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Medicine for the Material World

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ABSTRACT

It is clear that many of the inorganic materials of antiquity have been used both as medicines for human ills and also as agents in technological processes. This paper speculates that there might have been a stronger link between these two functions in the past, based on the concept of "active agents"—materials that are efficacious at curing human ills are also effective in curing "ills" in the material world, such as soft metal or discolored glass. More broadly, this paper is intended to encourage scholars to take a wider perspective on the role of inorganic materials in human lives, rather than being constrained by what might be an arbitrary division between the histories of medicinal pharmacology and technological processes.

It has been frequently recognized that the mineral raw materials of antiquity could have multiple uses—an obvious example, expanded upon below, is the use of a compound of zinc (zinc oxide; ZnO, calamine) as a treatment for eye disorders and skin diseases, but also the use of a related agent ($ZnCO_3$, also referred to as calamine) in the production of brass before the availability of metallic zinc to mix with copper. However, such multiple usage is rarely commented on or considered together, and the phenomenon of parallel utility has not been studied systematically. The reasons for this are obvious—one falls within the domain of the history of medicine, and the other within the purview of historical technology, and rarely do these fields overlap. The aim of this paper is twofold—one is to encourage researchers to bring these two disciplines closer together, but the second, more contentiously, is to suggest that crossover between pharmaceutical and technological regimes might have offered an additional driver for the adoption of new technologies in the material world. The term technology is here restricted to those actions that result in the production of a finished artifact—raw material collection and conversion; processing and manufacturing; recycling and re-use, etc. Technological change is often seen as a consequence of either technological "push" (the adoption of an innovative development) or societal "pull" (whereby specific technological improvements are identified as necessary and processes modified accordingly). Technological "push" can result when a new process (or a new step in a process) is developed, either by accidental minor variation or deliberate experimentation, resulting in some perceived improvement in the product. Occasionally, such gradual developments are superseded by something radical—a spark of individual innovation or a new process adopted as a result of the diffusion of ideas, perhaps by artisans traveling, or by immigrants bringing new technologies. Sometimes these new processes will wither and die, as a consequence of a lack of uptake of the product (the "flickering candle" effect; Pollard and Gosden 2023: 47), but occasionally the process is integrated into common practice and some new technology has been invented.

The dual use of mineral reagents, such as the compounds of zinc used to cure human ills and in technological processes, prompts us to ask what was the relationship between these two branches of human activity in the past. As noted above, in the modern world, these domains are usually considered to be separate, but was there some form of "technological transfer" in the past? If this did occur, then it might suggest some deeper philosophical relationship between the medical and material worlds—either a

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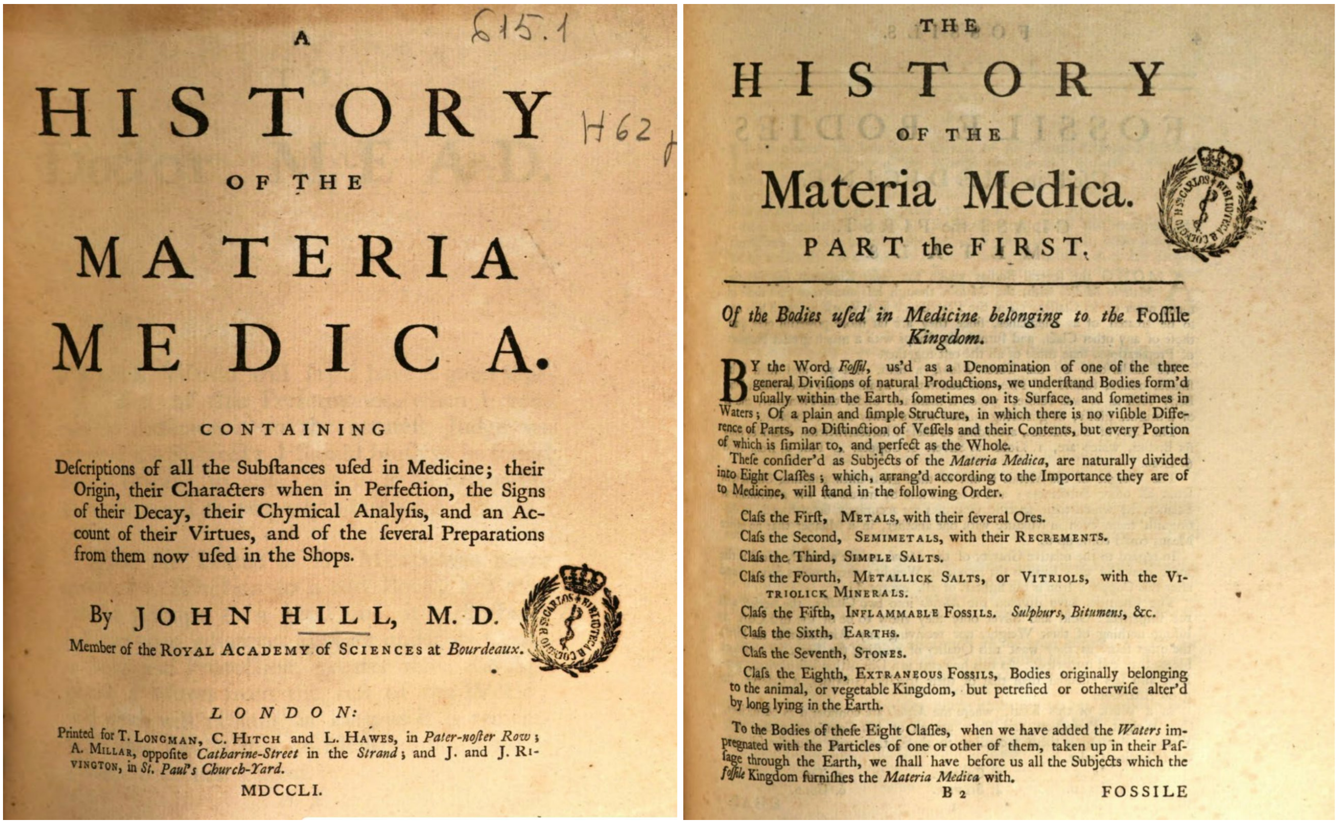
lack of clear distinction between animate and inanimate beings (as is still common in some parts of the modern world), or a feeling that the *materia medica* efficacious in treating human (or animal) conditions might also have some value in treating the "diseases" of the material world, if we take the view that technological processes such as the hardening of metals or the coloring of glass could be seen as the remediation of some perceived deficiency in the material. If this was true, then it could be that developments in pharmacology provided an additional driver for the adoption of technological change.

Evidence for such relationships is inevitably hard to come by, partly because most modern scholarship, constrained by the exclusivity of the medical and material worlds, rarely makes such connections, but also because it is virtually impossible to pinpoint the first use of a medicine or a technological process, either in time or space. Progress, albeit somewhat tenuous, can be made in two related ways—one is simply to observe coincidences of use in the archaeological record, as exemplified by the zinc example; the other is to seek literary evidence from the small part of the ancient world that was literate. Each of the individual worlds of medicine and material culture has extensive historical bibliographies and commentaries, which cannot be adequately summarized here (e.g., for the history of medicine, see Nutton (2024), and for a recent commentary on the history of technology, Pollard and Gosden (2023)).

Various compendia of medical agents have been produced across Europe, India and China for more than 2000 years. In Europe, the first known comprehensive text is that of Dioscorides (c. 40–c. 90 CE), whose five-volume "De materia medica" (Περὶ ὕλης ἰατρικῆς) became the reference pharmacopeia for more than 1500 years (Beck 2011; Riddle 1985). An English *materia medica* published by Hill (1751) has a reasonable claim to be the first trade catalogue for pharmaceutical supplies, giving an "account of their virtues, and of the several preparations from them now used in the shops". He classifies the materials into three groups—those belonging to the "fossil kingdom" (defined as "bodies formed usually in the Earth, sometimes on its surface, and sometimes in waters"), the vegetable kingdom and the animal kingdom. In most *materia medica*, the bulk of the identified products originate in the Vegetable Kingdom, but there are a substantial number of metals and minerals listed (Figure 1). Considering such literary records, a cursory glance at the typical contents of ancient treatises on the mineral components of *materia medica* would suggest that many if not all of the mineral agents listed there have also found some technological application.

On the face of it, this "dual use" of mineral agents is unsurprising. Essentially, if a material is employed for one purpose, it is perhaps inevitable that it will also be used for something else—a simple consequence of availability. If so, then the interest here is simply the observation of the transfer of these reagents between different sets of practitioners. One might, however, also ask a related question—given that the vast majority of active agents listed in most *materia medica* originate from the plant kingdom, why do these not feature more in our interpretations of technological processes that lead to the production of inorganic materials? The answer, of course, is that in most cases we do not really know whether this is true or not. For processes involving high temperatures (most obviously ceramic and glass manufacture,



A

HISTORY

OF THE

MATERIA

MEDICA.

CONTAINING

Deſcriptions of all the Subſtances uſed in Medicine; their Origin, their Characters when in Perfection, the Signs of their Decay, their Chymical Analyſis, and an Account of their Virtues, and of the ſeveral Preparations from them now uſed in the Shops.

By JOHN HILL, M. D.
Member of the Royal Academy of Sciences at *Bourdeaux*.

LONDON:
Printed for T. Longman, C. Hitch and L. Hawes, in *Pater-noſter Row*; A. Millar, oppoſite *Catharine-Street* in the *Strand*; and J. and J. Rivington, in *St. Paul's Church-Yard.*
MDCCLI.

THE

HISTORY

OF THE

Materia Medica.

PART the FIRST.

Of the Bodies uſed in Medicine belonging to the Foſſile *Kingdom.*

BY the Word *Foſſil*, us'd as a Denomination of one of the three general Diviſions of natural Productions, we underſtand Bodies form'd uſually within the Earth, ſometimes on its Surface, and ſometimes in Waters; Of a plain and ſimple Structure, in which there is no viſible Difference of Parts, no Diſtinction of Veſſels and their Contents, but every Portion of which is ſimilar to, and perfect as the Whole.

Theſe conſider'd as Subjects of the *Materia Medica*, are naturally divided into Eight Claſſes; which, arrang'd according to the Importance they are of to Medicine, will ſtand in the following Order.

Claſs the Firſt, Metals, with their ſeveral Ores.
Claſs the Second, Semimetals, with their Recrements.
Claſs the Third, Simple Salts.
Claſs the Fourth, Metallick Salts, or Vitriols, with the Vitriolick Minerals.
Claſs the Fifth, Inflammable Fossils. *Sulphurs*, *Bitumens*, &c.
Claſs the Sixth, Earths.
Claſs the Seventh, Stones.
Claſs the Eighth, Extraneous Fossils, Bodies originally belonging to the animal, or vegetable Kingdom, but petrefied or otherwiſe alter'd by long lying in the Earth.

To the Bodies of theſe Eight Claſſes, when we have added the *Waters* impregnated with the Particles of one or other of them, taken up in their Paſſage through the Earth, we ſhall have before us all the Subjects which the *foſſile* Kingdom furniſhes the *Materia Medica* with.

B 2 FOSSILE

FIGURE 1 | Title page and first page of text from Hill (1751).

and metal smelting), any hope of detecting evidence of organic constituents from a study of the finished products is likely to fail—apart from the well-known case of using plant ash as a source of alkali in glass-making (indicated by higher levels of magnesium and potassium oxides). Additional information is forthcoming from the limited number of literary sources on manufacturing processes that survive: many of these do in fact list vegetable components as part of the "recipe," including in the manufacture of glass. Some formulations are capable of rational explanation—for example, the use of a vegetable gum to bind together powdered components in a high-temperature reaction (e.g., Matin and Pollard (2017) on the processing of cobalt pigment in Iran), but others seem to have no purpose at all to the Western mind. There are several examples of this latter situation in the Indian technological literature. According to the translation by Ray (1956; 130), the *Rasaratnakara* (written by Nagarjuna sometime between the second and fourth centuries CE) contained recipes such as this for the manufacture of metallic zinc:

"*Rasaka* (calamine), digested repeatedly with fermented paddy-water, natron and clarified butter, and mixed with wool, lac, *Terminalia chebula*, and borax and roasted in a covered crucible, yields an essence of the appearance of tin: of this there is no doubt." *T. chebula* is the fruit of a deciduous tree native to South Asia, but its function in this recipe, as well as that of wool and lac, is not obvious. It is likely that a wide range of organic components was deemed necessary for the manufacture of inorganic materials, but we are largely ignorant of them.

Focusing on the mineral components of medicinal agents, it is interesting to consider whether there was an extensive overlap between these agents and those used in technology. Taking Hill (1751) as an example (Figure 1), we see that he classifies the "fossil kingdom" into eight groups, as follows:

i. "Metals with their several ores
ii. Semimetals with their recrements
iii. Simple salts
iv. Metallic salts, or vitriols, with the vitriolick minerals
v. Inflammable fossils; sulfurs, bitumens, etc.
vi. Earths
vii. Stones
viii. Extraneous fossils, bodies originally belonging to the animal, or vegetable kingdom, but petrified or otherwise altered by long lying in the earth."

The metals referred to are iron, lead, copper, silver, tin, and gold. The semimetals are quicksilver (mercury, including cinnabar), antimony, cobalt ("with the arsenics"), bismuth, and zinc ("with its ore calamine"). Perhaps unsurprisingly, the most significant (and somewhat earlier) Chinese *materia medica*, (李时珍), 本草綱目 *Bencao Gangmu* (1596), by Li Shizhen (2003) gives an almost identical list of metals, semimetals and minerals (Read and Pak 1928). Clearly, therefore, products derived from metals and their ores were important components in the pharmacopeia of Eurasia, despite the fact that many of these compounds were known to be poisonous.

Is there a deeper relationship between metals, ores and medicines, which goes beyond the simple fact that these products could be used both medicinally and as ingredients in technological processes? This question is of interest because it could offer an additional insight into the way in which ancient minds perceived the natural world. An important but as yet unanswerable question is "which came first—the use of natural materials in medicine or in technological processing?" Perhaps the question itself represents a false dichotomy. Medicinal, technological, and potentially other symbolic uses, may simply reflect different aspects of the same activity—human interaction with the natural world in search of useful commodities—and would not have been distinguished by the ancient mind.

On very slender evidence, we may tentatively suggest that medicine takes precedence. The need for medicine is widespread across the human species, and the knowledge of "useful herbs" is widely distributed if we include "folkloric" or "traditional" knowledge rather than the specialized profession of "medicine." Moreover, many mammals have been seen to use medicinal treatments, suggesting that the knowledge of the efficacy of medicine is deeply rooted in evolution—perhaps by several million years. Technology, too, of course, has deep roots (including parallels in the animal kingdom), but (contentiously!) one might argue that advanced technological processing (i.e., beyond the admittedly complex processes of lithic selection, shaping and polishing) did not really commence until the late Quaternary (c. 20,000 years ago), with the use of fire for the first ceramic production in the Far East, and the production of limes and mortars in the Near East. Tentatively, therefore, we may suggest that the search for medically active products in the natural world preceded that for raw materials usable in advanced technological processing. This simple binary argument is, of course, complicated by the knowledge that certain raw materials were sought out for painting pigments (caves and bodily art—at least 70,000 years ago) and also for items of personal adornment (e.g., malachite beads, etc., perhaps 10,000 years ago in Western Asia, leading ultimately to the smelting of copper; Roberts et al. 2009). Moreover, much of early prehistoric technology remains largely invisible—basket making, woodworking, weaving, etc. Nevertheless, despite these gross limitations, the argument that the use of mineralogical agents in medicine precedes that in technological processing seems at least plausible.

If so, then an important corollary to be considered is that the need for medicines may have been a primary driver in some extractive technology, with technological processes using the same materials coming along later. Perhaps, as Craddock (2009) has pointed out, the processing of metals and their ores was intimately related to, and in some cases driven by, the desire to make medicines, as well as the selection of brightly colored minerals for personal decoration. He notes that both Western and Indian medical traditions extensively use metals, but not in their simple form, as produced by the miner or smelter—they require "purification" before use in order to prevent harmful consequences. In the Indian tradition, this typically involves "killing" the metal by converting it to an oxide, via burning, roasting, or a chemical process. This even seems to have been applied to those metals extracted by reduction from their ores, as well as to those metals obtained native (gold, and possibly silver), despite the fact that it is effectively reversing the original smelting process, and is therefore energetically and economically disadvantageous. It is likely, however, that the reoxidation of a smelted metal allows for the production of a purer material than would the use of the original ore, even if it were an oxide. It also allows the preparation of the medicinal product to be carried out away from the mining site, if desired, and also on a relatively small scale compared to that generally required for smelting the original ore.

An example of the argument considered here is the use of zinc, both medicinally and technologically. As noted by Craddock (2009), zinc and its compounds in small doses are relatively nontoxic, and calamine lotion, containing a suspension of zinc oxide, has been and still is widely used in medicine as an external treatment for scratches and insect bites, and also for treating eye conditions. Pooley (1693) gives a good account of the roasting of "calamine" from mines in the West of England, noting that "Calamine, contrary to other dust which blinds, doth conduce much to the curing of sore eyes of men, and that it is frequently made use of for the taking of films from the eyes of horses and other beasts." Traditionally, calamine was a term applied to the carbonate ore of zinc ($ZnCO_3$), but it could also refer to the hydrated zinc silicate $Zn_4Si_2O_7(OH)_2 \cdot H_2O$ (now known as hemimorphite), and so the term smithsonite is now the correct name for the carbonate. Significantly, this description by Pooley does not acknowledge the technological use of calamine as an ingredient in the manufacture of brass (copper-zinc alloy), although in the same volume of *Philosophical Transactions* is a description by Povey (1693) of such a process, using ore from the same location. In this case, the ground roasted calamine is mixed with ground charcoal, and about 7 lb (c 3.2 kg) of this is added to 5 lb (c. 2.3 kg) of copper in a "gallon pot." Eight of these pots are loaded into a "wind furnace" and heated for 11 h, and the resulting brass is cast into "plates or lumps." Povey notes that 45 lb (20.4 kg) of raw calamine produces 30 lb (13.6 kg) of calcined material on roasting.

This twin use of calamine (medical and metallurgical) is extensively discussed by Craddock (2009), in the context of his work on the Zawar zinc mines in Rajasthan, India (Craddock et al. 1998). The interpretation of this site had initially created a challenge, in that the extensive underground workings for zinc ore had been dated to the end of the first millennium BCE, but the above-ground structures, showing clear evidence for the downward distillation of zinc in banks of retorts, are dated to the early second millennium CE. Associated with the earlier phase of use were a series of small slag heaps, which provided evidence for a process resulting in the production of zinc oxide. This zinc oxide could certainly have been used to produce brass (which was known in northern India in the later first millennium BCE), but the lack of evidence for large-scale production leads to the suggestion that it was intended for medicinal use. The later intensive exploitation of the mine in the medieval period, in which zinc was distilled from the ore, corresponds to a period when the direct process of manufacturing brass by combining metallic zinc and copper was known in India. Even if it is not as simple as assuming that the earlier exploitation was for medical products, and the later was for metallurgical purposes, such considerations emphasize the intimate relationship between medicine and metals. This warns us that we should see metallic ores as a multipurpose product, rather than purely as a raw material for tools and weapons or a source of accumulated wealth.

This proposed link between medicine and metal, combined with some historical ambiguity between the animate and inanimate worlds, provides what might be an important consideration in extending our understanding of the development of technology. Most of the earlier narratives on the history of technology have been framed within a model that might, with hindsight, be described as technological determinism. Essentially this paradigm derives from the 19th century European concept of progress, seeing technological change as an inevitable consequence of human development, driven by a desire to improve the functional efficiency of tools and processes. Many have argued that this is not an appropriate framework within which to view the historical technological developments of many societies, in most parts of the world and across most of time (e.g., Pollard and Gosden 2023). To give a simple example, it was generally assumed that the transition from the Stone Age to the Bronze Age in Europe was driven by the mechanical superiority of copper alloy tools and weapons over the preceding lithic equivalents. However, the discovery that the earliest copper tools tended to be made from relatively pure copper, and hence were fairly soft, led to the idea that the first deliberate alloying process was the production of arsenical copper (with a few percent arsenic), probably achieved by the selection of copper ores containing arsenic, aimed at producing a harder metal (e.g., Charles 1967). However, detailed metallurgical examination of weapons from the European Early Bronze Age revealed that many axes, even though some contained arsenic, had not been cold worked to develop the hardness of the edges, and, moreover, axes containing no arsenic were treated in the same way as those with arsenic (Budd 1991: 107). This would suggest that, initially at least, the impetus for the adoption of copper alloy weapons was not related to mechanical performance, but more probably related to symbolic power. Pollard (2023) has gone so far as to suggest that, because the production of copper involves the apparently magical transmutation of solid green rock into liquid red metal, the display of such a weapon might signify that the owner possesses dangerous magical powers, and should be avoided. This is not, of course, a denial of the subsequent technological skill of metalworkers to produce superbly functional tools and weapons, and remarkable vessels, but it does suggest that nontechnological drivers need to be taken into account in the developmental narrative.

This possibility that there may be a connection between the use of medicinal compounds to cure human ills and the use of similar compounds in technological processes to cure perceived "ills" in the inanimate world can be further investigated through a consideration of the use of antimony in antiquity—chosen because compounds of antimony are known to have been used in medical, technological and alchemical contexts. Stibnite (Sb_2S_5—a common ore of antimony) was used as one of the black materials for eye make-up in Ancient Egypt (kohl), but from Egyptian medical papyri dating from at least 1550 BCE it was also said to be effective against conjunctivitis and as a cure for headaches (Kamal 1926). Pliny, in his *Natural History* (first century CE: Bailey, 1929, 1932), devotes one chapter (Chapter 34 in Book 33) to list the seven medical uses of stimmi (stibnite).[2]

He says: "Stimmi is possessed of certain astringent and refrigerative properties, its principal use, in medicine, being for the eyes. … . It acts also as a check upon fluxes of the eyes and ulcerations of those organs; being used, as a powder, with pounded frankincense and gum. It has the property, too, of arresting discharges of blood from the brain; and, sprinkled in the form of a powder, it is extremely efficacious for the cure of recent wounds and bites of dogs which have been some time inflicted. For the cure of burns it is remarkably good, mixed with grease, litharge, ceruse, and wax."

Antimony has also featured strongly in alchemical writing—the most significant European work being *The Triumphal Chariot of Antimony*, attributed to a 15th century monk Basil Valentine, first published in Amsterdam in 1604 (Waite 1893). One technological use of antimony, probably related to its perceived alchemical properties, is in the parting of gold and silver, as described in the *Probierbüchlein* (Sisco and Smith 1949). Here stibnite was used in a cementation process in which sheets of electrum (gold/silver alloy) were layered with stibnite in a closed vessel and heated. The stibnite dissociates to produce sulfur, and the sulfur oxidizes the silver to the sulfide, leaving behind pure gold (Pollard and Gosden 2023: 39–40). Another major technological use of antimony was in glass to produce white or yellow opaque glass via the generation of calcium antimonate ($Ca_2Sb_2O_7$), at a date that appears simultaneous with the first production of glass in Egypt (mid-second millennium BCE; Shortland 2002). Importantly, Shortland (2002: 522) concluded that the antimony was added to the glass melt as either the metal, or as the sulfide or oxide, rather than directly as a calcium antimonate additive, so that the opaque and colored compounds are made in the melt.

In Hellenistic and Roman glassmaking, the desire for transparent (clear) glass was often confounded by the presence of contaminants such as iron compounds in the glass-making sand, resulting in a green or brown tinge. To counteract this, small amounts of antimony were added to the glass, resulting in a clear product because both antimony and iron have variable valency (antimony exists as Sb (III) and Sb(V) and iron as Fe (II) and Fe (III)), and form a redox couple in which the antimony is reduced to form Sb (III) and the iron is oxidized to Fe (III) which is much less strongly colored than Fe (II) (Pollard et al. 2017: 211–212). Antimony was introduced into glass as a decolorizer around the seventh century BCE (Smith 1963), and became common in Roman glass in the first century CE (Paynter and Jackson 2019). In parallel, manganese was also introduced as a decolorant (working in the same way) from the beginning of the second century BCE, but did not replace antimony.

In mid-second millennium BCE Egypt, therefore, we have the simultaneous use of stibnite as personal decoration, medicine and as an opacifier in glass. Is this a coincidence driven simply by availability, or is there some closer relationship between them? In first century CE Roman Europe, we have a further coincidence—the dominance of antimony-decolored glass, and the simultaneous use of antimony in Roman copper alloys, and particularly coinage metal. A small amount (up to 1%) of antimony in copper hardens the metal, and allows the coinage to take a sharper struck image. From Augustus (27 BCE–14 CE) to Nero (54 CE–68 CE), the base metal coinage was very pure copper and soft, but from Nero to Commodus (180 CE–192 CE), it shows a distinctive antimony-only impurity pattern (Pollard and Gosden 2023: 36–37). It is of course possible that this simultaneity in the use of antimony between glass and metal was simply a coincidence. For the coinage, it could be that as the Empire expanded a new copper source was found, which fortuitously gave a harder metal, although no copper sources that contain only antimony as a trace impurity are known. It is more likely that a small amount of antimony was added to the highly refined copper, in which case was this trial-and-error, technological transfer from glass to metal, or even some deeper connection?

It is worth at least considering whether the use of stibnite for curing diseases of the eye in humans prompted the trial of its use as an opacifier in glass, and later for clarifying the appearance of glass. The traditional explanations of independent innovation and trial-and-error experimentation within a particular material production process, of course, remain highly plausible, but the existence of such technological specialism—the complete independence of knowledge between different specializations—seems at least worth questioning. An alternative suggestion—that the glassmakers were aware that stibnite was efficacious at curing diseases of the eye, and might have some equally useful properties when added to glass, and that moneyers producing coinage were aware that antimony was beneficial in the production of glass and decided to use it to harden the copper—seems unlikely from a modern perspective because there is no rational relationship between diseases of the eye, the causes of color in glass and the softness of copper. However, if we re-focus the situation to think of using antimony to cure not only the diseases of the eye, but also to cure the "ill" of a green tinge in glass, and also the "ill" of softness in copper, then the proposition seems somewhat less irrational. In this scenario, antimony was being used as a medicine to cure a range of ills in the material world, in just the same way as it was used to cure human ills.

Previous work, including that of Craddock (2009) discussed above, has highlighted that extractive metallurgy should not always be seen simply through the lens of metal production. In some cases, the production of *materia medica* might have been an important aspect, or at least an important by-product. Building on this connection, the possibility exists that there may have been some "technology transfer" between the animate and inanimate worlds, with compounds known to be efficacious for curing ills in the animate world being applied in the material world, simply because they are recognized as having powerful properties. We must remember that the material world was seen as being composed of four or five "elements" (air, earth, fire, and water in the West and wood, fire, earth, metal, and water in China), combined together in various ratios for specific materials, and that one material could be transformed into another by the addition of various alchemical reagents to vary these proportions. If we accept this concept, then this suggests a very significant addition to the portfolio of potential drivers for technological change. Clearly, much more research is needed into the possible links between specific items in the *materia medica* and their potential use as technological agents. An obvious strategy is to look for parallels in the chronology of the use of inorganic agents in medical and technological processes, although this is clearly not without difficulties (not least because firm identifications of what is being referred to are often difficult). Even more challengingly, given that in most *materia* *medica* organic agents substantially outnumber the inorganic, we must acknowledge that there may be many ingredients used in ancient technological processes of which we are completely unaware. Nevertheless, the idea that there is some transfer between pharmaceutical compounds and technological processes seems deserving of further investigation.

Acknowledgements

This paper builds on many years of conversations about the extraction and use of metals, and how technological changes come about. Thanks are therefore due to many scholars, including Chris Gosden and Peter Bray.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Endnotes

[1] "Recrement" refers to superfluous by-products, such as slag.

[2] We note here that many of the chapters in Pliny's two books on metal refer to the medicinal applications of the various metals.

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