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Demetrios Michaelides

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24. Lemnian Earth, Alum and Astringency:  
   a Field-based Approach  

   Effie Photos-Jones and Allan J. Hall

Based on Galen’s account that Lemnian Earth (Λημνία γῆ; Λημνία σφραγίς; Terra Lemnia, ayiochoma) was an astringent medicine because of the occurrence, within, of a ‘bit of alum’, we present here our evidence to that effect. This evidence is supported by: a) the scrutiny of the classical texts; b) the geological prospection around the area of the alleged location of extraction of the Earth on the island of Lemnos, in the N. Aegean; c) our interpretation of the ritual of its extraction; and, lastly, d) the elucidation of its mineral composition. Lemnian Earth is a complex material consisting of clay minerals and inorganic salts like aluminium sulphate and iron oxide. Its composition may be affected by its possible association with the water from local natural springs. Astringency is the main property of alum and is still relatively little understood. Alum is also a bactericide; we argue that it was perhaps the combination of both properties of alum as an astringent and a bactericide that contributed to the celebrated medicinal attributes of Lemnian Earth. We also present here a brief description of the work undertaken by other researchers, as well as our impending new work on the nature of this intriguing material.

Introduction

Our research on the earths of the Aegean, mainly clay-based substances which were well-documented by the classical authors (Pliny Naturalis Historia, Dioscorides De Materia Medica, Galen De Simplicium Medicamentorum Temperamentis ac Facultatibus), has led us to believe that they were very versatile materials used for a variety of applications including paints, detergents and medicines (Photos-Jones and Hall 2011); and, furthermore, that the medicinal properties claimed for some earths were likely to be genuine.

Lemnian, Samian and Eretrian Earths were thought to have been particularly useful respectively as antidotes to snake bites (Philumenus De Venenatis Animalibus eorumque Remediis) (On poisonous animals and their remedies), inflammation of the eye, and ulcers (Dioscorides De Materia Medica); furthermore, belief in the efficacy of the Lemnian Earth, in particular, was sustained from Antiquity into the early 20th century. Deducing exactly what the classical authors understood to be the nature of these substances is certainly problematic, but it is not difficult to appreciate why belief in their efficacy as medicines has gradually faded and eventually totally disappeared. Recently, however, there has been a resurgence in interest in medicinal clays and the field of medical geology in general (Gomes and Silva 2007; Gomes 2013). In attempting to elucidate the nature of the earths we recognised two major problems: first, how and where does one start looking for them in the field, and second, what was/were the active ingredient/s which bestowed the medicinal properties on these clay-based substances.

It was primarily as a medicine that Lemnian Earth acquired its widespread reputation and in particular as an efficient antidote against poisons and snakebites. Pliny describes Lemnian Earth as being an antidote to poisons when poison was already swallowed and even against snake bites (Naturalis Historia [henceforth N.H.], XXIX.33 and XXXV.14); also, ‘in medicine it was used as an ointment around the eyes to relieve pain and inflammation’ (Pliny N.H. XXXV.14), and as a treatment for dysentery (N.H. XXVIII.24, XXIX.33.104, and XXXV.14). Given the richness of the record surrounding the nature, properties and the ritual of extraction of Lemnian Earth we believe we were justified in suggesting that the latter may provide an
environmental ‘framework’ on which geological and anthropogenic events can be pegged and which could underpin our understanding of the healing properties of this Earth.

Since the time of the conference in 2008 we have had the opportunity to publish a number of papers on the topic of alum (Hall and Photos-Jones, 2009; Photos-Jones and Hall 2010) and Lemnian Earth (Hall and Photos-Jones 2008; Photos-Jones et al. 2012) as well as one book (Photos-Jones and Hall 2011). This paper shifts attention from the local clay deposits and the local natural springs and the potential association between them and the pit from where the earth was extracted. We, therefore, summarise our attempts to establish the nature, composition, method of processing, and location of extraction, of Lemnian Earth. We have argued that Lemnian Earth the medicine and Lemnian Earth the raw material were two different products; the former resulting from the processing of the latter via a proposed ingenious enhancement of the natural geochemistry of the area, under the cover of a ritual, blessed by both ancient gods and Christian clergy. The elucidation of this enhancement led us to provide a theoretical composition for Lemnian Earth consisting of various components each bringing its own properties, e.g. kaolin and montmorillonite its absorbancy, iron oxide its red colour and alum its astringency (Hall and Photos-Jones 2008; Photos-Jones and Hall 2011).

**Lemnian Earth – the sources**

The earliest reference to the healing properties of Lemnian Earth is firmly embedded within the cycle of poetry associated with the Homeric poems, the Trojan War and its main participants, and in particular the hero Philoctetes who although setting off with the rest of the Greek army to fight at Troy, was left behind on account of having been bitten by a water snake, his wound festering and emanating a malodorous smell (Homer *Iliad* 2, 718–25).

Philostratus Flavius, a Lemnian sophist who lived in the 2nd century AD, in his chapter on Philoctetes (*Heroica* VI, 2), mentions that the priests of Hephaistos cured his wounds with Lemnian bole (βώλου τῆς Λημνίας). However, in the Sophocles version of the Philoctetes myth, the long-suffering hero had used a herb, rather than an earth, only available on the island of Lemnos (Sophocles *Philoctetes*, 659). Furthermore, Philoctetes’ wound did not heal until he finally arrived in Troy. Eustathius, Bishop of Thessaloniki, writing in the 12th century AD, in his comments on the *IIiad*, confirms that the priests of Hephaistos were in the habit of healing those who had been bitten by snakes (οἱ τοῦ Ἡραίστου ἱερεῖς ἐθεράπευον τοὺς ὀφεοδήκτους) with healing those who had been bitten by snakes (οἱ τοῦ Ἡραίστου ἱερεῖς ἐθεράπευον τοὺς ὀφεοδήκτους) with healing those who had been bitten by snakes (οἱ τοῦ Ἡραίστου ἱερεῖς ἐθεράπευον τοὺς ὀφεοδήκτους) with Lemnian Earth (Tourptsoglou-Stephanidou 1986, 84, n. 46).

Up to the middle of the 18th century there appear to have been very few, if any, doubts regarding the curative properties of Lemnian Earth. However, in the late 18th century questions were raised as to whether these attributes may not have rested simply on the belief that it ‘does’ cure. John Sibthorp, an English doctor and botanist visiting Lemnos in the late 18th century, having been present at the site on the day of its extraction, wrote:

> ‘on the 23rd of September … we saw the hole partly filled up and its soil which was a light colored clay … It could not possibly have a therapeutic value. Furthermore in the case of fever, when the stomach is weak, it would aggravate the illness which caused it (the fever) in the first place … this is an example of how superstition and ritual give credit to something which may have little or no value’ (Sibthorp in Tourptsoglou-Stephanidou 1986, 292) (all translations from the Greek are by the author).

Earlier travellers, most of them educated men of means, were equally puzzled, but, in their own accounts, each balanced the pros and cons differently. For example, Belon (in Tourptsoglou-Stephanidou 1986, 80) was convinced that it was the ritual that gave the Lemnian Earth its value, rather than the properties of the material itself.

Although there was essentially no scientific evidence regarding the source and nature of Lemnian Earth until the middle of the 19th century, the first contemporary chemical analyses indicated the presence of an aluminum-silicate clay, possibly with sodium and calcium, which would point to the montmorillonite group. It is unfortunate that potash was not mentioned in these early analyses (de Launay in Tourptsoglou-Stephanidou 1986, 505, n. 33), because confirmation of a lack of potash which is present in the common clay illite would be a further indication of montmorillonite. The high iron content reported suggests the presence of a red iron oxide/oxyhydroxide component in keeping with Lemnian Earth often being reported as a red substance. Therefore, at the time, it was concluded that Lemnian Earth was simply a clay. Hence, Louis de Launay’s statement below registering his frustration at not being able to pinpoint the active ingredient:

> ‘Perhaps the negative results derived from my analyses are one more proof of the risks posed by the application of chemistry to myths, particularly those that are among the oldest or the most vivid’ (de Launay in Tourptsoglou-Stephanidou 1986, 505).

There is little doubt that Lemnian Earth of the medicinal variety was fine-grained; the texture was certainly greasy/fatty and it appears to have ‘dissolved’ in the mouth (Belon in Tourptsoglou-Stephanidou 1986, 57).

Most medicinal Earths are discussed in association with astringency. Galen recognises the astringency in Lemnian Earth (τούτων δ’απασῶν ἡ Λημνία δύναμιν ἰσχυρότεραν ἔχει, προσέστι γαρ αὐτή τι καὶ στύψεως – of all the above...
The ritual of extraction

The ritual of the extraction of Lemnian Earth has fascinated many travellers since Galen’s visit to the island because it addresses many issues, practical, technical and religious, such as the exact location of the pit, the actual digging of it, the religious pageantry in the presence of state officials, the industrial process of earth enrichment, the sealing and distribution of the material, to select a few. All of these events are described as having taken place in the space of less than 12 hours and the totality and speed of their execution must have been so well rehearsed as to elude even the most astute of observers.

Regarding the ritual of the extraction we focus on two eyewitness accounts, which provide us with ample detail for the day’s activities, that of Galen in the 2nd century AD and that of Belon in the 16th century, who visited the site but not on the day of the extraction. Galen during his visit to the town of Hephaestias, in the north-eastern part of the island, was evidently shown the location of the extraction of Lemnian Earth, and was made aware of its association with the hill on which, according to mythology, Hephaistos fell after having been hurled from Mount Olympus by his own father Zeus.

‘... as to what the poet said about Hephaistos, that he fell in Lemnos, it seems to me that the fable refers to the nature of the hill, which has every appearance of having been burned, both on account of its colour, and from the fact that nothing grows on it. This then was the hill to which at the time I disembarked the priestess came’ (Galen in Brock 1929, 193).

The ritual of the preparation of the Lemnian Earth is described by Galen as follows:

‘The priestess collects this, to the accompaniment of some local ceremony, no animals being sacrificed, but wheat and barley being given back to the land in exchange. She then takes it to the city, mixes it with water so as to make moist mud, shakes this violently and then allows it to stand. Thereafter she removes the superficial water, and next the greasy part of the earth below this, leaving only the stony and sandy part at the bottom, which is useless. She now dries the greasy mud until it reaches the consistency of soft wax. Of this she takes small portions and imprints upon them the seal of Artemis namely the goat, then again she dries these in the shade till they are absolutely free from moisture’ (Galen in Brock 1929, 192).

Galen continues that the priestess, after filling a ‘whole wagon with earth, this she took into the town, as I have said, and from it prepared the far-famed Lemnian sphragis (seal)’ (Galen in Brock 1929, 192).

Belon who visited the same area nearly fourteen centuries later but not necessarily on the day of its collection gives directions to the site of its extraction:

‘From the corner of the castle [the ruined Byzantine castle of Kotsinas] towards the left, we walked towards the hill which is not more than four arrow-shots away. Between the port and the hill there is a small chapel called St Saviour’s, where the monks gather on the 6th of August, the date set for the extraction of the earth from its vein. After leaving the chapel and walking towards the hillock we found two paths, one to the left and one to the right leading to two springs, one about one arrow-shot away from the other’ (Belon in Tourptsoglou-Stephanidou 1986, 78).

Later on he adds:

‘they (priests and monks) walk towards and climb the hill which is not more than two arrow-shots away from the chapel … the one on our right (the Phthelidia) does not dry up in the summer, however, the one on the left does so completely … with horses we continued towards the right, towards a place where no trees grow, except of a carob tree, … and a willow which shadow the spring and where there are stone steps so that one can access the place where they extract the “sealed earth”. One climbs uphill and further up towards one’s left one can see the place where they extract the earth on the 6th of August. Because they extract it after opening a vein, nothing other than a long trench covered with earth can be seen’ (Belon in Tourptsoglou-Stephanidou 1986, 79).

The day’s events were preceded by a religious service at the chapel of St Sotiras (St Saviour). The Turkish governor of the island, Turkish and Greek notables, as well as some priests and monks took part in the ceremony. The digging began at or before sunrise and continued for six hours, after which the pit was closed and left undisturbed until the next year. Some Lemnian Earth was given to the officers present and other bystanders, but the bulk of it was sent to the Sultan in Constantinople. A certain amount was sold on the spot by the local magistrate to local merchants.

Two varieties of Lemnian Earth were produced. Belon mentions that the Turks clearly differentiated between two types of earth, thin – i makhtoum-i ahmer, i.e. the red earth, and the thin – i makhtoum-i ebiez, the white earth (Tourptsoglou-Stephanidou 1986, 111, n. 4), the latter considered of lower quality. It is, therefore, clear, from the accounts of both Galen and Belon, that colour reflected the grade, quality and use of the material. The weight of the sealed earth was c. 4 drams (i.e. c. 8 gr.).
Is the ritual of the extraction a covert geochemical process?

It is very likely that the extraction of Lemnian Earth witnessed by both Galen and Belon took place in the area of the Phthelidia spring about 1 km south of the ruins of the castle of Kotsinas. The spring is now tapped and lies about 150 m. east of the small chapel of St Sotiras. Although most accounts talk about a pit, there are some accounts which discuss a pit in association with either one or two or even three springs; however, what is made clear in these different accounts is that the springs are not linked in any way with the pit (Tourptsoglou-Stephanidou 1986, 161). They merely help locate the pit. There are, however, other accounts, mostly dated to the 16th century, which describe the pit in direct association with a spring. Carlier de Pinon writing in the 1550s and quoted by Tourptsoglou-Stephanidou (1986, 111, n. 4) mentions a spring integrally associated with the pit:

‘This earth they collect from the mud of a spring which is fenced with a wall and is always guarded by a group of soldiers. There is the custom every year on a particular day for the commander to take a few camel-loads of this earth following a ritual and to stamp it with the seal of the sultan’.

Tourptsoglou-Stephanidou, (1986, 504, n. 32) also refers to de la Vigne and a letter of his dated to February 22nd 1558, with the following information:

‘They prefer the white (earth) because it is the first one which comes out of the spring when they stir it… They collect it and they stamp it in Lemnos. The red (earth) is the one they prefer in France but it is the one that stays at the opening (mouth) of the spring after they have stirred it.’

In 1581, Jacopo Soranzo, emissary of Venice to the Sultan, gave the following account of the extraction activities:

‘On a hillock there is a spring; its water is directed through a channel to a pit which has formed naturally (by the accumulating water) … the pit is covered with planks cut and joined together like the cover for a box which they lock with a key. On the prescribed day (6th of August), they change the course of the water, so that it does not run towards the pit. They lift the cover and remove very carefully all the overlying water (in the pit), which they collect in buckets and (eventually) with sponges. Then they dig the mud and sort the best quality of earth out, first. Then they dig another type of earth, not as good, and then a third. With these three varieties of earth they make three different types of pellets as well as cups for drinking water; they seal them with the stamp of the Grand Efendi, and they fire them all to become hard’ (Soranzo in Tourptsoglou-Stephanidou 1986, 119, n. 7).

Finally, another detailed account of the extraction and processing of Lemnian Earth was given by John Covel based on his visit to Lemnos about 1677 (Covel in Tourptsoglou-Stephanidou 1986, 159). He does not specifically talk about a stream but gives a vivid description of the texture of the earth. He writes:

‘They extract the earth in the following way. Before sunrise they start digging a pit about 1.5 yards wide and a little above a man’s height in depth. Then they remove the earth which is soft as butter. The Greeks believe, and I think that the Turks believe it too, that it is the power of the holy liturgy that converted the hard rock to a soft clay; then they remove about 20–30 quintals of this earth, (one quintal being c.100kg), they fill up the pit again and leave it like this without any further guarding’ (Covel in Tourptsoglou-Stephanidou 1986, 161).

Covel also witnessed the processing of the Lemnian Earth at a large fountain in Hagiapate. Hagiapate or Aghios Ypatios was a Turkish village where the authorities had the right to take some Lemnian Earth and give it to local potters to make pots:

‘They first dissolve it in water, well working it with their hands; then let the water pass through a sieve and what remains they throw away. They let the water stand till settled, then take of the clear, and when dry enough, they mould in their hands; and most of this we have is shaped from thence. It is all here white, yet I had some given me flesh-coloured. I enquired diligently about it, and they all told me it came out of the same pit; but I expect some of these fellows have found some other place which they conceal’ (Covel in Tourptsoglou-Stephanidou 1986, 162).

Based on the above descriptions we suggest that there was a spring in the immediate vicinity of the pit from which the Earth was extracted. The water ‘passed over’ the pit in the course of a whole year. Sediments within the pit were allowed to settle and clay, silt and sand to separate. It is the fine naturally levigated clay that made up the medicinal Earth and which, when removed at source, required no further treatment. In support of this view, we quote Galen (De Simplicium Medicamentorum Temperamentis ac Facultatibus Liber IX (Chartier edition XIII, 249)) who makes it clear that Lemnian Earth should not be washed more than once:

‘... τινές δὲ δὲ τρίς δέονται πλυθῆναι, τὴν μὲν οὖν Λημνίαν ἐτοιμὴν λαμβάνεις ἀπὰ πεπλωμένην ὑπὸ τῆς ἱερίας, ἢ δευτέρου δὲ πλυθῆναι μὴ δεομένην’

‘Some (earths) are washed twice or three times; but the Lemnian Earth you receive ready washed only once by the priestess; it is not advisable to wash it a second time’ (authors’ translation).

This comment suggests that the medicinal Lemnian Earth contained a soluble component which was the main ingredient for its efficacy. Further washing would dilute the strength of Lemnian Earth. It is also possible that this soluble component was never associated with the pit but rather was introduced into the pit by the stream itself, in the course of the year. We suggest that the stream, which travelled over the volcanic rock of the area, may have carried a soluble component which may have been dissolved alum.
Field evidence for alum
We did not encounter alum in samples recovered from the Phthelidia spring area but there were several clues that alum could have been produced in this area, given the geological setting. The main clue is that some altered rocks from the Phthelidia spring area which were sampled contain alunite. Rock samples collected from the area are brown to brownish yellow or red with white parts. Petrographic and powder X-ray diffraction analyses indicated that the white parts contain alunite as the main component, with kaolin and cristobalite, whereas the red ochreous material contains alunite and kaolin, with hematite, iron oxyhydroxides and quartz (Hall and Photos-Jones 2008; Photos-Jones et al. 2012). Alunite is an insoluble potassium aluminium sulphate mineral similar in composition to alum. It is quite rare and is formed in relatively high temperature hydrothermal acid sulphate alteration of volcanic rocks. Alunite is often found associated with alum group minerals and native sulphur, as on Melos (Hall et al. 2003). Its presence in rocks at the Phthelidia spring therefore indicates that the hydrothermal processes in this area had the potential to produce alum-group minerals. This alteration process is explained in detail in relation to the origin of Melian alumen (Hall et al. 2003; Hall and Photos-Jones 2005). Even if it had been produced hydrothermally in abundance, alum is unlikely to be found in surface outcrops near the Phthelidia spring because the geothermal process is no longer active and, being very soluble, alum would have long ago been washed out of surface rocks by rainwater. The samples recovered show pronounced alteration. We infer that the different ‘varieties’ of Lemnian Earths with various textures (sticky, greasy and granular) and colours (white, yellow and red) that are referred to in the early texts are products of hydrothermal alteration, with various proportions of the alteration products. This is not unexpected in the proximity of a geological fault in a former volcanic area. This fault is inferred from the linear outcrop of crags of volcanic rock at Phthelidia and presumably also constituted the main focus for the former hydrothermal solutions. The existence of alunite in the rock samples collected is therefore only an indicator of the former potential presence of alum, but does provide corroborative evidence in the search for the active ingredient within the Lemnian Earth.

The deposits of altered rock could have been worked as described by Belon in ‘vein-like’ features, presumably located at geological faults and fracture zones. Over time, soluble sulphates such as alum would have been ‘washed’ by rain out of the high ground of altered volcanic rocks, into the alluvial sediment of the area of the currently surrounding fields. They could therefore have found their way into man-made traps (pits) set in place and worked by ritual as in the accounts given above. Alum could therefore have been concentrated by absorption by clay minerals as they settled out of the spring water over the period of a year. Altered volcanic rocks would be both exposed and under the spring water. Pivotal to the investigation is the nature of the bedrock over which water flowed. It is possible that more than one pit was used as a trap in any given year. Deciding which pit to excavate at any given time must have been the result of deliberation on the part of the foreman in charge but also of the authorities.

It should be emphasised that although a case is made here for the possible presence of dissolved alum in the spring waters, we cannot exclude the possibility that aluminium may exist in solution as a cation and, as such, be exchanged with the clay minerals that form the main constituents of the earth.

The nature and properties of alum
Alum is currently a mineral group name for a large number of highly soluble hydrated sulphates (usually aluminium-rich sulphates), such as alunogen, \(\text{Al}_2(\text{SO}_4)_3\cdot17\text{H}_2\text{O}\), potassium-alum, \((\text{K-alum}), \text{KAl(SO}_4\text{)\text{2}}\cdot12\text{H}_2\text{O}\). We therefore use the name ‘alum’ here for alum that is predominantly aluminium sulphate hydrate with or without potassium. Alum was of such commercial importance (as a mordant) in the 19th century that alum nomenclature was the subject of a book (Richardson 1927); it was argued that the word alum should be used only for potassium alum. The main concern seemed to be that K-alum was the standard material in use at that time, and its commercial status was being undermined by calling other minerals alum, in particular alunogen. In any case, alum (Latin: alumen; Greek: στυπτηρία, stypteria) has long been known for its astringency or styptic/haemostatic property. Although the word ‘astringency’ is probably best known for meaning a ‘sharp’ taste sensation, it also implies a ‘drawing together’, ‘shrinkage’ and ‘drying’ of soft body tissues. Astringency, in the latter sense, is a significant property of alum in relation to its medicinal and pharmaceutical uses.

Astringents known as stypts are employed to dry up excessive secretions and to stop oozing of blood. This astringency is a biochemical property, a physical effect involving the shrinking mucous membranes and the drying up of secretions. Astringency is also used to refer to a bitter taste sensation (Lawless et al. 1994). The reason for the taste relates to the biochemical properties of the astringents. The ‘taste’ aspect of ‘astringency’ is therefore not as ‘fundamental’ as the biochemical impact but it is understandable that that the word ‘astringent’ has become associated with the ‘quality of taste’ of fruit for example (Lawless et al. 1994; Eaks 1967).

An investigation of the use of alum as a mouth rinse (Murughan and Suryakanth 2004) led these authors to consider that the alum acted as a bactericide reducing levels
of *Streptococcus mutans* hence decreasing the risk of dental caries. The authors made it clear that the safety of the prolonged use of alum would need to be established before it could be used routinely. An early note by Young (1884) had warned that excessive use of alum can cause disintegration of teeth. Nevertheless, the study by Mourughan and Suryakanth (2004) provides good evidence of the antibacterial properties of alum.

Alum has long been used for large-scale water purification and acts as a flocculating agent, clearing water of microbes, clays as well as phosphorus and heavy metals (Linstedt et al. 1974). Martell et al. (1996) explain that the purification involves the precipitation of gelatinous aluminium hydroxide around any solid particles present, including bacteria. There is no antibacterial role envisaged in water purification. Yet a special use of alum for purification of contaminated water has been advocated, and in this case the alum is considered to be a bactericide (Ahmad, Jahan and Huq 1984); this study demonstrated that potassium aluminium sulphate (or potash alum) had an antibacterial effect in oral rehydration solution made with waters with a high bacterial count (gram-negative bacteria, *Vibrio cholerae* and *Escherichia coli*). Concentrations of only 500 mg/ml of potash alum per litre were effective within a few hours. The results of this study by Ahmed et al. (1984) clearly indicate the efficacy of alum as a bactericide.

In a recently published paper we have argued that minerals like alunite, montmorillonite and colemanite (the suggested active ingredient for the medicinal Samian earth being boron) but also zeolites are active in a biological environment with positive results (Photos-Jones et al. 2012, 636). This activity is related to their cation exchange properties. The antibacterial action of these minerals is a complex phenomenon and cannot be predicted on the basis of their mineral structure alone.

In parallel to our own work and that of our colleagues, there have been two separate sets of investigations on the nature of Lemnian Earth (Katsaros 2009, 365; Papoulis et al. 2011). These investigators ascribe the medicinal properties of Lemnian earth to the presence of As (and Pb) detected by chemical analysis in the rock/soils extracted at depth from the Kotsinas locality. However, they have also emphasised that in some samples the elevated amount of arsenic may not be beneficial but toxic, particularly under prolonged exposure (Papoulis et al. 2011). What is for certain is that the medicinal properties of the Lemnian Earth can not be defined in terms of composition and structure of the constituent parts alone. Studies of Egyptian bentonite for pharmaceutical use have shown that microbial tests are needed to establish the absence of pathogens and that the viable aerobic microorganisms need to be kept within allowed limits. (Abdel-Motelib et al. 2011). Although, in Antiquity, Lemnian Earth would not have undergone any quality control tests, it is expected that would have been largely relatively free of pathogens.

**Conclusions**

It is easy to pose the question ‘What was Lemnian Earth?’, and from our account so far it should be evident that this is not an easy question to answer. We have argued that the raw material was in itself the product of a man-induced enrichment process on an existing clay deposit. This information derives from documentary evidence, but it is not clear in its details. Yet we argue that it is consistent with many accounts that the earth was ‘wet’ or ‘moist’ when it was dug out. We suggest that the clay deposit (a mixture primarily of montmorillonite and kaolin) was being enriched over the course of the year by the waters of streams directed over it. The stream water may have been rich in alum or in aluminium deriving from a number of sources since it passed through what appears to be volcanically, hydrothermally altered rock; we have offered a tentative composition for Lemnian Earth consisting essentially of a clay with approximately 40% montmorillonite, 35% kaolin, 20% alum and 5% hematite (Hall and Photos-Jones 2008). We suggest that Lemnian Earth had alum as its active ingredient and one that might have worked as both an astringent and a bactericide when applied externally and when taken internally. The montmorillonitic clay not only provided the substrate but also could have acted as a poultice to reduce swelling. Its cation exchange capacities would have ensured the efficacy of the alum bearing minerals. One question that needs to be addressed pertains to the analysis of water samples for aluminium content from the surrounding springs. This is an ongoing project supported by field-based research.

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