapeutic powers since classical times. The Alectorius or Capon Stone is one such item, commonly reported in lapidary and medical literature from the second century BC to the late seventeenth century. Purportedly derived from various parts of the anatomy of a castrated cockerel, the stone has been associated in the literature with a wide range of therapeutic benefits including slaking thirst, increasing sociability, curing impotence, promoting conception, increasing lactation and treating diseases of the eye. **Carrasco & Duffin (2017)** raise the hypothesis for further discussion that, if viewed as a biliary calculus, the stone might conceivably possess parasympathomimetic properties: that is, it might contain pharmacologically active ingredients which, acting as mimics of the parasympathetic nervous system, could result in the collection of properties historically ascribed to it.

A further fabulous stone of animal origin is the snake stone or serpent stone. Scouring a wide and diffuse literature, **Pymm (2016)** produces a classification of serpent stones, identifying: (1) dragon stones or *Draconites*, largely mythical stones supposedly cut from the head of a living dragon and which, apart from the Lucerne Dragon stone, seem to be unrepresented by extant specimens; (2) snake stones, supposedly harvested from the heads of snakes and used to treat snakebite, with extant specimens comprising charred bone; (3) ammonite snake stones, associated with the legends of St Hilda and St Keyna in the Whitby and Keynsham areas of Britain, respectively, and also revered as *Salagrama Sila* or avatars of Vishnu in Hindu

mythology; (4) snakestone beads or adder stones, the *ovum anguinum* of Pliny the Elder; and (5) *Ophites*, probably referring to serpentinite.

Snakestone beads are addressed in more detail in a second contribution from **Pymm (2017)**, who finds they have been associated with fossil cidaroid echinoid tests (as *ovum anguinum*) and archaeological finds of holed stones, Neolithic and Iron Age glass and vitreous paste beads, and medieval spindle whorls. A survey of their medicinal uses shows that they were employed to ease childbirth, and in the treatment of some severe childhood diseases (e.g. teething, whooping cough and ague), snakebite and eye diseases, as well as having veterinary applications in the cases of diseased cattle. Furthermore, they were also utilized as charms against witchcraft and the activities of evil spirits, and as amuletic lucky stones.

The Eagle stone or *Aetites* is a fabulous stone credited with remarkable obstetrical powers; in European folklore it was believed to be effective in the control of childbirth by means of magnetic forces acting on the foetus. Anchoring the stone, usually a siderite nodule, in the abdominal region of the pregnant mother supposedly prevented abortion and miscarriage, helping to maintain the position of the baby within the womb, while delivery was facilitated by tying it to the leg. Eagle stones were also used to treat epilepsy, plague, dysentery, carbuncles and a range of other diseases, as well as deterring snakes and exposing thieves. They were sometimes set in silver mounts and worn as amulets. The stone itself was believed to be collected by eagles and taken to their nests, where it was used to ensure successful hatching of the eggs and to prevent adulling. **Podgorny (2017)** investigates the transfer of both the name and its attendant therapeutic virtues from early modern Spanish folk medicine to South America from the close of the fifteenth century onwards; ‘piedras de águila’ of the Andean region included terebratulid brachiopods including *Clarkeia anteniensis*, spiriferid brachiopods such as *Gypospirifer condor* and *Spirifer boliviensis*, and certain Andean minerals.

The unicorn is a mythical animal. While the origins of the unicorn myth are open to debate, reverence for, and belief in, the animal clearly took on a life of their own, propagated through classical and medieval legend and lore, and were reinforced by the discoveries of supposed actual remains, especially of the horn. Credited with the valuable property of being able to detect and neutralize poisons, unicorn horn became an indispensable therapeutic component of the *materia medica* (being adopted as a symbol of the apothecary in many European countries), as well as being pressed into service as an essential item of assaying tableware at grand feasts for the nobility. For example, a servant

proffers a wine goblet of unicorn horn to the royal couple, Esther (Jewish Queen) and Ahaseurus (Persian King), surrounded by musicians, in a fifteenth century tapestry depicting the exaltation of Esther to the Persian throne (Museo de Tapices de la Seo, Cathedral of Zaragoza, Spain; Torra de Arana *et al.* 1985). The question as to whether unicorn horn goblets and other unicorn *épreuves* were actually used for assaying purposes during medieval times is made clear by the protocols developed for the banquet celebrating the installation of George Neville (c. 1432–76) as Archbishop of York and Chancellor of England in 1467. Unicorn horn was passed over the tablecloth and tapestry hangings in order to test for poison during the laying out of the banquet linens; the prince washed his hands in water that had previously been tested with unicorn horn, and then dried them on a towel or napkin that had a complex journey to the table including being draped for a time over a unicorn horn sample held in a small dish. Each of the components of the meal was assayed by various means before they reached the table, and each of the drinks was tested by having a piece of unicorn horn dipped into them (Stevens 1723, appendix, p. 22; Warner 1791, p. 101 ff.; Scully 1995, p. 251). **Duffin (2017a)** reviews the history of unicorn horn as a component of medicinal remedies and finds that candidates for the horn included both narwhal ‘tusks’ and fossil remains, particularly of mammoths. The distinction between ‘true’ and ‘false’ horn was a matter of furious debate, while the incidence of fraudulent substitutes necessitated the development of a variety of tests of authentication. From the late sixteenth century onwards, further naturally occurring and synthetic materials with similar properties to unicorn horn were marketed as mineral unicorn (*Terra Silesiaca*) and Solar unicorn, respectively. These various ingredients were incorporated into a wide range of compound pharmaceutical preparations and used to treat a huge diversity of ailments and conditions.

Precious and semi-precious gems also had a place in the pharmacopoeia, being incorporated into various pastes, electuaries and simples to treat those members of the sick who could afford such expensive interventions. The deep, intense colours and durability of the stones led to beliefs in their possession of magical virtues. They were also used for personal adornment, of course, and there are numerous reports of jewels being ascribed curative powers, particularly during the sixteenth and seventeenth centuries, raising the question as to whether it is possible to determine whether they were worn predominantly for their aesthetic value or for their supposed prophylactic and therapeutic virtues. **Blaen (2016)** examines this contention using written sources and examples of contemporary material culture, concluding that the less

eye-catching gems – for example, toad stones (fossil fish teeth) – furnish the best examples of clearly medicinal amuletic stones.

The mineralized skeletons of Recent (and, to a lesser extent, fossil) corals were also popular ingredients in compound medicinal preparations. Harvested from the Mediterranean Sea by crude bottom-dredging techniques and by individual divers, variously coloured corals were employed medicinally, but the most popular (also as a gemstone and item in *naturalia* cabinets) was the red variety, *Corallum rubrum*. **Sameiro Barroso (2016)** surveys the various amuletic and therapeutic uses for which coral was recommended by the physician who became Pope, Petrus Hispanus (c. 1215–77). He advocated its use both as an amulet and as an ingredient in a variety of medicines used, for example, to treat a range of dental and gastric problems, syncope, and as an anti-haemorrhagic.

Utilized since Neolithic times, lead has been exploited for numerous purposes, ranging from a component in cosmetics through to plumbing materials to the more familiar diversity of industrial, military and automotive applications of the present day. Pollution of the atmosphere by anthropogenic lead was brought about by inefficient smelting processes, the addition of tetraethyl lead to motor fuel, and the residual effects use of its military use. The record of atmospheric contamination from various lead sources famously has been preserved in the ratios of the various isotopes of the element in Arctic and Antarctic ice cores. **Bergman (2016)** reviews the history of use of lead as a resource, its detection and importance as a toxic environmental contaminant, its uptake by the body, and its impact on both human health and the environment.

We hope it is clear both from this volume and its predecessor that geology and medicine share many historical links; the intellectual roots of both disciplines can be traced to similar and, in some cases, identical, classical, middle eastern and European sources; numerous medical personnel not only brought innovation to their chosen profession but also made significant contributions to the development of the Earth Sciences; and a wide range of geological materials has been employed, with varying degrees of efficacy, in the development of the *materia medica*. The common historical ground between geology and medicine is rich with further possible research opportunities, and we hope that this albeit early excursion into the field will prove to be both a useful resource and a stimulus to further enquiry.

The Editors and the History of Geology Group would like to thank the Geological Society of London for their support throughout the development and realization of this project, as well as the considerable number of referees from a wide

range of academic disciplines who lent their professional expertise to the critical assessment of the contributions to this volume and the improvement of its content.

References

- AGRICOLA, G. 1556. *De re metallica libri XII. Quibus officia, instrumenta, machinae, ad omnia denique ad metallicam spectantia, non modo luculentissime describuntur, sed et per effigies ... adjunctis latinis germanicisque appellationibus ita ob oculos ponuntur, ut clarius tradi non possint. Ejusdem de animalibus subterraneis liber ... Cum indicibus diversis.* H. Froben & N. Bischoff, Basle.
- BERGMAN, B.P. 2016. Lead, isotopes and ice: a deadly legacy revealed. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 19, 2016, <https://doi.org/10.1144/SP452.2>
- BLAEN, T. 2016. 'Not used to be worn as a Jewel': the wearing of precious stones in early modern England – ornaments or medicine? In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 22, 2016, <https://doi.org/10.1144/SP452.10>
- BOODT, A.B.De. 1609. *Gemmarum et lapidum Historia, Qua non solum ortus, natura, vis & precium, sed etiam modus quo ex iis olea, salia, tincturae, essentiae, arcana & magisteria arte chymica confici possint, ostenditur.* Typis Wecheliani, apud Claudium Marimum & heredes Ioannis Aubrii, Hannoveriae.
- BUFFETAUT, E. 2016. From giant birds to X-rays: Victor Lemoine (1837–97), physician and palaeontologist. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 19, 2016, <https://doi.org/10.1144/SP452.3>
- CAMPBELL THOMPSON, R. 1936. *A Dictionary of Assyrian Chemistry and Geology*. Clarendon Press, Oxford.
- CARRASCO, J. & DUFFIN, C.J. 2017. Alectorius: a parasymphathomimetic stone? In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online February 21, 2017, <https://doi.org/10.1144/SP452.15>
- CARTER, T. & SPURGEON, A. 2016. Duncan and Son: changing professional boundaries in the geological and medical sciences in the nineteenth and twentieth centuries. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 19, 2016, <https://doi.org/10.1144/SP452.8>
- DUFFIN, C.J. 2013. Lithotherapeutical research sources from antiquity to the mid-eighteenth century. In: DUFFIN, C.J., MOODY, R.T.J. & GARDNER-THORPE, C. (eds) *A History of Geology and Medicine*. Geological Society, London, Special Publications, **375**, 7–43, <https://doi.org/10.1144/SP375.25>
- DUFFIN, C.J. 2017a. 'Fish', fossil and fake: medicinal unicorn horn. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online March 1, 2017, <https://doi.org/10.1144/SP452.16>
- DUFFIN, C.J. 2017b. A dwarf on giant's shoulders: Sir John Hill and geology. In: BRANT, C. & ROUSSEAU, G. (eds) *Fame & Fortune: Sir John Hill and London Life in the 1750s*. Palgrave, London, in press.
- DUFFIN, C.J., MOODY, R.T.J. & GARDNER-THORPE, C. (eds). 2013. *A History of Geology and Medicine*. Geological Society of London, Special Publication, **375**, <http://sp.lyellcollection.org/content/375/1>
- ERMAN, A. 1901. Zaubersprüche für Mutter und Kind. Aus dem Papyrus 3027 des Berliner Museums. *Abhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, **1901**, 1–52.
- GESSNER, C. 1565. *De Rerum Fossilium Lapidum et Gemmarum maximè, figures & similitudinibus Liber: non solum Medicis, sed omnibus rerum Naturae ac Philologiae studiosis, utilis & iuncundus futurus.* Jacobus Gesnerus, Tiguri.
- HOCH, E. 2017. Earth science as a philosophical background to medicine: an essay based on the autobiography of Dr Otto Sperling (1602–81). In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online April 10, 2017, <https://doi.org/10.1144/SP452.18>
- LISTON, J.J. & ALCALÁ, L. 2017. The obstetrician, the surgeon and the premature birth of the world's first dinosaur: William Hunter and James Parkinson. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online January 18, 2017, <https://doi.org/10.1144/SP452.7>
- MACGREGOR, A. 2013. Medicinal terra sigillata: a historical, geographical and typological review. In: DUFFIN, C.J., MOODY, R.T.J. & GARDNER-THORPE, C. (eds) *A History of Geology and Medicine*. Geological Society, London, Special Publications, **375**, 113–136, <https://doi.org/10.1144/SP375.1>
- MATHER, J.D. & DUFFIN, C.J. 2016. Nathaniel Hodges and the purging wells of Shooter's Hill. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 19, 2016, <https://doi.org/10.1144/SP452.4>
- PANTALONI, M., CONSOLE, F., LORUSSO, L., PETTI, F.M., FRANCHINI, A.F., PORRO, A. & ROMANO, M. 2017. Italian physicians' contribution to geosciences. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online March 22, 2017, <https://doi.org/10.1144/SP452.17>
- PHOTOS-JONES, E., EDWARDS, C., HÄNER, F., LAWTON, L., KEANE, C., LEANORD, A. & PERDIKATSI, V. 2017.

- Archaeological medicinal earths as antibacterial agents: the case of the Basel Lemnian *sphragides*. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online February 2, 2017, <https://doi.org/10.1144/SP452.6>
- PODGORNY, I. 2017. The name is the message: eagle-stones and materia medica in South America. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online February 27, 2017, <https://doi.org/10.1144/SP452.14>
- PORRO, A., FRANCHINI, A.F., FALCONI, B., GALIMBERTI, P.M. & LORUSSO, L. 2016. Water and the city of Milan at the end of the nineteenth century. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 22, 2016, <https://doi.org/10.1144/SP452.9>
- PYMM, R. 2016. 'Serpent stones': myth and medical application. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 19, 2016, <https://doi.org/10.1144/SP452.1>
- PYMM, R. 2017. 'A charm to impose on the vulgar': the medicinal and magical applications of the snakestone bead within the British Isles. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online February 2, 2017, <https://doi.org/10.1144/SP452.13>
- RETSAS, S. 2016. Geotherapeutics: the medicinal use of earths, minerals and metals from antiquity to the twenty-first century. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 20, 2016, <https://doi.org/10.1144/SP452.5>
- SABATÉ CASELLAS, F. & TORRES GALLARDO, B. 2017. Pau Estorch Siqués (1805–71) and his 'magnes venenorum'. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online February 2, 2017, <https://doi.org/10.1144/SP452.12>
- SAMEIRO BARROSO, M.do. 2016. Coral in Petrus Hispanus' 'Treasury of the Poor'. In: DUFFIN, C.J., GARDNER-THORPE, C. & MOODY, R.T.J. (eds) *Geology and Medicine: Historical Connections*. Geological Society, London, Special Publications, **452**. First published online December 22, 2016, <https://doi.org/10.1144/SP452.11>
- SCULLY, T. 1995. *The Art of Cookery in the Middle Ages*. The Boydell Press, Woodridge.
- STENO, N. 1667. *Elementorum myologiae specimen, seu musculi descriptio geometrica. Cui accedunt canis carchariae dissectum caput, et dissectus piscis ex canum genere*. [Joseph Cocchini], Florence.
- STENO, N. 1669. *De solido intra solidum naturaliter contento dissertationis prodromus*. [Jacobum Moukeek], Florence.
- STEVENS, J. 1723. *The History of the Antient Abbeys, Monasteries, Hospitals, Cathedrals and Collegiate Churches. Being Two Additional Volumes to Sir William Dugdale's Monasticon Anglicanum. Volume II*. Jos. Smith, Tho. Taylor, Luke Stokoe, John Senex, W. Taylor, T. Meighan, J. Batley, And. Johnston, W. Bray, R. King, and Tho. Cox, London.
- TORRA DE ARANA, E., HOMBRÍA TORTAJADA, A. & DOMINGO PÉREZ, T. 1985. *Los Tapices de la Seo de Zaragoza*. La Caja de Ahorros de la Inmaculada, Aragon.
- VAI, G.B. & CALDWELL, W.G.E. (eds) 2006. *The Origins of Geology in Italy*. Geological Society of America, Special Papers, **411**.
- VAI, G.B. & CAVAZZA, W.G.E. 2006. Ulisse Aldrovandi and the origin of geology and science. In: VAI, G.B. & CALDWELL, W.G.E. (eds) *The Origins of Geology in Italy*. Geological Society of America, Special Papers, **411**, 43–63.
- VESALIUS, A. 1543. *De Humani Corporis Fabrica Libri Septem*. [ex officina Ioannis Oporini], Basiliae.
- WARNER, R. 1791. *Antiquitates Culinae or Curious Tracts Relating to the Culinary Affairs of the Old English, With a Preliminary Discourse, Notes and Illustrations*. R. Blamire, London.