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Metals as Living Bodies. Founts of Mercury, Amalgams, and Chrysocola

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Ancient and medieval alchemical works include several comparisons between the generation and development of metals and those of plants, animals, and living beings. These comparisons could refer to adopt physiological models in the explanation of the natural formation of metals and their artificial transformation, to justify the place occupied by alchemy within the broader study of the natural world, and to stand as metaphorical descriptions of specific alchemical procedures. This article analyses these features by focusing on the relationship between mercury and gold, the latter being the “perfect” metal that constituted both an ambitious goal of alchemical practice and one of its key ingredients. The interrelationship between gold and mercury emerges in complex myths about metallic rivers, in the use of gold-mercury amalgams in ancient technology, and in the discussion that alchemists developed around the enigmatic *chrysocola* (literally “gold solder”). These three foci are discussed in relation to a variety of ancient sources – from Aristotle and the Stoics to late antique, Byzantine, and Syriac alchemical texts – to explore the different forms of conceptualising metals as living bodies and the interactions of these models with ancient theories on the formation of metals and the alchemical practices aimed at their transformation.

Metals and minerals as living bodies

We usually think of a given metal as a physical substance strictly determined by its own atomic structure and the chemical and physical properties arising from such a structure.

The authors have co-written the concluding remarks and subdivided the analysis of the sources and related questions into two parts: the first and fourth sections are the work of Vincenzo Carlotta; the second and third sections are by Matteo Martelli.

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For us, it is almost impossible to seriously conceive of a metal as a living body with a lifecycle encompassing birth, growth, reproduction, decay, and eventual death. For centuries, however, alchemists have compared alchemical operations to physiological processes related to the reproduction of living beings and the birth and nurturing of their offspring. These comparisons draw on a rich tradition of metaphors and alchemical images imbued with a variety of meanings over time: the union of opposite principles into a single substance; the gradual development of distinct operations of alchemical practice; the connotation of alchemy as a natural rather than an artificial process. Nonetheless, if alchemical operations can be understood in comparison to physiological processes, does it mean that metals too were conceptualised as living beings?

The significance of images representing metals and minerals as living and animated substances can hardly be overstated for the alchemical tradition. Surprisingly, though, few studies have focused on the emergence and development of this crucial feature in Greek alchemy. André-Jean Festugière devoted special attention to the problem, especially in his study on the relationship between the Hermetic treatise *Pupil of the World* and alchemical literature.¹ According to Festugière, Greek alchemists compared alchemical transmutation with the generation of living beings because of their “vitalistic” understanding of metallic substances. More precisely, alchemists maintained that metals are alive and so are born, grow up, feed, and reproduce *themselves* within the earth. Festugière argued that this idea should be considered as one of the fundamental hypotheses of Greek alchemy – an idea foundational to other peculiar features of alchemical literature such as the repeated comparisons between metals and plants, the distinction between the soul and the body of metals, and the reference to a process of death and resurrection of the metallic substances.²

In evaluating Festugière’s interpretation, the first point to address is the conceptualisation of metallic bodies as living beings. The Greek and Latin vocabulary used to describe the generation of metals within the earth, for example, was largely the same used to illustrate the generation of living beings, such as plants and animals. Robert Halleux studied this fascinating feature, convincingly arguing for a link between the linguistic element and a widespread popular belief that metals, just like plants, are living beings that generate and grow up within the earth.³ Possibly originating among miners and metalworkers, this belief (which was shared by many other cultures) also influenced, to a certain extent, the educated description of peculiar phenomena connected to the mineral world. Both Strabo (ca. 64 BC – 24 AD) and Pliny the Elder (first century AD) claimed that some of the most productive

¹ See André-Jean Festugière, “La Création des âmes dans la Korè Kosmou,” in *Pisciculi. Studien zur Religion und Kultur des Altertums. Franz Joseph Dölger zum sechzigsten Geburtstage dargeboten von Freunden, Verehrern und Schülern*, ed. Theodor Klauser and Adolf Rucker (Münster, Westphalia: Achendorff, 1939), 102–16 (reprint in *Hermétisme et mystique païenne* [Paris, 1967, 230–48]).

² See also André-Jean Festugière, *La révélation d’Hermès Trismégiste*, 4 vols. (Paris: Les Belles Lettres, 1944–1954), 1:309–54.

³ See Robert Halleux, “Fécondité des mines et sexualité des pierres dans l’Antiquité gréco-romaine,” *Revue belge de philologie et d’histoire* 48, no. 1 (1970): 16–25. Some central points developed by Halleux are based on Mircea Eliade’s anthropological studies: see Mircea Eliade, *Forgerons et Alchimistes* (Paris: Flammarion, 1956).

mines around the Mediterranean were replenished, and became even more productive, after lying fallow for a period of time.⁴ According to Halleux, the notion of metals as living beings laid the foundation not only for the many comparisons between the generation of metals and plants, but also for the correlated distinction between a male and a female form of some metals and minerals.⁵

Even though this form of the conceptualisation of metals as living beings was still quite widespread in late antiquity, the philosophical tradition provided explanations of the formation of metallic bodies as completely inanimate beings. Despite significant differences between Platonic and Aristotelian theory, both philosophers agreed that metals came about from the solidification or congelation of a specific kind of moist substance within the earth – a process fundamentally different from the generation of any living being.⁶ Because of the apparent conflict between an animate and an inanimate conception of metallic substances, it is difficult to determine which position was genuinely adopted by Greek alchemists – whether the two notions were held as completely distinct or whether some alchemists sought to harmonise them into a single understanding of metallic substances and their generation.

A series of metaphors based on the conception of metallic bodies as living beings was early on crystallised into the technical language of Greek alchemy. The most apparent case is possibly the pervasive reference to the anatomy and physiology of plants in order to illustrate the characteristics of metals. In Pseudo-Democritus' *Four Books* (first century AD), metallic and mineral substances are sometimes referred to as “plants” (*botanai*), whilst their colour – either natural, or artificially transformed – is called their “flower” (*anthos*).⁷ Although it is significant that a central part of Greek alchemy's technical vocabulary was based on a comparison between metals and plants, the lexical use alone is not sufficient to conclude that Greek alchemists actually claimed the existence of any “physiology” of the metals comparable to that of the plants.

Some early alchemical texts reflect interesting developments in the metaphorical connection between metals and plants. A good example is Pelagius's alchemical work (fourth century AD), where he ascribes the following metaphor to Zosimus:

καὶ ὅτι περὶ τούτου Ζώσιμος ἔλεγεν. καὶ ὅτι δένδρον φυτουργούμενον, φυτὸν ποτιζόμενον, καὶ ὑπὸ πλήθους ὕδατος σηπόμενον, καὶ διὰ τῆς τοῦ ἀέρος ὑγρότητός τε καὶ θερμότητος αὐξάνόμενον ἀνοφορεῖ, καὶ τῇ πολλῇ γλυκύτητι καὶ τῇ ποιότητι τῆς φύσεως καρποφορεῖ.⁸

⁴ See Strabo, *Geography*, 5.2.6 and Pliny the Elder, *Natural History*, 34.165. See also Halleux, “Fécondité des mines,” 20–21.

⁵ See Halleux, “Fécondité des mines,” 21–23. On the broader concept of generation and gender in Antiquity, see Laurence M. V. Totelin, “Animal and Plant Generation in Classical Antiquity,” in *Reproduction: Antiquity to the Present Day*, eds. Nick Hopwood, Rebecca Flemming and Lauren Kassell (Cambridge: Cambridge University Press, 2018), 53–66.

⁶ For a detailed discussion of the theories on the generation of metals in ancient and late antique natural philosophy, see Robert Halleux, *Le problème des métaux dans la science antique* (Paris: Les Belles Lettres, 1974), 65–114.

⁷ In some cases, Pseudo-Democritus actually employed vegetal substances in the alchemical practice; accordingly, it is not always easy to distinguish the references to real plants from the metaphorical uses of these terms. See Matteo Martelli, “Dissoluzioni, distillazioni e passaggi di stato nel *Corpus* degli alchimisti greci,” in *Metamorfosi tra scienza e letteratura*, eds. Francesco Citti, Lucia Pasetti and Daniele Pellacani (Firenze: Olschki, 2014), 81–99 (on 93–97).

⁸ Pelagius Alch., *On This Divine and Sacred Art*, in *Collection des anciens alchimistes grecs*, ed. Marcellin Berthelot and Charles-Émile Ruelle, 3 vols. (Paris: Georges Steinheil, 1887–1888) (hereafter CAAG), vol. 3, 261.4–8.

And this is what Zosimus said on this topic [i.e. the raising of the waters, that is distillation]: [he said] that [the operation is like] a cultivated tree, a watered plant, and when it is putrefied by the amount of water and grows by the moistness and hotness of the air, [then] it bears flowers, while, due to the great sweetness and the quality of [its] nature, it bears fruits.

The metaphor of the growing plant cannot be found in any of Zosimus's extant works (third to fourth century AD.) However, since Pelagius was a close contemporary, its attribution to Zosimus seems reliable.⁹ The image of a growing plant is used to illustrate the process of distillation, that is, the action of converting any substance into a vapour by means of heat, and then condensing the vapour into liquid form.¹⁰ In antiquity the growth of plants, their blossoming, and the ripening of their fruits were generally explained as a result of the action of the heat of the season and their own internal heat on the watery elements within the plants.¹¹ It can also be noted that in this passage the putrefaction produced by the water and the elementary qualities of the air, and the sweetness leading to the production of fruit, are all elements expressed in terms that appear especially close to Aristotle's description of the processes of putrefaction (*sēpsis*) and concoction (*pēpsis*) in his second book, *On Generation and Corruption*, and in the fourth book of his *Meteorology*.¹² A feature of Pelagius' work is the introduction of a great number of Aristotelian terms and concepts into the alchemical tradition. It may therefore be argued that while the image of a growing plant can be ascribed to Zosimus, this specific metaphorical formulation may have been deeply influenced by Pelagius' own interpretation of the process.

Apart from its original attribution, the metaphor of the growing plant is part of a wider group of images linking mineral substances to plants. Yet it appears especially significant since, in this case, the link is not based primarily on the conception of metals as living beings. The growth of a plant, in fact, can explain the distillation of a substance because both processes are brought about by the action of heat on a moist substance. The connection between plants and metals, therefore, does not seem to depend exclusively on a "vitalistic" conception of metallic substances, but, at least in some important cases, was fundamentally based on notions elaborated by philosophical and medical traditions.

The tension between an animate and inanimate description of metals is best illustrated in the opposition between two eminently different substances: gold (corresponding to the perfect stability and purest form of any metal) and mercury

⁹ Jean Letrouit, "Chronologie des alchimistes grecs," in *Alchimie: art, histoire et mythes*, eds. Didier Kahn and Sylvain Matton (Paris: S.É.H.A, Milan: Arché, 1995), 11–93 (on 46–47).

¹⁰ See Pelagius Alch., *On This Divine and Sacred Art*, CAAG, vol. 3, 260.19–261.3. On the use of images connected to plants and their physiology to describe alchemical operations, see also Martelli, "Dissoluzioni, distillazioni e passaggi di stato," 97–8.

¹¹ Hippocrates, *On the Nature of the Child*, 22 and 26, in *Hippocrates. Über die Natur des Kindes. De Genitura und De Natura Pueri*, ed. Franco Giorgianni (Wiesbaden: Reichert Verlag, 2006), 200–02, and 212–14. See also Luciana Repici, *Uomini capovolti. Le piante nel pensiero dei Greci* (Bari: Laterza, 2000), 22–27, and 245–58.

¹² See Cristina Viano, "Mixis and Diagnōsis: Aristotle and the 'Chemistry' of the Sublunary World," *Ambix* 62, no. 3 (2015): 203–14.

(ever-changing and extremely reactive in its interactions with gold). The following discussion focuses on the relationship between gold and mercury to further assess the degree to which, in antiquity and late antiquity, alchemical metaphors describing metals as living bodies reproduce and display both converging and diverging conceptualisations of metallic and mineral substances.

Mercury as a living body: rivers and dragons

If minerals and metals – mercury and gold included – are alive, they must be ensouled. In antiquity, the soul (*psychē*) constitutes the principle of life that rules activities in living beings; namely, growth and sensation, reasoning and movement. Aristotle’s *On the Soul* opens with a preliminary discussion on *psychē* as the source of movement in the body. Here, Aristotle collects earlier definitions of the soul and mentions Thales (among others), who believed that the magnet possessed a *psychē* since it attracts iron, thus making the metal move.¹³ This reasoning also occurs in the earliest mention of mercury in Greek classical literature. Within the framework of an attack against the idea that the soul must be in motion in order to bring about movement,¹⁴ Aristotle argues against Democritus’s view that bodies are moved by a soul made of spherical atoms in motion. Democritus’s argument also rested on a mythical example: he compared bodily movement to that of a hollow wooden statue of Aphrodite, which Daedalus put in motion by pouring mercury into it.¹⁵ As emphasised by Neoplatonic commentators, the self-moving nature of liquid mercury corresponded to the spherical atoms of the soul, which, being always in motion, push bodies and make them move.¹⁶ John Philoponus (sixth century AD) insists on the mechanics of mercury’s action: the metal “is very easily moved and continuously rolling over and by its own pushing causes movement to the statue.”¹⁷ Democritus’s analogical reasoning might have been informed by the simple observation of mercury’s behaviour: once spilled, the liquid metal easily breaks into small globules that roll on flat surfaces and tend to combine into larger spheres that break again when pressure is applied.

¹³ Aristotle, *On the Soul*, 1.2, 403b20–405b30, in *Aristotelis De anima*, ed. William D. Ross (Oxford: Clarendon Press, 1956), 5–10. Thales’ fragment is edited in Georg Wöhrlé, *Die Milesier: Thales, mit einem Beitrag von Gottfried Strohmaier* (Berlin: De Gruyter, 2009), 52–55 (Th. 3). On the use of the term *psychē* in this fragment, see Michael Clarke, “The Wisdom of Thales and the Problem of the Word ΙΕΠΟΣ,” *The Classical Quarterly* 45, no. 2 (1995): 296–317 (on 297–99).

¹⁴ Aristotle, *On the Soul*, 1.3, 406a1–407b26 in Ross, *De anima*, 10–15.

¹⁵ Aristotle, *On the Soul*, 1.3, 406b15–19 in Ross, *De anima*, 12. Democritus’ fragment is edited in Herman A. Diels and Walther Kranz, *Fragmente der Vorsokratiker*, 6th ed., 3 vols. (Zurich: Weidmann, 1951–1952), vol. 2, 109 (Fragment A 104). See Matteo Martelli, “Properties and Classification of Mercury between Natural Philosophy, Medicine, and Alchemy,” *A.I.O.N.* 36 (2014): 17–47 (on 17–18).

¹⁶ See, in particular, Hermias’ and Philoponus’ commentaries on Aristotle’s *On the Soul*; Michael Hayduck, ed., *Simplicii in libros Aristotelis De anima commentaria* (Berlin: Reimer, 1882), 39.22–32, and Michael Hayduck, ed., *Ioannis Philoponi in Aristotelis De anima libros commentaria* (Berlin: Reimer, 1897), 175.14–22.

¹⁷ Translation by Philip van der Eijk, *Philoponus, On Aristotle On the Soul 1.3–5* (London, New Delhi, New York, Sydney: Bloomsbury, 2006), 35. The Greek text is edited in Hayduck, *Ioannis Philoponi in Aristotelis De anima*, 115.1–3: ὁ ὑδράργυρος εὐκίνητος γὰρ καὶ συνεχῶς μετακυλιόμενος καὶ τῇ αὐτοῦ ὥσει κινῶν τὸ ζῶανον.

In drawing a distinction between self-moving bodies and bodies moved by external causes, the Stoics also included natural springs, fire, and metals in the first category as ensouled natural bodies that, like plants and animals, can move by themselves. Origen's *On the First Principles* (early third century AD) is our main source on this point:

ἐν ἑαυτοῖς δὲ ἔχει τὴν αἰτίαν τοῦ κινεῖσθαι ζῶα καὶ φυτὰ καὶ ἀπαξᾶπλῶς ὅσα ὑπὸ φύσεως καὶ ψυχῆς συνέχεται· ἐξ ὧν φασιν εἶναι καὶ τὰ μέταλλα, πρὸς δὲ τούτοις καὶ τὸ πῦρ αὐτοκίνητον ἐστὶ, τάχα δὲ καὶ αἱ πηγαί.¹⁸

Animals, plants and in general those things that are kept together by nature and the soul have in themselves the cause of movement. Among these, there are *metalla* [“mines” or “metals”] as well, they say; in addition, fire is self-moving, and perhaps springs too.

The Greek *metalla*, rendered as “veins of metals” (*metallorum venas*) in Rufinus' Latin translation (early fifth century AD) of Origen's passage, is somehow ambiguous.¹⁹ Indeed, the term could refer both to metals and to mines.²⁰ In another passage, Origen specifies that ores, once removed from the mines, are like pieces of wood that have lost their capacity to sprout; both ores and wood are thus no longer ensouled bodies and can only be moved by external causes.²¹ Therefore, metals seem to be alive (and self-moving) as long as they are not detached from their living veins. The Stoic biological understanding of the physical world as a living being is here extended to geological phenomena. Seneca explains that, like veins and arteries in human bodies, underground channels carry various kinds of fluids:²² “some that harden when fully developed (from them entirely depends the yield of mines [*metallorum fructus*] – from which greed seeks gold and silver – and substances that turn from liquid into stone), some that are formed from the decay of earth and moisture (such as bitumen and other things of that sort).”²³ Subterranean fluids are equated with bodily fluids (*umores*) of different kinds, such as blood, marrow, and saliva; their differences determining the variety of mineral substances and metals, from gold and silver to bitumen. The middle-Stoic philosopher Posidonius (second to first century BC) already referred

¹⁸ See Origen, *On the First Principles*, 3.1.2, in *Origenes, Vier Bücher von den Prinzipien*, eds. Herwig Görgemanns and Heinrich Karpp (Darmstadt: Wissenschaftliche Buchgesellschaft, 1976), 464. See also Hans von Arnim, *Stoicorum Veterum Fragmenta*, 4 vols. (Stuttgart: Teubner, 1964) (hereafter SVF), vol. 2, 287. On this passage, see Halleux, “Fécondité des mines,” 25.

¹⁹ Among modern translators, Görgemanns and Karpp (*Origines*, 465), for instance, rendered the term *metalla* as “metals” (die Metalle), while the term is translated as “metal mines” (mines métalliques) in Henri Crouzel and Manlio Simonetti, *Origène, Traité des principes, Tome III: Livres III – IV* (Paris: Cerf, 1980), 21.

²⁰ See Halleux, *Le problème des métaux dans la science antique*, 17–60.

²¹ Origen, *On Prayer*, 6.1 (= SVF, vol. 2, 288), in *Origenes Werke*, ed. Paul Koetschau, Band 2 (Leipzig: J.C. Hinrichs, 1899), 311. See Thomas Bénatouïl, “Échelle de la nature et division des mouvements chez Aristote et les stoïciens,” *Revue de Métaphysique et de Morale* 4 (2005): 537–56 (on 550–51).

²² Seneca, *Natural Questions*, 3.15. See Halleux, *Le problème des métaux*, 133–34.

²³ Translation (slightly modified) by Harry M. Hine, *Seneca, Natural Questions* (Chicago: University of Chicago Press, 2010), 34. The expression *metallorum fructus* is a correction to Seneca's text which was proposed by Dionigi Vottero, “Emendamenti al testo delle *Naturalis Quaestiones* di Seneca II,” *AAT* 114 (1980): 347–67 (on 348–49); the MSS read *metallorum humus*, which is translated as ‘metal-producing soil’ in Thomas H. Corcoran, *Seneca, Natural Questions*, vol. 1: Books 1–3 (Cambridge, MA: Loeb, 1971), 235.

to founts of liquid bitumen and soil “efflorescing” with different metals (tin, silver, and white gold).²⁴ Mercury is never mentioned in these sources. However, because of its liquid nature, mercury could be easily identified with a mineral fluid that, after streaming underground, wells up in certain mines. Such a conceptualisation of mercury seems to be implied in Pliny the Elder’s *Natural History* (33.99): “There is also a mineral found in these veins of silver which contains a humour, in round drops, that is always liquid, and is called quicksilver (*argentum vivum*, literally ‘living silver’).”²⁵ The activity of this liquid metal, moreover, might have fostered the idea that mercury was somehow alive even after being extracted from the mines (being thus detached from its underground living veins). After all, its Latin name was *argentum vivum*, even though this expression had no Greek equivalent until the translations of western medieval treatises into Byzantine Greek.²⁶

Even so, the idea of mercury as a living being is further reinforced in Graeco-Egyptian alchemical literature. The *Book on Mercury* attributed to Zosimus of Panopolis (only preserved in Syriac translation) includes a long list of *Decknamen* (code names), many of which associate the metal with organic fluids and living beings, in particular, animals and plants. Mercury (*zīwag* in Syriac) received a range of descriptive names: “the foam of all sorts and of all animals, especially of a rabid dog,” “the bile of all animals,” “the milk of all animals,” and “the milk and resin of all trees and plants.”²⁷ Corresponding associations are also included in a Byzantine *Lexicon on the Making of Gold*, where mercury is called “milk of a black cow,” “juice of all trees and plants,” “dragon’s bile” – it is even associated with an ejaculating dragon.²⁸ Zosimus further explains that practitioners distinguished between different kinds of mercury, which were given different names: “living mercury” when it comes from lead; “colouring mercury” when it comes from cinnabar; “river water” or “dragon’s bile” when it comes from tin.²⁹ An etiological account is then provided for the last two code names, which would have referred to a stream of tin/mercury that wells up and chases, like a

²⁴ See Ian G. Kidd and Ludwig Edelstein, *Posidonius*, vol. 3, *The Translation of the Fragments* (Cambridge: Cambridge University Press, 1972), 307–9 (fragments 235, 236 and 239).

²⁵ Pliny the Elder, *Natural History*, 33.99: ‘Est et lapis in iis venis, cuius vomica liquoris aeterni argentum vivum appellatur’, trans. by Harris Rackham, in *Pliny, Natural History, Books 33–35* (Cambridge, MA: Loeb, 1952), 77–9. On Stoic influences on Pliny’s metallurgical accounts, see Ernesto Paparazzo, “Pliny the Elder on Metals: Philosophical and Scientific Issues,” *Classical Philology* 103 (2008): 40–54.

²⁶ In his Byzantine translation of Thomas Aquinas’ commentary on Aristotle’s *De anima* (Book I 7, 23) Gennarios Scholarios (fifteenth century AD) rendered *argentum vivum* as ἄργυρον χυτὸν ἤγουσ ζῶντα. See Martin Jugie, Louis Petit, and Xenophon A. Siderides, *Oeuvres complètes de Georges (Gennadius) Scholarios*, vol. 6 (Paris: Maison de la bonne presse, 1933), 358.

²⁷ See Matteo Martelli, “Alchemical Lexica in Syriac: Planetary Signs, Code Names and Medicines,” *Asiatische Studien* 75 (2021): 485–512 (on 504–5).

²⁸ CAAG, vol. 1, 6.14 (γάλα βοῦδος μελαίνης); 12. 6 (ὀπὸς πάντων δένδρων καὶ βοτάνων); 6.23 (δράκοντος χολή); 5.24 (ἀποσπερματισμὸς δράκοντος, sic).

²⁹ Cambridge University Library, MS Mm. 6.29, fols. 57v – 58r. The Syriac term for tin is *zws*, i.e. a transcription of the Greek Ζεὺς (Zeus). The term *zws* is quite common in Syriac alchemical collections, probably because of the association between the planet Jupiter and the metal: see Rubens Duval, “Notes de lexicographie syriaque et arabe,” *Journal asiatique*, n.s. 2 (1893): 1888–901.

By the same token, Zosimus's mythological account mirrors a "vitalistic" understanding of the mineral world, vividly dramatised in the narrative: tin/mercury wells out of the spring where it resides and chases a beautiful maiden like a dragon until it is caught by men who cut it off and let it solidify in deep holes around the spring.

As David G. White points out, the Syriac passage must be compared with a rich dossier of Sanskrit and Chinese texts that provide a very similar account about the extraction of mercury.³⁵ In the Indian tradition, mercury is identified with the semen of the god Shiva, which was dispersed in the river Ganges. The river, however, could not bear the heavy metal, which was deposited on the side of the Himalaya where it produced all the other metals in contact with the earth.³⁶ The story is further developed in seven Sanskrit alchemical writings that date from the thirteenth to the early seventeenth centuries: mercury, lodged in a well, rushes after a beautiful maiden who, in most versions, rides a horse. When mercury returns to the well, it remains trapped in natural depressions (or pits dug by men of the land), where it solidifies. Chinese texts relate a similar myth. The earliest known version appears in the *Collected Works on Preserving, Restoring and Purifying* by the painter Zhu Derun (1294–1365 AD) in which mercury chases riders wearing golden armour.³⁷ Interestingly, White notes that the Chinese story is presented as the report received by two Yuan imperial guards from members of the Fo-lin embassy, "likely a variant of Fu-lin, a common Chinese word for Byzantium or Roman Syria."³⁸ Ferdinand de Mély tentatively argued in favour of a Syrian origin of the Chinese account.³⁹

On the other hand, a Byzantine origin of the Chinese story is also possible. In this respect, I have been able to identify a Byzantine text that we can add to this rich dossier of sources on the founts of mercury. The Byzantine scholar John Tzetzes (twelfth century AD) refers to a "river of mercury" in his work entitled *Chiliades*, a prominent example of auto-exegetical commentary which includes more than four hundred "stories" (*historiai*) that Tzetzes collected to gloss his own letters. In his sixth letter, Tzetzes argued that poets often attribute feelings to stones, even if they knew that they cannot have sensations or feel pain. The petrified Niobe cried, according to Homer. The stone *sidēritis* could talk and even make prophecies, according to Orpheus. Likewise, the magnet loves iron, "not to speak," Tzetzes continues, "of the objects of love of liquid silver (i.e. mercury)

³⁵ White, "Variations on the Indo-European 'Fire and Water' Mytheme"; David G. White, *Daemons are Forever. Contact and Exchanges in the Eurasian Pandemonium* (Chicago, IL: Chicago University Press, 2021), 172–83.

³⁶ The myth already appears in the *Rāmāyana* and the *Mahābhārata*: see Sreeramula Rajewara Sarma, Yaduendra Sahai, "Gushing Mercury, Fleeing Maiden: A Rasaśāstra Motif in Mugal Painting," *Journal of European Ayurvedic Society* 4 (1995): 149–62 (on 152–53).

³⁷ For the Sanskrit and Chinese relevant sources, see White, "Variations on the Indo-European 'Fire and Water' Mytheme", 679–86; White, *Daemons are Forever*, 172–8.

³⁸ White, "Variations," 687; White, *Daemons are Forever*, 179.

³⁹ Fernard de Mély, "L'alchimie chez les Chinois et l'alchimie grecque," *Journal asiatique*, 9th series, 6 (1895): 314–40 (see 332–4 for a comparison between the Chinese account and the Syriac passage ascribed to Zosimus).

and the other stones.”⁴⁰ This last reference to mercury is explained in the *Chiliades* (6.67, lines 634–41):

Περὶ τῶν χυτῶν ἀργύρων ζζ΄
 Λέγουσι τὴν ὑδράργυρον πάντες ἔρᾶν χρυσοῦ. / Τοῦ ποταμοῦ δ’ οἱ θέλοντες ταύτης τι
 ρεῖθρον κλέψαι, / βόθρους ὀρύττουσι πολλοὺς τοῦ ποταμοῦ μακρόθεν, / εἶτα ἰππέα τάχιστον,
 χρυσοῦν βαλόντες δέρος, / λέγουσι πλησιάσαι μὲν τοῦ ποταμοῦ τῇ κοίτῃ, / εὐθύς δε φεύγειν
 ὡς περὸν πάλιν εἰς ὀπισθίαν. / Εἰς βόθρους δ’ ἡ ὑδράργυρος διώκουσα ἐμπίπτει, / ἐξ ὧν
 ἐλθόντες ἄχρυσοι συλλέγουσιν ἐκείνην.⁴¹

On liquid silver (chap. 67)

Everyone says that mercury loves gold. Those who want to collect [lit. steal] some mercury from the river streams dig many pits far away from the river. A very quick rider – they say – dressed with a golden fleece, comes near the riverbed, but he immediately does an about-turn and runs away as if he was winged. Mercury chases [the rider] and falls into the pits, from which they collect it when they come without any gold.

As in the Chinese version, Tzetzes insists on gold as the metal that attracts mercury, moved by a kind of “chemical” love rather than by an explicit sexual desire as referenced in the Sanskrit texts or in the Syriac passage attributed to Zosimus. The rider, indeed, wears a golden fleece, which, echoing the myth of the Argonauts, brings to mind the use of leather in gold mining (as we will see, gold-mercury amalgams were pressed through leather to separate the precious metal from mercury).⁴² On the other hand, the identification of Tzetzes’ sources are almost impossible. His story does not include any reference to previous or contemporary authors, since Tzetzes wanted to present himself as a man “without books” (*abiblē̄s*), whose work was “the result of his prodigious memory as well as of his ability to write fast and off the top of his head.”⁴³ We cannot exclude, however, that Tzetzes may have recalled stories from earlier alchemical sources.

Mercury and gold kinship: the amalgams

Tzetzes’ story provides a lively representation of mercury’s aptitude in forming amalgams with gold. Graeco-Egyptian authors often conceptualise this chemical

⁴⁰ See Pietro Luigi M. Leone, *Ioannis Tzetzae epistulae* (Leipzig: Teubner, 1972), 14.8–18, in particular, lines 15–18: τὴν μάγνησσαν δὲ ἀκούεις ὅπως ἔρᾶ τοῦ σιδήρου, εἴ γε τέως αὐτὴν οὐχ ἐώρακας, ἵνα χυτῶν ἀργύρων καὶ λίθων ἐτέρον παραδράμῃ τοὺς ἔρωτας. As seen above, Thales already provided magnet (μάγνησσα in Tzetzes’ passage) with a soul. The late antique lapidaries described the magnet’s attraction for the iron as a kind of mother love (see, e.g. *Orphic Lapidary*, 306–12). Other stones were considered as “ensouled” in this tradition, such as the “ensouled orites” (ἔμψυχος ὀρείτης) mentioned in the *Orphic Lapidary*, 362 (I thank an anonymous reviewer for drawing my attention to this passage). This name might be related to the Akkadian *šadānu balṭu* (“living hematite,” where *šadānu* might simply refer to an ore that comes from the mountain): see Robert Halleux and Jacques Schamp, *Les lapidaires grecs* (Paris: Les Belles Lettres, 2003), 101 and 310 n. 7; Erica Reiner, “Astral Magic in Babylonia,” *Transactions of the American Philosophical Society* 4 (1995): 1–150 (on 122).

⁴¹ Pietro Luigi M. Leone, *Ioannis Tzetzae Historiae* (Napoli: Libreria scientifica editrice, 1968), 235.

⁴² On this interpretation of the Golden Fleece myth, see below.

⁴³ Aglae Pizzone, “The *Historiai* of John Tzetzes: A Byzantine ‘Book of Memory’?,” *Byzantine and Modern Greek Studies* 41, no. 2 (2017): 182–207 (on 190).

relationship as *sungeneia* (“kinship”), a natural tie between specific substances that could also materialise as a force of attraction between them. The attraction between a magnet and iron is a case in point, a paradigmatic example that we have already mentioned with regard to Thales (as quoted by Aristotle) and Tzetzes’s letters. Pseudo-Democritus too introduced this example in a passage quoted by Zosimus. Interestingly, the quotation is followed by two further examples dealing with mercury:

Ὁ φιλόσοφος πάλιν· «Συγγένειαν ἔχει ἡ μαγνησία καὶ ὁ μαγνήτης πρὸς τὸν σίδηρον». Πάλιν ὁ διδάσκαλος· «Πάλιν συγγένειαν ἔχει ἡ ὑδράργυρος πρὸς τὸν κασσίτερον. Ὁ φοιτητὴς φησιν· «Υδράργυρος ποιεῖ μίγμα κασσιτέρου».⁴⁴

The philosopher [i.e. Pseudo-Democritus] says again: ‘*magnēsia* and magnet have kinship with iron’. His master [Ostanes] in turn says: ‘mercury again has kinship with tin.’ His pupil [Pseudo-Democritus] says: ‘mercury produces an amalgam with tin.’

Mercury, indeed, was believed to have a great affinity with many metallic bodies as reported by Synesius.⁴⁵ Still, the Neoplatonic philosopher Gemistos Plethon (ca. 1355–1452) explicitly equated the attraction between the magnet and iron with the capacity of mercury to absorb gold and like substances.⁴⁶

Similar statements written in texts mirrored what could be actually observed in ancient workshops. Mercury-gold amalgams, indeed, were used in many technologies akin to alchemy, such as gilding, the making of golden inks, and, to a certain extent, gold mining. They were also exploited in medicine, in particular to treat mercury poisoning – a risk, one may argue, to which ancient alchemists and goldsmiths working with this substance were particularly vulnerable.

Gold is malleable and difficult to grind finely. When pulverised gold was needed, such as in the making of golden inks, it was amalgamated with mercury to be turned into a pulverulent mass. The precious metal was then separated from mercury either by pressing the amalgam through cloths or by distillation. After being purified, the gold powder was mixed with a fixing agent such as gum Arabic. Similar procedures are already described in the third century Leiden Papyrus⁴⁷ and continued to be recorded both in Byzantine and in Syriac manuscripts.⁴⁸ The late Byzantine recipe-book entitled *The Chrysopoieia of Cosmas*, for instance, opens with the description of the same method used to process gold: “Take 3 *hexagia* of pure gold, 1 *hexagion* of mercury, and prepare an amalgam as goldsmiths do. Wash the amalgam with

⁴⁴ Citation in Zosimus, *On the Body of Magnēsia*, CAAG, vol. 2, 197.12–15.

⁴⁵ *The Philosopher Synesius to Dioscoros*, 8.163–64, in *The Four Books of Pseudo-Democritus*, ed. Matteo Martelli (Leeds: Maney publishing, 2013), 136–37. Synesius attributed this idea to the Egyptian alchemist Pebichios.

⁴⁶ See *Laws*, 2.26 in *Pléthon: Traité des Lois*, ed. Remi Brague (Paris: Vrin, 1982), 80–81.

⁴⁷ See e.g. recipes 33 and 69, in *Papyrus de Leyde, Papyrus de Stockholm, Recettes*, ed. Robert Halleux (Paris: Les Belles Lettres, 1981), 93 and 100. See Shirley M. Alexander, “Medieval Recipes Describing the Use of Metals in Manuscripts,” *Marsyas* 12 (1964–1965): 34–53 (on 37–39).

⁴⁸ Jimmy Daccache and Alain Desreumaux, “Les textes des recettes d’encre en syriaque et garshuni,” in *Manuscripta syriaca. Des sources de première main*, eds. Françoise Briquel Chatonnet and Muriel Debié (Paris: Geuthner, 2015), 195–246.

water to eliminate its darkness and squeeze it well through a linen cloth to eliminate mercury.”⁴⁹

Gold-mercury amalgams were also used to gild metals such as silver and copper-alloys. Depending on the ratio between the two metals, the amalgams could be either pulverulent masses or kinds of paste. The paste was spread over the metals (in particular, silver or copper) as a paint; the mercury was then driven away by heating, leaving a thin coat of gold on the surface.⁵⁰ In some cases, mercury could simply act as a glue used to apply gold leaves on the surface of the metallic objects to be gilded.⁵¹

A limited use of amalgams was also made by physicians, who were well aware of the toxicity of mercury. The metal, indeed, is recorded in almost every ancient handbook on poisonous substances, where various remedies are listed to help those who ingested mercury.⁵² A special antidote is described in the treatise *On Simple Medicines* attributed to Dioscorides and usually referred to as *Euporista* (lit. “On easily available medicines”):

ύδραργύρου <δὲ> ποθείσης ἀρμόζει γάλα πινόμενον· ἐμείτω δὲ αὐτό· καὶ τὰ πρὸς λιθάργυρον δὲ ἀναγεγραμμένα ποιᾷ. ἄκρωσ δὲ βοηθοῦνται χρυσοῦ ἔλασματιον μικρόν τι καταπίνοντες περιφερές· περιχωνεύεται γὰρ τῷ χρυσοῦ διὰ συγγένειαν καὶ συνολισθαίνει διὰ τῆς ἕδρας.⁵³

If mercury has been ingested [lit. drunk] it is appropriate to drink milk; but do vomit it; the prescriptions recorded against cerussa work too. However, those who ingest a small, rounded leaf of gold, have the greatest relief. In fact, thanks to its kinship [*syngeneia*] with gold, mercury melts into an amalgam and is expelled through the anus.

The special kinship between gold and mercury is here explicitly mentioned to explain why the two metals mingle into amalgams even within the human body. The affinity between the two metals is explained in terms of attraction by Pliny the Elder in his *Natural History* (33.99–100):

omnia ei innatant praeter aurum; id unum ad se trahit. ideo et optime purgat, ceteras eius sordes expuens crebro iactatu fictilibus in vasis. ita vitiis eiectis ut et ipsum ab auro discedat, in pelles subactas effunditur, per quas sudoris vice defluens purum relinquit aurum.

⁴⁹ Andrée Colinet, *Recettes alchimiques (Par. Gr. 2419; Holkhamicus 109), Cosmas le Hiéromoine, Chrysopoée* (Paris: Les Belles Lettres, 2010), 66.

⁵⁰ On fire gilding, see e.g. Alessandra Giumlia Mair, “Plating and Surface Treatments on Ancient Metalwork,” *Advances in Archaeomaterials* 1 (2020): 1–26 (on 4–8); Andrew Oddy, “A History of Gilding with Particular Reference to Statuary,” in *Gilded Metals: History, Technology and Conservation*, ed. Terry Drayman-Weisser (London, Archetype, 2000), 1–19.

⁵¹ Cold mercury gilding was described by Pliny the Elder (*Natural History*, 33.64–65, 100, 125) according to Ottavio Vittori, “Pliny the Elder on Gilding: A New Interpretation of His Comments,” *Gold Bulletin* 12 (1979): 35–39; Ottavio Vittori, “Interpreting Pliny’s Gilding: Archaeological Implications,” *Rivista di archeologia* 2 (1978): 71–81.

⁵² See e.g. Aelius Promotus, *On Venomous Beasts and Poisonous Drugs*, 72, in *Der Traktat peri tōn iobōlōn thriōn kai dhlēthriōn farmākōn des sogenannten Aelius Promotus*, ed. Sybille Ihm (Wiesbaden: Reichert Verlag, 1995), 74–75; Dioscorides, *De materia medica*, 5.95, in *Pedanii Dioscuridis Anazarbei de materia medica quinque libri*, ed. Max Wellmann, 3 vols. (Berlin: Weidmann, 1906–1914), 3:66.

⁵³ Pseudo-Dioscorides, *Euporista* 2.168, in Wellman, *Pedanii Dioscuridis Anazarbei de materia medica*, 3:317.

All substances float on its [i.e. mercury's] surface except gold, which is the only thing that it attracts to itself; consequently, it is also excellent for refining gold, as if it is briskly shaken in earthen vessels it rejects all the impurities contained in it. When these blemishes have been thus expelled, to separate the quicksilver itself from the gold it is poured out on to hides that have been well dressed, and exudes through them like a kind of perspiration and leaves the gold behind in a pure state.⁵⁴

The special attraction between mercury and gold explains, according to Pliny, why the former was used to “purify” or “refine” gold; presumably crushed gold ores were first mixed with the liquid metal that was then separated by pressing the amalgam through leather.⁵⁵

The use of leather in the recovery of gold is recorded by Strabo and Appian (second century AD), who provided a rational reading of the mythical Golden Fleece: it would have referred to the fleecy skins (μαλλωτὰ δέρρα) and thick fleeces (βαθύμαλα) by which local miners collected the gold-dust carried down by mountain rivers.⁵⁶ While no reference to mercury is found in these interpretations,⁵⁷ descriptions of the use of mercury for gold mining are reported by later Arabic sources, such as al-Hamdānī (ninth to tenth century AD) and al-Bīrūnī (tenth to eleventh century AD).⁵⁸ The latter also records an ingenious method for recovering gold from rivers in Gandhara. Men dug pits at river sources that carried tiny nuggets of gold and sand, then filled these pits with mercury so that “when (gold) particles pass over the quicksilver, the gold sticks to the quicksilver and the sand passes over.”⁵⁹ Interestingly, these mercury-filled pits are reminiscent of the pits in which the liquid metal remained trapped in the myths on the founts of mercury discussed above. In these myths, however, there was no reference to the extraction of gold, the main focus of al-Bīrūnī's account.

Gold mining, on the other hand, was a focus of Graeco-Egyptian and Byzantine alchemists. The earliest Byzantine alchemical manuscript (MS *Marcianus* gr. 299, fols. 138r – 140v) transmits two passages from Agatharchides' *On the Red Sea* (second century BC) as reported by the Byzantine scholar Photios.⁶⁰ The first passage deals with gold mining in the Red Sea region, introduced in the alchemical manuscript by the heading, “On mined ores. How to prepare gold in those places where it is found.”⁶¹ Zosimus of Panopolis identified ores – *psammoi* (literally,

⁵⁴ Translation by Rackham, *Pliny, Natural History*, 77–79.

⁵⁵ See George Rapp, *Archaeomineralogy* (Berlin: Springer, 2009), 242.

⁵⁶ Strabo, *Geography*, 11.2.19; Appian, *Roman History*, 12.103.

⁵⁷ On the use of amalgams in gold mining, see Paul T. Craddock, “Early History of the Amalgamation Process,” in *King Croesus' Gold: Excavations at Sardis and the History of Gold Refining*, eds. Andrew Ramage and Paul T. Craddock (London: British Museum Press, 2000), 233–37.

⁵⁸ Ahmad Y. al-Hassad and Donald R. Hill, *Islamic Technology: An Illustrated History* (Cambridge: Cambridge University Press, 1986), 246–47.

⁵⁹ Al-Bīrūnī, *Kitāb al-jamāhir fī ma'rifat al-jawāhir* (*The most comprehensive book on the knowledge of precious stones*), trans. Hakim M. Said (Islamabad: Pakistan Hijra Council, 1989), 203.

⁶⁰ See Letrouit, “Chronologie des alchimistes grecs,” 66–68; Alexandre M. Roberts, “Framing a Middle Byzantine Alchemical Codex,” *Dumbarton Oaks* 73 (2019), 69–102 (on 94).

⁶¹ Περὶ τῶν μεταλλικῶν λίθων. Ἐν οἷς ὁ χρυσὸς ἐν ἐκείνοις τοῖς τόποις ὅπως κατασκευάζεται. The passage in MS *Marcianus* gr. 299, fols. 138r–140r12 matches Photios' summary of Agatharchides' account (with a few variant readings): see

“sands”) – with one of the main sources of wealth for Egyptian kings, who strictly controlled the mining and working of precious metals. Through a network of state officials, this control extended over the specialised workers who mastered the different steps of the *chaîne opératoire* that led from ores to precious metals, such as sand-washing and roasting.⁶² Some steps of this process were likely discussed in Zosimus’s lost work *According to the Operation*, which, to some extent, dealt with the process known as *taricheia* (literally, “maceration”).

A commentary on this lost work has been preserved by Byzantine alchemical manuscripts under the name of the Neoplatonic philosopher Olympiodorus of Alexandria (sixth century AD).⁶³ According to this commentary, the term *taricheia* had to do with the treatment of a muddy earth, which contained “metallic bodies.”⁶⁴ After being dried, the earth was washed to separate the “bodies” (that Olympiodorus identified with gold, silver, and lead) from the sand, which is lighter and thus floats on the water.⁶⁵ Interestingly, other alchemical authors associated the *taricheia* process both with the black colour and with *melanōsis* (literally, “becoming black”), that is, the first step of the metallic transmutation. Black sand, indeed, is often found in alluvial deposits of gold. Agatharchides insists on the black colour of the rocks in which auriferous quartz veins were trapped.⁶⁶ These rocks were mined, hammered, and milled into a kind of flour that was then washed on a wood board so that the earthy part dissolved and flowed away while the gold ores stuck to the board.⁶⁷

None of these texts explicitly mentions the use of mercury to process the black sand and recover gold. Only Olympiodorus, after discussing Zosimus’s *taricheia*, refers to mercury in a section entitled *On Chrysocolla* (“gold solder”). Here, he takes the term *chrysocolla* literally, referring to “the gluing of gold to gold, that is, the gold leaves that have been separated from the sand.”⁶⁸ The reference to

⁶¹ *Continued*

René Henry, *Photius, Bibliothèque, tome VII («codices» 246-256)* (Paris: Les Belles Lettres, 1974), 151–56 (codex 250.22–29).

⁶² Zosimus, *On the Final Account*, 1, in Festugière, *La révélation d’Hermès Trismégiste*, 1:364. I have translated ἀμολυσία and ἔψησις as “sand-washing” and “roasting.” The term *chaîne opératoire* (introduced by André Leroi-Gourhan and mainly used in archaeology and anthropology) refers here to the sequence of actions from the acquisition of raw material to the production of an artefact. On its use in the history of technology, see e.g. Marcos Martínón-Torres, “*Chaîne opératoire*: The Concept and Its Application within the Study of Technology,” *Gallaecia* 21 (2002): 29–43.

⁶³ Its extant version was extensively compiled and modified by an anonymous Byzantine alchemist: see Cristina Viano, “Olympiodore l’alchimiste et la *taricheia*. La transformation du minerai d’or: *technê*, nature, histoire et archéologie,” in *Greek Alchemy from Late Antiquity to Early Modernity*, ed. Efthymios Nicolaidis (Turnhout: Brepols, 2018), 59–69 (on 59–61).

⁶⁴ Olympiodorus introduces the technical expression γῆ σωματοφόρος, literally, “earth bearing a (metallic) body” (CAAG, vol. 1, 71.4).

⁶⁵ CAAG, vol. 1, 71.1–11. See Viano, “Olympiodore l’alchimiste et la *taricheia*,” 59–69.

⁶⁶ *On the Red Sea*, 5.22; see Stanley M. Burstein, *Agatharchides of Cnidus, On the Erythraean Sea* (London: The Hakluyt Society, 1989), 59.

⁶⁷ For a comparison of Agatharchides’ account with archaeological findings, see Thomas Faucher, “Ptolemaic Gold: The Exploitation of Gold in the Eastern Desert,” in *The Eastern Desert of Egypt during the Greco-Roman Period: Archaeological Reports [online]* (Paris: Collège de France, 2018), <https://doi.org/10.4000/books.cdf.5241>.

⁶⁸ CAAG, vol. 1, 73.7–9: Χρυσόκολλά ἐστίν, τουτέστιν τὸν χρυσὸν πρὸς τὸν χρυσὸν κολλῆσαι, ἃ τινὰ ἐστὶ τὰ πέταλα τοῦ χρυσοῦ τὰ χωρισθέντα ἀπὸ τῶν ψάμμων.

the previous section is evident: gold pieces that were to be joined together are the metallic bodies extracted by means of maceration and washing. They were roasted, but fire (Olympiodorus warns) could make the mercury evaporate,⁶⁹ as if gold had been previously amalgamated with the liquid metal. If mercury was used to refine gold, it had to be distilled off according to the standard procedure. Conversely, Olympiodorus seems to prefer avoiding dissipation, since he identified mercury – which he also called “the cloud that runs away” (νεφέλη ἢ τρέχουσα) – with the “dyeing spirit” (βαπτικὸν πνεῦμα) of the *chrysocola*, perhaps to be understood here as the gold-mercury amalgam itself.

Olympiodorus on mercury and *chrysocola*

Olympiodorus’ section *On Chrysocola* follows his discussion of maceration (*tari-cheia*) and washing (*plysis*). The kind of washing required in this case is described as the passage of a substance that has been deprived of its body back to a bodily state:

τὴν τῶν ἀσωματοθέντων σωματώσιν καὶ τῶν πνεύματων, τουτέστιν τῶν ψυχῶν αὐτῶν διὰ μόνης τῆς φύσεως τελούμενα καὶ οὐ διὰ χειρῶν ὡς τινες νομίζουσιν. ὁ γὰρ Ἑρμῆς φησιν· ὅταν λάβῃ μετὰ τὴν μεγάλην θεραπείαν, τουτέστιν τὴν πλύσιν τῆς ψάμμου.⁷⁰

Making corporeal those things that have been made incorporeal and the spirits, that is, their souls: [these operations] are completed by nature alone, not by [human] manipulations, as some people believe. Indeed, Hermes says: “when you take [a substance] after the great tending [*therapeia*], that is the washing of the mineral sand.”

The washing of the mineral substances leading to the operation of *chrysocola* involves the transformation of spirits into bodies. These spirits are identified with the souls of the substances transformed during the washing. In many Greek alchemical works, a soul (*psychē*) or a spirit (*pneuma*) are attributed to metallic and mineral substances. Like any living being, the substances transformed by the alchemists have a soul, but for them the soul corresponds primarily with their colour. There are many examples of colour change during alchemical operations that are described as the departure of the soul of a metal from its body and the arrival of a new (or renewed) soul within that body.⁷¹

In the above passage, Olympiodorus characterises the transformation of spirits into bodies as a natural process instead of an artificial manipulation. Olympiodorus’ claim is corroborated by a quotation attributed to Hermes where he refers to the “washing of the mineral sand” as the great “*therapeia*,” a Greek term describing

⁶⁹ CAAG, vol. 1, 73.9–19.

⁷⁰ Olympiodorus Alch., *On Zosimus’s According to the Operation*, CAAG, vol. 1, 72.18–21. On the alchemical work ascribed to Olympiodorus, see Cristina Viano, “Olympiodore l’alchimiste et les Présocratiques: Une doxographie de l’unité (*De arte Sacra*, § 18–27),” in Kahn and Matton, *Alchimie: art, histoire et mythes*, 95–143; Cristina Viano, *La matière des choses. Le livre IV des Météorologiques d’Aristote et son interprétation par Olympiodore* (Paris: Vrin, 2006), 199–206; Viano, “Olympiodore l’alchimiste et la *taricheia*,” 59–69.

⁷¹ See Cristina Viano, “Una substance, deux natures: les alchimistes grecs et le principe de la transmutation,” in “Dualismes. Doctrines religieuses et traditions philosophiques,” eds. Fabienne Jourdain and Anca Vasiliu, special issue, *Chōra Revue d’étude anciennes et médiévales* (2015), 309–25.

the service of a person to a god or another person, the tending of plants and cultivations, and the nursing and medical care provided to a child and a diseased person respectively.⁷² Furthermore, the conceptualisation of the vapours released during these operations as spirits and souls emphasises the natural quality of the procedure. Olympiodorus suggests that the kind of washing preceding the operation of the *chrysocolla* is a process comparable to the death of a living being and the birth of another. Accordingly, the alchemists do not impose their artificial agency over natural processes, but rather align their own actions with the course of nature.

The following preparation of the *chrysocolla*, understood in its literal meaning as “gluing of gold to gold,” involves the slow heating of foils of a gold mineral until they produce a vapour (νεφέλη, lit. “cloud”), which should be carefully treated to avoid its dissipation. The result is the production of foils of *chrysocolla* that can transmute other metals into gold. Olympiodorus also states that the foils of the gold mineral are called “foils of *klaudianon*” by Zosimus, while the vapour they produce is mercury. According to Olympiodorus, only dyes prepared from mercury provide a stable gold colour to metals, but the foils of the gold mineral, or *klaudianon*, and the vapour of mercury are both unable to withstand heating by themselves.⁷³ At the end of this section, Olympiodorus explains the use of the term “preparation” (οικονομία) as follows:

μάθοις ἄν, ὃ φίλε τῶν Μουσῶν, ὅτι τὸ τῆς οἰκονομίας ὄνομα, τί ποτέ ἐστίν. καὶ μὴ ὑπολάβῃς ὡς τινες τὴν διὰ χειρῶν ἐνέργειαν μόνον ἀρκοῦσαν εἶναι, ἀλλὰ καὶ τὴν διὰ τῆς φύσεως γινόμενην, ὑπὲρ ἀνθρώπων οἶσαν. [...] καὶ τὸ τῆς οἰκονομίας ὄνομα ἐν μυρίαῖς τόποις λέλεκται δι’ ὅλων τῶν ἀρχαίων· κάτοχον γὰρ τρόπον τινὰ βούλονται εἶναι. τί δὲ κάτοχον τίνοσ, εἰ μὴ ἄρα φεύγοντός τινος ἢ κάτοχος ὑδράργυρος; καὶ αὕτη φεύγει τὸ πῦρ. λέγει γὰρ Ζώσιμος· πῆξον τὴν ὑδράργυρον τῷ τῆς μαγνησίας σώματι. χρυσόκολλαν δὲ εἰρήκασι τὴν μίξιν ἀμφοτέρων· τὸ δὲ ἐκ τούτων ἐξίον ἐγκάτοχον τῷ μισγομένῳ οἶδα συντηρεῖν.⁷⁴

Friend of the Muses, learn what the term “preparation” means. And do not assume, as some people do, that the manual operation is enough. Instead, [this operation] is produced by nature since it surpasses any human being. [...] Also, the term “preparation” has been used by all the ancient [alchemists] in countless cases as they wish any [preparation] to be in a fixed state. What can be fixed, if mercury, being fleeting, is not fixed? Indeed, mercury flees from fire. For Zosimus says: “Make mercury solid with the body of *magnēsia*.”⁷⁵ They said that the *chrysocolla* is the mixture of both substances, and I know how to preserve the product of their purification fixed tightly to what has been mixed with it.

⁷² See Henry George Liddell and Robert Scott, *A Greek-English Lexicon. A New Edition Revised and Augmented throughout by Sir Henry Stuart Jones*, 2 vols. (Oxford: Clarendon Press, 1940), s.v. *θεραπεία*; see also Pierre Chantraine, *Dictionnaire étymologique de la langue grecque. Histoire des mots*, vol. 2 (Paris: Klincksieck, 1970), s.v. *θεράπων*.

⁷³ See Olympiodorus Alch., *On Zosimus’s According to the Operation*, CAAG, vol. 1, 73.6–19.

⁷⁴ Olympiodorus Alch., *On Zosimus’s According to the Operation*, CAAG, vol. 1, 73.20–74.12.

⁷⁵ This quotation is extremely common in the Greek alchemical corpus. While Olympiodorus ascribes it to Zosimus, its first attestation can be traced back to Pseudo-Democritus, *Natural and Secret Questions*, in Martelli, *The Four Books*, 86.67.

As we have already noted, the operations described by Olympiodorus show strong similarities to the amalgamation of gold and mercury, but the instruction to avoid the dissipation of mercury illuminates a fundamental difference between Olympiodorus' procedure and the extraction of gold through its amalgamation with mercury. The identification of mercury with the dyeing spirit of the *chrysocola*, instead, refers to the previous discussion of the washing of the mineral ores and the necessity to transform the spirits and souls of the alchemical substances back into bodies by harnessing processes taking place in nature, rather than relying on artificial operations.

Later in his commentary, Olympiodorus introduces an oracle about *chrysocola*:

καὶ ἄλλος χρησμός αὐτοῦ οὕτως φησὶν· χρυσόλιθον λάβε, ὃν καλοῦσιν ἄρρενα τὸν χρυσοκόλλης καὶ ἄνδρα συμπεφυρμένον. σταγόσιν γὰρ αὐτοῦ τίκει τὸ χρυσίον Αἰθιοπίδος γῆς. ἔνθα μυρμῆκων γένος χρυσόν τε ἐκφέρει, καὶ ἀνάγει, καὶ τέρπεται. καὶ θεὸς σὺν αὐτῷ γυναικῆ ἀτμίδος ἕως ἐκστραφῆ· ὕδωρ δὲ θεῖον πικρόν· εἰ δὲ ἐστυμμένον, ἢ καὶ ἰῶνται Κύπριον καὶ Αἰγυπτίας χρυσοβοστρύχου χυλόν· χρίε πέταλα τῆς φαεσφόρου θεᾶς καὶ Κυπρίδος πυρρᾶς τε καὶ χώνευε χρυσὸν ἀγκαλούμενος.⁷⁶

And another of his [i.e. Apollo's] oracles says as follows: "Take the gold stone [*chrysolithos*], which is called the male of the *chrysocola*, and the husband mixed together [with her]. Through his drops, indeed, the gold of the Ethiopian land is born. There, a certain kind of ants carries it out of [the earth], leads it up, and is delighted. And put with him the woman of the vapour until he is transmuted: [this is] the sharp divine water. If [this water] has been fixed firmly, then [these substances] treat the Cyprian juice, [the juice] of the golden-tressed Egyptian woman. Coat the foils of the light-bringing goddess, that is, Cypris [i.e. Aphrodite] with red hair, and cast the gold, while you make an invocation."

Apollo's oracle, whose source remains unknown, links *chrysocola* to the natural generation of gold ores in the Ethiopian region. The gold mines of this region, which are described in Agatharchides's *On the Red Sea*, were well known to Greek alchemists, while accounts of gold-digging ants can be found since Herodotus (fifth century BC).⁷⁷ According to Herodotus, this kind of ant lives in India near Caspatyrus and the Pactic country (probably a region in the vicinity of Gandhara). Solinus (third century AD) and later sources locate these ants in Ethiopia.⁷⁸ However, there are no clear sources for the distinction between a male component of the *chrysocola*, called "gold stone" (*chrysolithos*), and a female component of the vapour. The "sharp divine water," a key ingredient in the Greek alchemical tradition,⁷⁹ is then identified with this vapour, while the combination of male and

⁷⁶ Olympiodorus Alch., *On Zosimus's According to the Operation*, CAAG, vol. 1, 95.8–15.

⁷⁷ See Herodotus, *Histories*, 3.102–105. On Agatharchides, see above, p. 13.

⁷⁸ See Gaius Iulius Solinus, *Polyhistor*, 30.23; see also Isidore of Sevilla, *Etymologiae*, 12.3.9–10. For a recent survey of ancient and medieval sources about gold-digging ants, see Chloe Peters, "Some Ants Go Marching Two by Two, Others Dig for Gold: The Textual Descriptions and Visual Depictions of Ants in the Medieval Bestiary Tradition" (MA thesis, Central European University, Vienna, 2022).

⁷⁹ See Matteo Martelli, "Divine Water in the Alchemical Writings of Pseudo-Democritus," *Ambix*, 56, no. 1 (2009): 5–22 and Viano, "Una substance, deux natures," 309–25.

female components of the *chrysocolla* produces a substance that is used to coat metallic foils and cast gold. The oracle's conclusion adopts highly metaphorical language, but it is clear that the effect of this resulting substance brings about a transformation from a red and "Cyprian" substance that corresponds to copper, the red metal whose richest mines were in Cyprus, into a bright and golden substance, which is indeed gold.

As in the previous description of the procedure of *chrysocolla*, extraction of gold from mines is followed by references to a process involving the transformation of a golden mineral through the action of a vapour that does not dissipate but is kept together with the mineral until the transformation is completed. In this case, though, mercury is substituted with the divine water and a clear distinction between male and female components of *chrysocolla* is introduced. The product of this operation is then linked to the transmutation of copper into gold, marking the passage from an operation somewhat still linked to the extraction of metallic ores to an unequivocally alchemical operation.⁸⁰

Shortly after the alleged oracle of Apollo, Olympiodorus introduces the *tetrasōmia*, that is, the alloy of four base metals, and identifies this substance with lead only. Then, a quotation from Zosimus only preserved in this passage is introduced:

ἰδὸν ἐξ ἀρχῆς εἰρημένον περὶ τῶν στοιχείων, καὶ ἐνταῦθα δημηγορεῖται. [...] τὰ γὰρ τέσσαρα σώματα ἢ τετρασωμία ἐστίν· περὶ ἧς τετρασωμίας φησὶν ὁ Ζώσιμος· εἶτα οὕτως ἢ τάλαινα ἐν σώματι τετραστοίχῳ πεσοῦσα ἢ καὶ πεδηθεῖσα, εὐθέως καὶ χρώμασιν ὑποπίπτει οἷς βούλεται ὁ τῆ τέχνησιν πεδήσας ἢ λευκόν, ἢ ξανθόν, ἢ μέλαν αὐτήν, ἢ μέλανι, ἢ λευκῷ, ἢ ξανθῷ. εἶτα ὑποδεξαμένη τὰ χρώματα καὶ κατ' ὀλίγον ἐβῶσα ἕως γήρους ἔρχεται καὶ τελευτᾷ ἐν τῷ τετραστοίχῳ σώματι, τουτέστιν χαλκῷ, σιδήρῳ, κασσιτέρῳ καὶ μολύβδῳ, καὶ συντελευτᾷ ἐν τῇ ἰώσει, τούτοις ὡς φθειρομένη, καὶ μάλιστα τότε μὴ δυναμένη φεύγειν· ἅτε δὴ συμπλακείσα αὐτοῖς, καὶ μὴ δυναμένη φεύγειν. πάλιν μετ' αὐτῶν ἀντεπιστρέφει, συνδεδεμένον ἔχουσα τὸν δῶκοντα καὶ ἔξωθεν ὑπὸ ὀργάνου κυκλικῷ.⁸¹

Here is what was said on the elements from the beginning, and herein it is said openly. [...] For the *tetrasōmia* is the four bodies: about this *tetrasōmia*, Zosimus said: "Then the suffering [*tetrasōmia*], which is fallen or even imprisoned into the body made of the four elements, falls at once under the colours that are wished for by the person imprisoning [it] by means of the art [i.e. alchemy]: white, yellow, or black by means of the black, white, or yellow [operations]. Then, when it has received the colours and attained youth little by little, it proceeds up to its old age, is completed in the body made of the four elements – that is copper, iron, tin, and lead –, and is perfectly completed during the rusting (process), as it is destroyed with them and especially then it cannot escape – inasmuch as it has been intertwined with them, it cannot escape. Once again, it is reversed back together with them, when by means of the circular apparatus it has been combined completely also outside [of it] with that which chases."

⁸⁰ The contiguity between extraction of metallic substances and their alchemical transmutation also emerges from the reference at the end of this passage to an invocation. This instruction echoes Olympiodorus' cursory mention of invocations during the washing of the mineral ores, see Olympiodorus Alch., *On Zosimus's According to the Operation*, CAAG, vol. 1, 72.16–17.

⁸¹ Olympiodorus Alch., *On Zosimus's According to the Operation*, CAAG, vol. 1, 96.1–17.

Here, Olympiodorus establishes a direct connection between the *tetrasōmia* and the four elements of the physical world (fire, air, water, and earth). In a previous passage, Olympiodorus points out that the four elemental qualities (hot, cold, dry, and wet) can be understood as two pairs of male and female qualities.⁸² He further states that all substances generating from the earth, such as metals and plants, are classified by Zosimus “according to their colours and their natures, specific and generic respectively, as all things are both male and female.”⁸³ Also, Olympiodorus later quotes two sayings ascribed to Horus and Maria, Zosimus’s teacher: “For the central aspect of the entire art – as Horus says – is ‘to take secretly the seed of the man, yet that everything be of both sexes;’ as Maria says at some point: ‘Join together the male and the female, and what is sought will be found: indeed, without this process of copulation, nothing can be achieved; for nature delights in nature, etc.’”⁸⁴ The male and female components of the material substrate of alchemical transmutation, therefore, are crucial elements in Olympiodorus’s discussion of mineral and metallic substances and are connected directly to the four elements. While the elemental theory offers a philosophical foundation for the alchemical operations illustrated by Olympiodorus, the distinction between male and female aspects of the material substrate strengthens the link between alchemical practice and natural processes involving living beings.⁸⁵

The association (found in the oracle of Apollo) between the male component of the *chrysocola* and its female vapour is followed and clarified by the discussion of the *tetrasōmia*. On the one hand, the combination of male and female aspects of a single substance refers to the mixture of opposite elements and elemental qualities resulting in the composition of every physical substance. In this sense, the union of male and female stands for the equilibrium maintained – at least for a certain time – by the material substrate, despite being made of opposite qualities. On the other hand, the transformation of the *tetrasōmia* into black, white, and yellow colours – that is, the alchemical transmutation of the base metals – is presented both as an imprisonment and as a process of natural growth. The combination of the metallic substrate with these colours is consistently presented as the confinement of substances that tend to escape from each other. At the same time, the introduction of these colours marks the beginning of a growth from youth to old age. At that point, the colours, which tend to escape, are unified to the base metals of the *tetrasōmia*, and a final stage of destruction and reconstitution brings about the

⁸² See Olympiodorus Alch., *On Zosimus’s According to the Operation*, CAAG, vol. 1, 85.6–86.19.

⁸³ Olympiodorus Alch., *On Zosimus’s According to the Operation*, CAAG, vol. 1, 78.18–20: χρωαῖς καὶ φύσει ἀλλεπαλλήλοις, ἰδικαῖς καὶ γενικαῖς ἀρρενοθήλη ὄντα.

⁸⁴ Olympiodorus alch., *On Zosimus’ According to the Operation*, CAAG, vol. 1, 102.11–16: τὸ γὰρ κυρίως τῆς ὄλης τέχνης, φησὶν Ὁρος: λαθραῖως εἰληφέναι τὸ τοῦ ἀρρενος σπέρμα, ἀλλὰ πάντα ἀρρενόθηλυ ὑπάρχειν. ὡς ποῦ φησιν ἡ Μαρία: ζεύξατε ἄρρενα καὶ θήλειαν, καὶ εὕρησεται τὸ ζητούμενον· χωρὶς γὰρ ταύτης τῆς οἰκονομίας τῆς συζυγίας, οὐδὲν δύναται κατορθοῦθαι· ἢ γὰρ φύσις τῆ φύσει τέρπεται. καὶ τὰ ἐξῆς.

⁸⁵ On the philosophical framework established by Olympiodorus, see Viano, “Olympiodore l’alchimiste et les Présocratiques,” 95–143; and Cristina Viano, “Les alchimistes gréco-alexandrins et le *Timée* de Platon,” in *Alchimie et ses racines philosophiques. La tradition grecque et la tradition arabe*, ed. Cristina Viano (Paris: Vrin, 2005), 91–107. See also above, n. 5.

complete stability of the colouration. The opposition between bodily substrate and colouring spirit is presented as the key challenge for the alchemists; a challenge only solved by recreating a form of natural growth while opposite constituents are forcibly maintained together within the alchemical apparatus.

The operations described by Olympiodorus in relation to *chrysocolla* can notably be compared to some processes described by the alchemist Synesius (fourth century AD).⁸⁶ In his commentary on Pseudo-Democritus' alchemical work, Synesius emphasises the role of mercury in alchemical operations. Mercury can receive all colours from other metals. The colour of the metals is described as their "soul" or "spirit" and, when it is separated from their bodies, it dissipates unless united with a new bodily substance. When mercury loses its own proper colour, which is white, it has the unique ability to receive every other colour and provide them with a suitable substrate to subsist within a physical body.⁸⁷ The resulting composition of "decoloured" mercury and the colour of another metal can be applied to a different metallic substance to steadily change its colour and, thus, transmute it into a different metal. In particular, the union of this kind of mercury with the yellow colour of gold produces a dye-like substance able to transmute other metals into gold.⁸⁸

Synesius clarifies the association of the colour of a metal with its "soul" when he claims, "that is how also the mercury that we produce with art takes any form and remains – as I said – fixed and strictly bound together with the *tetrastoichos* [i.e. the alloy formed by the four elements (metals)], which it masters and by which it is mastered."⁸⁹ The colour of the metals corresponds to their form (εἶδος), while the final material substrate of the alchemical transmutation is the *tetrastoichos*. The latter was interpreted by the alchemists either as the union of the four elements of the physical world (fire, air, water, and earth), in which case it stands for every natural substance, or as the alloy of the four base metals (copper, iron, tin, and lead), in which case it represents all metallic bodies.⁹⁰ Mercury is the vehicle that allows a specific form to subsist when deprived of its original bodies so that it can be united with a new material substrate.⁹¹ In this respect, Synesius's account of the role of mercury in alchemical practice seeks to offer a philosophical justification of alchemical transmutation: it offers a clear identification of the form of the

⁸⁶ On Synesius' alchemical work, see Martelli, *The Four Books*, 26–28 and 48–57. Based on some similarities between Olympiodorus and Synesius, Olivier Dufault has argued for the development of a "form-transfer theory" shared by various Greek alchemists. The present analysis will also point out similarities in the conceptualisation of alchemical operations between Olympiodorus and Synesius, while refrain from inferring from them a common "theory" about alchemical transmutation; see Olivier Dufault, "Transmutation Theory in the Greek Alchemical Corpus," *Ambix*, 62, no. 3 (2015): 215–44 (esp. 230–38).

⁸⁷ See esp. Synesius Alch., *Notes on Democritus's Book*, in Martelli, *The Four Books*, 132.133–134.144.

⁸⁸ See Martelli, *The Four Books*, 245–46, n. 15 and 17.

⁸⁹ Synesius Alch., *Notes on Democritus's Book*, in Martelli, *The Four Books*, 134.160–136.163: οὕτως οὖν καὶ ἡ ὑδράργυρος φιλοτεχνουμένη ὑφ' ἡμῶν πᾶν εἶδος αὐτῆ ἀναδέχεται καὶ πεδηθεῖσα, ὡς εἴρηται, ἐν τῷ τετραστοίχῳ σώματι ἰσχυρὰ καὶ ἀδίκτος μένει, κρατοῦσα καὶ κρατουμένη. English trans. by Martelli, *The Four Books*, 135–137.

⁹⁰ See Martelli, *The Four Books*, 246–47, n. 18.

⁹¹ See Viano, "Les alchimistes gréco-alexandrins et le *Timée* de Platon," 91–107 (on 97–99).

metals with their colour, and suggests a model to explain how the form of a given substance can be transferred to a different material substrate.

Within his discussion of mercury, Synesius, however, incorporates some elements that are difficult to reconcile with a purely philosophical explanation of the natural world. Synesius quotes Pseudo-Democritus's mention of *chrysocola* in its common meaning of malachite, a green mineral, to clarify the change in colour produced by the mercury dye. As the complexion of a human being changes into a shade of green colour when the person becomes pale, so does the colour of a metal change into the yellow of gold.⁹² Then, Synesius underscores that Pseudo-Democritus's reference to *chrysocola*, a feminine noun in Greek, is followed by mention of *klaudianon*, a masculine noun in Greek.⁹³ Synesius does not entirely clarify the reason behind the discussion of these two points; he briefly offers a parallel between the opposition of male and female minerals and that of dry and wet substances, but then moves on to further commentary on Pseudo-Democratean passages. Both the change of human complexion and the distinction between masculine and feminine nouns are aspects that Synesius introduces to better explain the colouration through mercury dyes. In his own account, however, the explanatory role of these two remarks remains unclear.

Olympiodorus likewise establishes a significant relationship between *chrysocola* and *klaudianon*. While Synesius's interpretation of this connection is based on the opposition between masculine and feminine nouns, Olympiodorus does not refer to the opposition between male and female substances in his first treatment of *chrysocola*, where he also mentions *klaudianon*.⁹⁴ However, in the oracle ascribed to Apollos, Olympiodorus introduces a similar opposition to explain the operation of the *chrysocola*. Moreover, Olympiodorus' quotations from Zosimus underline a correspondence between the opposition between male and female substances and that among opposite elementary qualities. Similarly, Synesius links the opposition between male and female to that between dry and wet substances. The last and most significant point of comparison is the role ascribed to mercury by both Synesius and Olympiodorus. The former introduces the opposition between *chrysocola* and *klaudianon* as an interpretative tool to understand Pseudo-Democritus's recipes in terms of colourations through mercury dyes.⁹⁵ The latter, instead, only mentions the *klaudianon* briefly, as he focuses on the operation of the *chrysocola*. Also in this case, though, the *chrysocola* is related to a change in the colour of the metallic substances using mercury.

Since Synesius's alchemical works were also sources for Synesius' commentary on Pseudo-Democritus and, on some occasions, Olympiodorus quotes directly from Synesius, the precise source used by both is difficult to identify. Nonetheless, the

⁹² See Synesius Alch., *Notes on Democritus's Book*, in Martelli, *The Four Books*, 138.186–200.

⁹³ See Synesius Alch., *Notes on Democritus's Book*, in Martelli, *The Four Books*, 138.201–208.

⁹⁴ See Olympiodorus Alch., *On Zosimus's According to the Operation*, CAAG, vol. 1, 73.6–19.

⁹⁵ On the connection between *chrysocola* and mercury in the production of silver and gold, see also Synesius Alch., *Notes on Democritus's Book*, in Martelli, *The Four Books*, 126.43–53.

similarities between these two alchemical works show the existence of an alchemical tradition connecting *chrysocolla* and *klaudianon* with colourations by mercury.⁹⁶ Synesius is also an exemplary case of the association between the soul or spirit of a metallic substance – not only with its colour, but specifically with mercury. The role of mercury as a “dyeing spirit” mentioned by Olympiodorus is, therefore, corroborated and further qualified through the comparison with Synesius’ parallel treatment of *chrysocolla* and mercury. Moreover, both Synesius and Olympiodorus link the union of mercury as a dyeing spirit to a suitable material substrate with the combination of male and female elements among the constituents of the natural world.

The operation of *chrysocolla*, as primarily discussed by Olympiodorus, is presented in the above-analysed passages in close connection to the extraction and purification of mineral ores and entails the prolonged action and eventual fixation of vapours of mercury over a metallic body. The latter operation, however, is fundamentally different from the former, as it marks the passage from extraction techniques to the alchemical transmutation of metals. Olympiodorus suggests that this action of vapours over bodies leads to the passage of an incorporeal substance into a corporeal state – a kind of transformation dependent from the philosophical consideration of the interactions among the four elements, and the way in which the formal aspects of metallic and mineral substances subsist within their material substrate. The idea of the soul of a metal as the bearer of its qualities, and primarily its colour, is thus linked both to the operative features of alchemy – representing the release of vapours which, in the alchemical apparatus, are condensed or act directly upon other substances – and to the philosophical notion of the soul as the formal principle of every living substance.

Concluding remarks

Olympiodorus points out that, at least in the procedure of the *chrysocolla*, the transformation from incorporeal to corporeal substances can be achieved only by following operations already taking place in nature, rather than artificial manipulations. Accordingly, the operations related to the *chrysocolla* are largely conceptualised through the reference to natural processes: the union of male and female constituents; the birth, growth, and death of plants and animals, especially with respect to the entrance and departure of their souls. The sexualisation of the natural world and the reference to various biological processes, however,

⁹⁶ A key element for the present historical reconstruction could come from the many references to *chrysocolla* in connection with mercury in Zosimus’ *Chapters to Eusebeia*. Although this work can be authentically attributed to Zosimus, the version preserved in the manuscript tradition is extensively abridged and compiled. Until a new and reliable critical edition of the *Chapters to Eusebeia* becomes available these references confirm the existence of a tradition linking *chrysocolla* and mercury but cannot be contextualised precisely within the Greek alchemical tradition. See Zosimus of Panopolis, *Chapters to Eusebeia*, CAAG, vol. 2, 150.7–12; 162.17–163.12; 170.5–9; 173.10–26; 195.4–197.4. See Michèle Mertens, *Zosime de Panopolis, Mémoires authentiques* (Paris: Les Belles Lettres, 1995), liv–lx.

represent an integration, rather than an alternative, to the philosophical notions related to the radical manipulations that the alchemists claimed to carry out on gold, mercury, and many other natural substances. Biological models were already part of different philosophical traditions: as discussed above, the Stoics speculated on stones and minerals as living substances that grow and flow under the earth like organic fluids in the human body. The distinction between organic and inorganic processes was often blurred in ancient philosophical and technical writings, and beliefs on the gender of ores, their birth and reproduction were encapsulated in the same Greek and Latin terminology used in reference to the mineral word, as Robert Halleux has convincingly argued.⁹⁷ Plants were sometimes “mineralised,” such as in the case of corals, which were understood as plants that are soft under the water, but petrify when exposed to air,⁹⁸ or in the case of a petrified oak root, which was presented by the Byzantine philosopher Psellos (eleventh century AD) as a telling example of the transformative power of nature upon which alchemy too rested.⁹⁹ Metals and minerals were, in turn, “botanised”: in alchemical literature, as seen above, mercury was associated with the juice of plants; as discussed in Chapter 47 of Pseudo-Aristotle’s *On Marvellous Things Heard*, gold was said to grow from soil in which it was previously buried.

In Olympiodorus’s passage, the alchemical preparation of *chrysocolle* through the action of mercury vapours and the extraction and purification of mineral ores, and especially gold, were linked together by the remarkable chemical reactions occurring in nature between mercury and gold, and most notably the operations related to their swift and thorough amalgamation upon contact. Amalgams were the most evident expression of a special kinship between the two metals, which was instantiated in various procedures carried out in ancient and medieval workshops. Furthermore, gold and mercury became central actors in mythologies that elaborated on their properties and mutual “attraction.” Through processes of cultural cross-pollination, vivid narratives about rivers of mercury that, like dragons, chase gold-clad riders emerged in different traditions and were included in alchemical writings from Byzantium to China. Indeed, these interactions between gold and mercury were conceptualised as processes that were extraordinary and natural at the same time, challenging the boundaries between inanimate metals and living bodies.

⁹⁷ See above, “Metals and minerals as living bodies.”

⁹⁸ See Ovid, *Metamorphoses*, 4.740–52; *Orphic Lapidary*, 558–72, in Halleux and Schamp, *Les lapidaires grecs*, 112. See Sonia Macri, “Lynx-stone and Coral: ‘Liquid Rocks’ between Natural History and Myth of Transformation,” in *Transformative Change in Western Thought. A History of Metamorphosis from Homer to Hollywood*, eds. Ingo Gildenhard and Andrew Zissos (London: Legenda, 2013), 131–52 (on 139–47).

⁹⁹ Psellos, *Letter on the Making of Gold*, 4, ed. Joseph Bidez, “Michel Psellus, *Épître sur la Chrysopée*,” in *Catalogue des manuscrits alchimiques grecs*, vol. 6 (Bruxelles: Lamertin, 1928), 28–30. See Marco Bellini, “Psellos’ Petrified Root: Transmutations and Natural Wonders from Classical Antiquity to Byzantine Times,” *Physis* 55 (2020): 223–41.

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